# PROGRAM AT-A-GLANCE

## WEDNESDAY
**MARCH 7, 2012**

- **8:00 AM – 6:00 PM**
  - Registration
  - Northern Hemisphere Foyer

- **1:30 – 5:30 PM**
  - Pediatric Craniovertebral Society Meeting
  - Oceanic 1

- **Special Course I** – Neurosurgical Spine: Business and Compensation
  - Northern Hemisphere A1

- **Special Course II** – Cases and Complications with the Masters
  - Northern Hemisphere A2

- **Special Course III** – Spinal Deformity
  - Northern Hemisphere A3

- **Special Course IV** – Advanced MIS Techniques/Managing MIS Complications
  - Americas Seminar

- **Special Course V** – Management of Perioperative Pain, Perioperative Complications
  - Asia 3

- **Special Course VI** – Brazil: Spine Surgery in Brazil – in conjunction with the Spine Section of Brazilian Neurosurgical Association
  - Asia 4

- **Special Course VII** – Updates on Spine Trauma, Spinal Cord Injury, and Cervical Spine Trauma Guidelines
  - Northern Hemisphere A4

- **6:00 – 8:00 PM**
  - Opening Reception
  - Cabana Deck at the Pool

## THURSDAY
**MARCH 8, 2012**

- **6:00 AM – 6:00 PM**
  - Registration
  - Northern Hemisphere Foyer

- **6:30 – 7:00 AM**
  - Continental Breakfast
  - Southern Hemisphere Foyer

- **7:00 – 9:00 AM**
  - Scientific Session I
  - Southern Hemisphere I-III

- **9:00 AM – 7:00 PM**
  - Exhibit Hall and Poster Viewing
  - Northern Hemisphere B-E

- **10:15 AM – 12:15 PM**
  - Oral Platform Presentations I
  - Southern Hemisphere I-III

- **12:30 – 1:25 PM**
  - Lunch and What's New Session II
  - Northern Hemisphere B-E

- **2:30 – 4:30 PM**
  - Scientific Session II
  - Southern Hemisphere I-III

- **4:30 – 5:15 PM**
  - Oral Poster Presentations I & II
  - Southern Hemisphere I-III and Americas Seminar

- **5:15 – 6:45 PM**
  - Reception in the Exhibit Hall
  - Northern Hemisphere B-E

## FRIDAY
**MARCH 9, 2012**

- **6:00 AM – 5:00 PM**
  - Registration
  - Northern Hemisphere Foyer

- **6:30 – 6:55 AM**
  - Continental Breakfast
  - Southern Hemisphere Foyer

- **7:00 – 9:00 AM**
  - Scientific Session III
  - Southern Hemisphere I-III

- **9:00 – 9:20 AM**
  - Mayfield Awards
  - Northern Hemisphere B-E

- **9:00 AM – 2:00 PM**
  - Exhibit Hall and Poster Viewing
  - Southern Hemisphere I-III

- **10:15 AM – 12:15 PM**
  - Oral Platform Presentations II
  - Southern Hemisphere I-III

- **12:30 – 1:25 PM**
  - Lunch and What's New Session III
  - Northern Hemisphere B-E

- **2:30 – 3:00 PM**
  - Scientific Session IV
  - Southern Hemisphere I-III

- **3:00 – 4:30 PM**
  - Oral Poster Presentations III & IV
  - Southern Hemisphere I-III

- **5:15 – 6:45 PM**
  - Reception in the Exhibit Hall
  - Northern Hemisphere B-E

## SATURDAY
**MARCH 10, 2012**

- **6:00 AM – 12:30 PM**
  - Registration
  - Northern Hemisphere Foyer

- **6:30 – 6:55 AM**
  - Continental Breakfast
  - Southern Hemisphere Foyer

- **7:00 – 7:20 AM**
  - Scientific Session IV – Oral Poster Presentations III
  - Southern Hemisphere I-III

- **8:00 – 10:00 AM**
  - Beverage Break and What's New Session IV
  - Northern Hemisphere B-E

- **10:15 AM – 12:15 PM**
  - Oral Platform Presentations III & IV
  - Southern Hemisphere I-III

- **12:30 – 12:50 PM**
  - Annual Business Meeting
  - Southern Hemisphere I-III

- **1:30 – 3:00 PM**
  - Beverage Break and What's New Session V
  - Northern Hemisphere B-E

- **3:30 – 5:00 PM**
  - Scientific Session V
  - Southern Hemisphere I-III

- **5:15 – 6:00 PM**
  - Lunch in the Exhibit Hall
  - Northern Hemisphere B-E

- **6:00 – 7:30 PM**
  - Oral Poster Presentations V
  - Southern Hemisphere I-III

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Special Thanks to These Companies for Providing an Educational Grant in Support of the 2012 Annual Meeting!

### NEUROSURGICAL EDUCATION AMBASSADOR:
**BIOMET**

### NEUROSURGICAL LEADERSHIP AMBASSADOR:
**Medtronic**

### FUTURE OF NEUROSURGERY AMBASSADOR:
**SYNTHES**

### RESIDENT EDUCATION PARTNER:
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**Spineology**

(as of February 10, 2012)
PURPOSE OF THE SPINE AND PERIPHERAL NERVES SECTION

To foster the use of spinal neurosurgical methods for the treatment of diseases of the spinal neural elements, the spine and peripheral nerves. To advance spinal neurosurgery and related sciences, improve patient care, support meaningful basic and clinical research, provide leadership in undergraduate and graduate continuing education, and promote administrative facilities necessary to achieve these goals.

PREVIOUS MEETINGS

2011 Phoenix, Arizona
2010 Orlando, Florida
2009 Phoenix, Arizona
2008 Lake Buena Vista, Florida
2007 Phoenix, Arizona
2006 Lake Buena Vista, Florida
2005 Phoenix, Arizona
2004 San Diego, California
2003 Wesley Chapel, Florida
2002 Lake Buena Vista, Florida
2001 Phoenix, Arizona
2000 Rancho Mirage, California
1999 Lake Buena Vista, Florida
1998 Rancho Mirage, California
1997 Newport Beach, California
1996 Lake Buena Vista, Florida
1995 Phoenix, Arizona
1994 Fort Lauderdale, Florida
1993 Tucson, Arizona
1992 Miami, Florida
1991 Rancho Mirage, California
1990 Captiva Island, Florida
1989 Cancun, Mexico
1988 Phoenix, Arizona
1987 Boca Raton, Florida
1986 San Diego, California
1985 Greenleaf, Florida

YOUR OPINION IS PIVOTAL!

A link to the online evaluations will be sent to the e-mail address that you used to register for the meeting. Links to the evaluation system will also be online at www.spinesection.org. You will be able to login with either your last name and the e-mail address where the link was sent or your Annual Meeting badge number and your last name.

After logging in, simply follow the links to Claim Credits. Each session evaluation will be listed on this page. You will also be able to submit a request for CME credits at the same time though submission of evaluations is not mandatory to receive CME credit.

Your feedback is critical in helping the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves plan future education and Annual Meetings.
Dear Colleague:

On behalf of the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves Executive Committee, Annual Meeting Committee and Meritorious Award Recipient, we welcome you to the Walt Disney World Swan and Dolphin for the 2012 Annual Meeting. "Spine Surgery in the Era of Excellence: Will You Measure Up?"

Our expert faculty, dynamic scientific program and more than 200 scientific abstracts provide you with the latest advances in spine and peripheral nerve surgery as well as the information you need to advance your practice and ultimately improve patient care. Our informative Scientific Sessions offer complication management and avoidance strategies while exploring how we define and achieve excellence in spine and peripheral nerve surgery. Our extensive program also features two David Cahill Memorial Controversies Sessions with master spine specialists debating their perspectives on critical issues including, black disc disease, asymptomatic schwannoma and more. Additionally, with nine Special Courses and five luncheon symposia, this meeting provides the optional education necessary for you to achieve excellence in your daily practice. Through didactic lectures, interactive case presentations and discussion, these optional courses will enhance your overall meeting experience.

The Exhibit Hall features the latest developments and advances in spine and peripheral nerve surgery with more than 60 exhibitors displaying their latest products and services in neurosurgical and orthopedic technology. Visit with your corporate partners on Thursday and Friday during complimentary beverage breaks, Lunch in the Exhibit Hall and What’s New sessions to hear the latest information to enhance and improve your practice.

In addition to the outstanding education available, you will experience valuable networking events throughout the week including the Opening Reception on Wednesday evening and Reception in the Exhibit Hall on Thursday afternoon. Residents and young neurosurgeons will have the opportunity to hear a special presentation from Dr. Gerald E. Rodts, Jr. during the Young Neurosurgeons’ Dinner on Friday evening.

We thank you again for joining us in Orlando for the 2012 Annual Meeting and hope you will take time to experience the magic that only can be found at the Walt Disney World Swan and Dolphin.

Sincerely,

[Images of Christopher E. Wolfa, Daryl R. Fourney, and Marjorie C. Wang]

Christopher E. Wolfa, MD, FAAN
Chairperson

Daryl R. Fourney, MD
Annual Meeting Chairperson

Marjorie C. Wang, MD, MPH
Scientific Program Chairperson

2012 ANNUAL MEETING COMMITTEES

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Daryl R. Fourney

Scientific Program Chairperson
Marjorie C. Wang

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2012 Poster Awards and Grading Committee
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John J. Knightly
Srinivas K. Prasad
Christopher E. Wolfla, MD, FAANS

Christopher E. Wolfla, MD, FAANS, graduated with High Honors from Indiana University, Bloomington, and received his medical degree from Indiana University School of Medicine. He completed his Neurosurgery residency at Indiana University Medical Center under the direction of Drs. Robert L. Campbell and Paul B. Nelson. After residency, Dr. Wolfla completed a Fellowship in Spinal Neurosurgery at the Medical College of Wisconsin under the direction of Drs. Sanford J. Larson and Dennis J. Maiman. Upon completion, he joined the faculty of the University of Oklahoma Health Sciences Center, Department of Neurosurgery, where he held the Greenberg Endowed Chair. In 2005, Dr. Wolfla returned to the Department of Neurosurgery at the Medical College of Wisconsin. He is currently Professor of Neurosurgery and Residency Program Director.

Dr. Wolfla has an active clinical practice centered on spinal neurosurgery. He has authored more than 35 scientific articles and chapters in medical texts. His research interests have focused on spine biomechanics and spinal cord physiology. Dr. Wolfla is a member of Phi Beta Kappa, Alpha Omega Alpha and Beta Theta Pi.

Dr. Wolfla has served on the Executive Committee of the Congress of Neurological Surgeons since 2000 and has held the offices of Member-at-Large, Education Committee Chair, Scientific Program Chair, Annual Meeting Chair, Secretary, Vice President, and President-Elect. In addition, Dr. Wolfla has served on the Executive Committee of the AANS/CNS Joint Section on Disorders of the Spine and Peripheral Nerves, where he has held the offices of Member-at-Large, Treasurer, and Chair-Elect. He is the current Section Chair.

Dr. Wolfla has a wide variety of hobbies and outside interests. He is married to Catherine Slocum Wolfla. Together they live in Brookfield, Wisconsin and have two children – Andrew (18) and Julie (13).

PRESIDENTIAL ADDRESS

My Biases

THURSDAY, MARCH 8  ♦  8:50 AM
Dennis J. Maiman, MD, PhD

Dennis J. Maiman, MD, PhD, was born on July 26, 1953, in Milwaukee, Wisconsin. He attended the University of Wisconsin, Milwaukee and then the Medical College of Wisconsin (MCW), graduating in 1977. He carried out his neurosurgical residency at the Medical College of Wisconsin under the directorship of Sanford J. Larson, MD, PhD. He subsequently completed a fellowship in spinal surgery and spinal cord injury. He was appointed Assistant Professor of Neurological Surgery in 1984. He was also appointed Chief of Spinal Cord Injury at the VA Medical Center, and in 1986 was the Founding Medical Director of the Spinal Cord Injury Center at Froedtert Hospital. Simultaneously, he obtained a PhD in Biomedical Engineering from Marquette University (1985) and was promoted to Associate Professor in 1986. In 1992 he was promoted to Full Professor and became Director of the Spine Fellowship Program. He was also instrumental in the creation of SpineCare, a transdisciplinary evidence-based nonoperative program, which has since grown to four sites.

In March 2009, he became Professor and Chairman of the Department of Neurological Surgery and was awarded the Sanford J. Larson Professorship in the Department of Neurosurgery/MCW in 2011. He was also the Director of Clinical Neuroscience for the Medical College of Wisconsin and Froedtert Hospital until 2011. He is a member of the major neurosurgical associations as well as NASS and the Cervical Spine Research Society. He has been an ad hoc reviewer for multiple neurosurgical and spine journals and multiple grant review boards.

His research interests have been in the areas of biomechanics of the spine and pathophysiology of spinal cord injury, and its treatment. His predominant clinical interest is in spinal disorders and spinal cord injury. His bibliography includes 140 papers and co-authorship of Surgery of the Adult Lumbar Spine.

He has been married to Donna (nee Ziger) Maiman since 1976. Together they have four children, and ten grandchildren. Off campus interests include study of Jewish law, shooting, the eternal search for the trophy Muskie, piano, and a rabid passion for bicycling.
Ronald I. Apfelbaum Research Award

The Apfelbaum Award, sponsored by Aesculap, is for either basic or clinical research related to the spine with funding up to $15,000. This research award is intended to establish funding for research related to the spine, and to provide a means of peer review for clinical research projects to help improve the quality of the proposal and therefore, enhance competitiveness for National Institutes of Health (NIH) funding. The award is also meant to create an annual funding mechanism to establish the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves as a known source for quality clinical research aimed at answering questions pertaining to the treatment of disorders of the spine and peripheral nerves.

Jason Liauw, MD

Jason Liauw, MD, is a Johns Hopkins Neurosurgery resident pursuing a spine fellowship. Dr. Liauw received his undergraduate degree from Washington University in St. Louis and medical degree from Stanford University School of Medicine. During his tenure at Stanford University, Dr. Liauw was an American Heart and Stroke Association Fellow under Dr. Gary Steinberg. This research award will support his project studying the therapeutic potential of Forteo for augmenting spinal fusion.

David Kline Research Award

The Kline Award, sponsored by Integra Foundation, is for either basic or clinical research related to peripheral nerves with funding up to $15,000. This research award is intended to establish funding for research related to the peripheral nerves, and to provide a means of peer review for clinical research projects to help improve the quality of the proposal and therefore, enhance competitiveness for National Institutes of Health (NIH) funding. The award is also meant to create an annual funding mechanism to establish the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves as a known source for quality clinical research aimed at answering questions pertaining to the treatment of disorders of the spine and peripheral nerves.

Chetan Bettegowda, MD

Chetan Bettegowda, MD, grew up in Charlotte, NC and completed his undergraduate studies in Biology and Religion at Duke University. He then entered the MD/PhD program at Johns Hopkins University School of Medicine, where he completed his PhD thesis in the laboratory of Bert Vogelstein. Upon completion of his medical education, Dr. Bettegowda entered the neurosurgery residency program at Johns Hopkins where he is a currently a chief resident. Dr. Bettegowda’s clinical interests are in neurosurgical oncology, including tumors of the brain and spine. His research interests are in the global genetic profiling of central nervous system tumors and using the knowledge gained from these studies to develop blood based tumor biomarkers that can be used to follow disease burden.
The Larson Award, sponsored by DePuy Spine, is limited to clinical research with funding up to $30,000. This research award is intended to establish funding for clinically relevant research related to the spine and peripheral nerves, and to provide a means of peer review for clinical research projects to help improve the quality of the proposal and therefore, enhance competitiveness for National Institutes of Health (NIH) funding. The award is also meant to create an annual funding mechanism to establish the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves as a known source for quality clinical research aimed at answering questions pertaining to the treatment of disorders of the spine and peripheral nerves.

Daniel C. Lu, MD, PhD
Daniel C. Lu, MD, PhD, completed his neurosurgery training at University of California, San Francisco and spine fellowship with Dr. Kevin Foley at University of Tennessee. Dr. Lu is a faculty member at University of California, Los Angeles. He directs laboratory research efforts at understanding the molecular basis for conditions affecting the spine. For the Larson Award, Dr. Lu will be conducting a one-year prospective trial in determining the “fingerprint” for symptomatic disc degeneration by looking at the molecular, radiographic and clinical profile of degenerated discs. This will potentially serve as a screening tool to predict success with operative management and establish the basis for potential therapeutic molecular targets.

The Cahill Fellowship, sponsored by Synthes Spine, is awarded annually to one U.S. or Canadian trained neurosurgical resident to provide supplemental funding for advanced education and research in disorders of the spine or peripheral nerves in the form of fellowship training away from their parent institution. The amount of the award is $30,000. Applicants should be residents in training or ABNS eligible fellows, must provide a letter of acceptance from the designated mentor and program, a letter of support from their training program director, a description of the proposed fellowship with the educational or research goals, and a current CV.

Mark Mahan, MD
Mark Mahan, MD, is currently a fifth year resident at the Barrow Neurological Institute in Phoenix, AZ. Born in Tulsa, OK, Mark graduated magna cum laude from Princeton University in 1998. He worked in leveraged finance at a major Wall Street bank and then in private equity for five years after his graduation. Unfulfilled academically, Mark left finance and matriculated at Columbia University’s College of Physicians and Surgeons, graduating AOA in 2007. During residency at the BNI, Mark has found interest in regenerative peripheral nerve procedures and has established plans to spend his sixth year pursuing an in-folded fellowship under the direction of Dr. Robert Spinner at the Mayo Clinic and Dr. Justin Brown at UCSD. Mark is researching high resolution magnetic resonance imaging of peripheral nerves, distal nerve transfers for bladder reanimation, and other projects.
The Cloward Fellowship, sponsored by Medtronic, is awarded annually to one U.S. or Canadian trained neurosurgical resident to provide supplemental funding for advanced education and research in disorders of the spine or peripheral nerves in the form of fellowship training away from their parent institution. The amount of the award is $30,000. Applicants should be residents in training or ABNS eligible fellows, must provide a letter of acceptance from the designated mentor and program, a letter of support from their training program director, a description of the proposed fellowship with the educational or research goals, and a current CV.

John E. Ziewacz, MD
John Ziewacz, MD, is currently chief resident in neurosurgery at the University of Michigan-Ann Arbor. He is a 2005 graduate of the Johns Hopkins University School of Medicine and a 2010 graduate of the Harvard School of Public Health with a concentration in Health Policy. His research time was spent studying surgical safety and outcomes research at the Center for Surgery and Public Health in Boston under Dr. Atul Gawande. He became interested in spine surgery while working with Drs. Frank LaMarca and Paul Park at the University of Michigan. He will pursue fellowship training at UCSF in July 2012 under the direction of Dr. Praveen Mummaneni. He plans to pursue a career in academic spine surgery.

The Crockard International Fellowship, sponsored by DePuy Spine, is awarded annually to a neurosurgical resident or neurosurgeon from outside of the U.S. or Canada to provide supplemental funding for advanced education and research in disorders of the spine in the form of a fellowship experience in the United States or Canada. The amount of each award is $5,000. Applicants must provide a letter of acceptance from the designated mentor and program, a letter of support from their training program director if applicable, a description of the proposed fellowship with the educational or research goals, and a current CV.

Andrei N. Kuzmin, MD
Andrei N. Kuzmin, MD, is a neurosurgeon at the Chelyabinsk State Clinical Hospital in Chelyabinsk, Russia. Dr. Kuzmin finished his residency in neurosurgery at the Urals State Medical Academy, Department of Neurology and Neurosurgery, Ekaterinburg, Russia in 2007 and received his medical degree from Chelyabinsk State Medical Academy in 2002.

Dr. Kuzmin’s clinical interest is the study of modern methods of surgical management of patients with complex spine disorders.
**Sonntag International Fellowship**

*The Sonntag International Fellowship, sponsored by Medtronic, is awarded annually to a neurosurgical resident or neurosurgeon from outside of the U.S. or Canada to provide supplemental funding for advanced education and research in disorders of the spine in the form of a fellowship experience in the United States or Canada. The amount of each award is $5,000. Applicants must provide a letter of acceptance from the designated mentor and program, a letter of support from their training program director if applicable, a description of the proposed fellowship with the educational or research goals, and a current CV.*

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**Olaolu C. Akinbo, MBBS**

Olaolu Charles Akinbo, MBBS, received his medical training at the College of Medicine, University of Lagos, Nigeria where he obtained Bachelor of Medicine and Surgery degrees (MBBS) in 1998. His residency training in Neurosurgery was at the Department of Neurological Surgery, University College Hospital (UCH), Ibadan, Nigeria. During his residency, Dr. Akinbo conducted research on the Epidemiology of Neurotrauma and Motorcycle Head Injury under the supervision of Professors M.T. Shokunbi and A.O. Malomo. His interest in spine surgery developed during this time as well. Dr. Akinbo plans to hone his skills further in general and complex spinal surgeries under Dr. Praveen V. Mummaneni at the University of California, San Francisco through an observational fellowship. The Sonntag International Fellowship award will contribute towards making this a reality.

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**Regis W. Haid, Jr., MD Adult Deformity Award**

*Introducing the Regis W. Haid, Jr., MD Adult Deformity Award, sponsored by Globus Medical, a new opportunity made available in 2012 intended for primary neurosurgical investigators interested in clinical research in the field of adult spinal deformity. This research award is intended to provide up to $30,000 in research funding for clinically relevant research related to adult degenerative spinal deformity, and to provide a means of peer review for clinical research projects to help improve the quality of the proposal and therefore, enhance competitiveness for National Institutes of Health (NIH) funding. The award is also meant to create an annual funding mechanism to establish the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves as a known source for quality clinical research aimed at answering questions pertaining to the treatment of disorders of the spine and peripheral nerves.*

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**Justin S. Smith, MD, PhD, FAANS**

Justin S. Smith, MD, PhD, FAANS, received his medical degree from Mayo Medical School and PhD in Molecular Neuroscience from Mayo Graduate School, both in Rochester, Minnesota. He completed a general surgery internship and neurological surgery residency at the University of California at San Francisco, where he served as Chief Resident in Neurological Surgery. Dr. Smith advanced his spine training in two fellowship programs. The first was an adult and pediatric deformity spine fellowship at the University of Virginia jointly sponsored by the Departments of Neurosurgery and Orthopaedic Surgery. Under the tutelage of Richard G. Fessler, MD, he completed a minimally invasive spine fellowship at Northwestern University in Chicago, Illinois. He is currently co-director of the UVA Spine Center, and is an Assistant Professor of Neurological Surgery at the University of Virginia. Within the Department of Neurological Surgery, Dr. Smith serves in several leadership roles including Director of Minimally Invasive Spine Surgery, co-director of Spine Division and co-director of Spine Fellowship.
The Mayfield Awards are presented annually by the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves to the neurosurgical residents or BC/BE fellows in North American training programs who author outstanding manuscripts detailing a laboratory or clinical investigation in the area of spinal or peripheral nerve disorders. This award is also applicable to individuals in DO training programs. The manuscript for this award is presented by attaching related information to their abstract during the abstract submission process. Two awards are available, one for clinical research and one for basic science research. Each recipient will receive an honorarium of $2,000 to cover the expenses of attendance at the Annual Meeting of the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves. Abstracts to be considered for the Mayfield Awards should be identified as such on the Annual Meeting abstract submission form and submitted prior to deadline.

Mayfield Award Recipients 1984 – 2011

2011
Basic Science: Mohammed F. Shamji
Clinical Science: Tyler J. Kenning

2010
Basic Science: Wilson Zachary Ray
Clinical Science: Raqeeb Haque

2009
Basic Science: Daniel L. Master
Clinical Science: Matthew B. Maserati

2008
Basic Science: Ann Margaret Parr
Clinical Science: Dennis E. Cramer, Matthew M. Kang

2007
Basic Science: Sharad Rajpal
Clinical Science: Florian Roser

2006
Basic Science: Toshitaka Seki
Clinical Science: Benson Yang

2005
Basic Science: John Y. K. Lee
Clinical Science: Nicholas H. Post

2004
Basic Science: Bryan B. Barnes
Clinical Science: Michael Y. Wang

2003
No Awards Presented

2002
Basic Science: Edward R. Smith
Clinical Science: Ketan R. Bulsara

2001
Basic Science: Ketan R. Bulsara
Clinical Science: Gordon W. Tang

2000
Basic Science: Neill M. Wright
Clinical Science: Viswanathan Rajaraman

1999
Basic Science: Steven Casha
Clinical Science: Nicholas Theodore

1998
Tord D. Alden

1997
Michael A. Morone

1996
Basic Science: Paul C. Francel
Clinical Science: Paul D. Sawin

1995
Simcha J. Weller

1994
Timothy C. Ryken

1993
Basic Science: Allan D. Levi
Clinical Science: Gerald F. Tuite

1992
Rajiv Midha

1991
Peter G. Gianaris

1990
R. John Hurlbert

1989
Richard K. Simpson, Jr.

1988
No Award Presented

1987
John A. Feldenzer

1986
No Award Presented

1985
Abhijit Guha

1984
Mark N. Hadley

J. Bridger Cox, MD

J. Bridger Cox, MD, is currently in his fifth year of his neurosurgical residency at the University of Florida, expecting to complete his training in June 2014. Dr. Cox’s clinical interests are in spine surgery, specifically deformity correction and spine tumors. Outside of the operating room, Dr. Cox has an interest in socioeconomic and policy issues within neurosurgery. During his research year, Dr. Cox completed a clinical spine year under Dr. Patrick Jacob and Dr. Daniel Hoh. Dr. Cox is a member of AO Spine, the Congress of Neurological Surgeons, the American Association of Neurological Surgeons, and the Florida Medical Association. He attended the University of Oklahoma, graduating magna cum laude with a degree in Political Science in 2003. He obtained his medical degree in 2007 at the University of Oklahoma Health Sciences Center in Oklahoma City. Dr. Cox was a member of the men’s varsity golf team at the University of Oklahoma. He is a National Merit Scholar and spent time during undergrad studying at Oxford University in England. He continues to enjoy playing golf, as well as hunting, fishing, and travelling.

Friday, March 9, 9:07 – 9:12 AM

119. Decreased Incidence of Venous Thrombo-Embolism After Spine Surgery with Early Aggressive Chemoprophylaxis
Joseph Bridger Cox, Catherine Koepnick, R. Patrick Jacob, Daniel J. Hoh
Alexander E. Ropper MD
Alexander E. Ropper, MD, received a BA from the University of Pennsylvania and an MD from Tufts University School of Medicine (AOA). He is currently a fifth year resident in neurosurgery at Brigham and Women’s Hospital and Harvard Medical School. His research at Brigham and Women’s Hospital and the Boston VA Healthcare System in the laboratories of Yang Teng, MD, PhD focuses on stem cell based restorative therapies for spinal cord injury.

Friday, March 9, 9:00 – 9:05 AM
118. Human Mesenchymal Stem Cells Seeded in a Polymer Scaffold: A Novel Treatment Approach for Spinal Cord Injury
Alexander E. Ropper, Devang Thakor, Inbo Han, Dou Yu, Hariprakash Haragopal, A. John Popp, Yang D. Teng

The Outcomes Committee Award is presented annually by the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves to a neurosurgical resident or BC/BE neurosurgeon in North America who authors an outstanding abstract presenting the results of a clinical investigation in the area of spine or peripheral nerve disorders, that demonstrates sound methodological design and includes evaluation of patient-oriented outcomes as the primary endpoint. The recipient of the award will be selected by the members of the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves Outcomes Committee. The award is a gift from The David and Jean Wallace Fund. The recipient will receive a $2,000 honorarium to help cover the expenses of attendance at the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves Annual Meeting. Abstracts to be considered should be identified on the Annual Meeting abstract submission form and submitted prior to the deadline.

Jun Jae Shin, MD, PhD
Jun Jae Shin, MD, PhD, graduated from the neurosurgery residency at Severance Hospital, Yonsei University College of Medicine, Seoul, Korea. He received his BM degree from Yonsei University and MD-PhD degrees from Yonsei University College of Medicine. He completed a fellowship at Severance Hospital. He is now performing a research fellowship in NeuroSpine Center and Research Laboratory with Dr. Jon Park at Stanford University Medical Center.

Friday, March 9, 9:14 – 9:19 AM
120. The Relevance of Intramedullary High Signal Intensity and Gadolinium (Gd-DTPA) Enhancement to the Clinical Outcome in Cervical Compressive Myelopathy
Jun-Jae Shin, Ji Hae Lee, Woo Ho Cho, Jon Park

2011 AWARD RECEPIENTS
Ronald I. Apfelbaum Research Award – Zachary Adam Smith, MD
David Kline Research Award – Jacob D. Alant, MBChB, MMED, FRCS(C)
Sanford Larson Research Award – Erica F. Bisson, MD
Cahill Fellowship – Timothy David Uschold, MD
Cloward Fellowship – Michael J. Dorsi, MD
Sonntag International Fellowship – Gurpreet Singh Gandhoke, MD
Outcomes Committee – Cheerag D. Upadhyaya, MD, MS
CME CREDIT
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 Congress of Neurological Surgeons and the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves. The CNS is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide continuing medical education for physicians.

US Physicians: The CNS designates this live activity for a maximum of 26.75 AMA PRA Category 1 Credits™. Physicians should only claim credit commensurate with the extent of their participation in the activity.

The same number of AMA PRA Category 1 Credits™ awarded will be applied toward the Continuing Education Award in Neurosurgery.

*A maximum of 18.75 AMA PRA Category 1 Credits™ may be earned for Scientific Sessions only.

Physician Assistants/Physician Extenders/Nurses and Other Allied Health Professionals: Attendees will receive credits for attendance at the general Scientific Program and for any optional events attended. Each physician assistant/physician extender/nurse/allied health professional should contact his or her individual membership association and certification board to determine the requirements for accepting credits. All attendees will receive a Certificate of Attendance.

Additional CME Credits can be earned by attending the following:

Special Courses
Attendees will receive a maximum of four (4) AMA PRA Category 1 Credits™ for each eligible half-day Special Course. Physicians should only claim credit commensurate with the extent of their participation in the activity.

Luncheon Symposia
Attendees will receive a maximum of two (2) AMA PRA Category 1 Credits™ for each eligible Luncheon Symposium. Physicians should only claim credit commensurate with the extent of their participation in the activity.

Posters
Physicians may claim AMA PRA Category 1 Credit™ directly from the AMA for preparing a poster presentation, which also includes the published abstracts. Physicians may claim them on their AMA PRA certificate application or apply directly to the AMA for an AMA PRA Category 1 Credit™ certificate. Physicians may claim AMA PRA Category 2 Credit™ for viewing scientific posters. Physicians should self-claim credit on their AMA PRA certificate application form.

GENERAL INFORMATION

Speaker Ready Room
The Speaker Ready Room, located in the Speaker Ready Room prior to their presentation. All Scientific Session Faculty are required to check in at the Speaker Ready Room 24 hours prior to their presentation.

Exhibit Hall
Northern Hemisphere B-E
Thursday, March 8 9:00 AM – 7:00 PM
Friday, March 9 9:00 AM – 2:00 PM

Registration
Northern Hemisphere Foyer
Wednesday, March 7 8:00 AM – 6:00 PM
Thursday, March 8 6:00 AM – 6:00 PM
Friday, March 9 6:00 AM – 6:00 PM
Saturday, March 10 6:00 AM – 12:30 PM

No Smoking Policy
Smoking is not permitted at any official AANS/CNS Section on Disorders of the Spine and Peripheral Nerves Annual Meeting events. Smoking is also prohibited inside and on the grounds of the Walt Disney World Swan and Dolphin.

Disclaimer
The material presented at the 2012 Annual Meeting has been made available by the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves and the CNS for educational purposes only. These materials are not intended to represent the only, nor necessarily the best method or procedure appropriate for the medical situations discussed, but rather are intended to present an approach, view, statement or opinion of the faculty, which may be helpful to others who face similar situations.

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

Some drugs and medical devices demonstrated or described within the print publications of the AANS/CNS Section of Disorders of the Spine and Peripheral Nerves jointly sponsored by the CNS 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 wants to use in compliance with applicable laws.

Neither the content (written or oral) of any course, seminar or other presentation in the program, nor the use of a specific product in conjunction therewith, nor the exhibition of any materials by any parties coincident with the program, should be construed as indicating endorsement or approval of the views presented, the products used or the materials exhibited by the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves jointly sponsored by the CNS, or by its committees, commissions or affiliates.

OPENING RECEPTION
Wednesday, March 7 6:00 – 8:00 PM
Cabana Deck at the Pool
Enjoy a lavish array of food and refreshments while reconnecting with colleagues and meeting new contacts at the Opening Reception. Take in the magic and wonder of the reception at the Walt Disney World Swan and Dolphin. Each medical attendee and spouse/guest registered for the meeting will receive one complimentary ticket. Resort casual attire is recommended.

RECEPTION WITH EXHIBITORS
Thursday, March 8 5:15 – 6:45 PM
Northern Hemisphere B-E
Join us for this special event in the Exhibit Hall! Interact with colleagues and corporate contacts while enjoying pre-dinner cocktails and hors d’oeuvres. Business casual attire is recommended.

YOUNG NEUROSURGEONS’ DINNER
Friday, March 9 6:30 PM
Southern Hemisphere V
Special Presentation by
Dr. Gerald E. Rodts, Jr.
All residents, fellows and young neurosurgeons are welcome. RSVP to DePuy Spine, Booth #207.
<table>
<thead>
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<th>Chairperson Elect</th>
<th>Secretary</th>
<th>Treasurer</th>
<th>Immediate Past Chairperson</th>
<th>Members–at–Large</th>
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*Relationship refers to receipt of royalties, consultanship, funding by research grant, receiving honoraria for educational services elsewhere, or any other relationship to a commercial company that provides sufficient reason for disclosure.

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Other – Depuy Spine (6); K2M (6);
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Stryker (6)

John Chi, MD
Consulting Agreement – Synthes (2) (3)

Theodore J. Choma, MD
Consulting Agreement – Gents, Inc (2)
Stryker Spine (2)

Dean Chou, MD
Honoraria – Stryker (2)

Domaqoi Coric, MD
Consulting Agreement – Depuy Spine (2);
Pioneer Surgical (2); Spinal Motion (2);
Spine Wave (2)

Reginald J. Davis, MD
Consulting Agreement – Vertiflex (2)

Mark B. Dekutoski, MD
Consulting Agreement – Mayo Medical
Ventures/Medtronic (2)
Honoraria – AO Foundation (6)
Other – Broadwater Associates CME
Group (6); Depuy (6); Medtronic (6);
Stryker (6); Synthes (6)

Vedat Deviren, MD
Consulting Agreement – NuVasive (2);
Stryker (2)
Other – Medtronic; Depuy (6); Stryker
(6); Synthes (6); Johnson & Johnson (6);
NuVasive (6)
Royalty – NuNasive (6)

Richard G. Fessler, MD
Consulting Agreement – Medtronic (2)
Honoraria – Depuy (6)
Ownership Interest – In Queue
Innovations (7)
Royalty – Depuy (6); Medtronic (6);
Stryker (6)

Kevin T. Foley, MD, FACS
Consulting Agreement – ArthroCare (2);
Medtronic (2); NuVasive (2)
Intellectual Fees – ArthroCare (6)
Ownership Interest – Discogenics (3);
TrueVision (3)
Royalty – Medtronic (6)

Steven D. Glassman, MD
Royalty – Medtronic (2)
Salary – Norton Health Care (5)

Ziya L. Gokaslan, MD
Honoraria – AO North America (7)
Other – AANS (6); AO Foundation
Lectures (6); AO North America
Fellowship Funding (6); Depuy (6);
AOSpine Research Support (6);
Medtronic (6); NREF Fellowship Funding
(6); Spinal Kinetics Stock (8); US Spine
Stock (8)
Ownership Interest – Spinal Kinetics
Stock (8)
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<th>Name</th>
<th>Relation to Industry</th>
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<td>Michael W. Groff, MD</td>
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<td>Ownership Interest – Acrotech (6); J&amp;J (6); Pfizer (6); Pioneer (6); Proctor and</td>
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<td>Regis W. Haid, MD</td>
<td>Consulting Agreement – Globus Medical (2); Piedmont Health Care (2)</td>
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<td>Other – NuVasive (6); Globus Medical (6); Medtronic (6)</td>
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<td>Robert Hart, MD</td>
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<td>Michael S. Hisey, MD</td>
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<td>Richard A. Hostin, MD</td>
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<td>R. Patrick Jacob, MD</td>
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<td>Michael Janssen, MD</td>
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<td>J. Patrick Johnson, MD</td>
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<td>Iain H. Kalfas, MD</td>
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<td>Adam S. Kanter, MD</td>
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<td>Branko Kopjar, MD</td>
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<td>Tyler R. Koski, MD</td>
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<td>Frank La Marca, MD</td>
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<td>Virginie Lafage, PhD</td>
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<td>John C. Liu, MD</td>
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<td>Matthew McGirt, MD</td>
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<td>Mark R. McLaughlin, MD</td>
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<td>Ownership Interest – Spine Wave (6)</td>
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<td>Stefan A. Mindea, MD</td>
<td>Consulting Agreement – DePuy (6); Globus (6); Medtronic (6)</td>
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<td>Praveen V. Mummaneni, MD</td>
<td>Consulting Agreement – DePuy Spine (6); Medtronic (2)</td>
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<td>Gregory Mundis, MD</td>
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<td>Eric W. Nottmeier, MD</td>
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<td>Pierce D. Nunley, MD</td>
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<td>Michael F. O’Brien, MD</td>
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<td>David O. Okonkwo, MD</td>
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<td>Mick J. Perez-Cruet, MD</td>
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</table>
Disclosures

Daniel L. Peterson, MD
Consulting Agreement – OrthoKinematics (6); OsteoMed (6); Stryker (6)
Other – LDR Spine (6)

Frank Phillips, MD
Consulting Agreement – NuVasive (2)

Luiz Pimenta, MD
Consulting Agreement – NuVasive (2); Zyga Tech (2)

Eric A. Potts, MD
Consulting Agreement – Lanx (2); Medtronic (2)
Ownership Interest – Lanx (8)
Royalty – Medtronic (6)

Sriniivas K. Prasad, MD
Consulting Agreement – Synthes Spine (6)
Honoraria – Stryker Spine (6)

Daniel Refai, MD
Consulting Agreement – Aesculap Implant Systems (2); Stryker Education (2)

Laurence D. Rhines, MD
Honoraria – Biomet (2); Medtronic (2); Stryker (2)

W.B. Rodgers, MD
Consulting Agreement – Exactech (2); NuVasive (2)
Ownership Interest – NuVasive (2)
Royalty – NuVasive (2)

Gerald E. Rodts, Jr., MD
Consulting Agreement – Globus Medical, Inc. (2); Medtronic (2); Orthofix, Inc. (2)
Other – SpineUniverse.com (3)
Royalty – Globus Medical, Inc. (2)

Timothy C. Ryken, MD
Consulting Agreement – Eisai (2); Medtronic Inc (2); Merck Inc./Schering-Plough Inc. (2)

Charles A. Sansur, MD
Consulting Agreement – Medtronic (2); Synthes (2)

Rick Sasso, MD
Other – Cerapdics (6)
Royalty – Medtronic (6)

Frank Schwab, MD
Consulting Agreement – DePuy Spine (2)
Honoraria – Medtronic (6)
Other – Medtronic (6); Nemaris (7); SRS (6)
Ownership Interest – Nemaris (8)

Daniel M. Sciubba, BS, MD
Consulting Agreement – Globus (2)
Honoraria – Depuy (6); Medtronic (6)

Christopher I. Shaffrey, MD, FACS
Consulting Agreement – Biomet (6)
Honoraria – Depuy (6); Stryker (6)
Other – AOSpine North America (6); Department of Defense (6); Journal of Neurosurgery (4); National Institutes of Health (6); NuVasive (6); Spine (4)
Royalty – Medtronic (6)

Jonathan D. Sherman, MD
Consulting Agreement – Depuy (2); Medtronic (2)

Justin S. Smith, MD, PhD
Consulting Agreement – Axial Biotech (2); Biomet (2); Medtronic Sofamor Danek (2)
Honoraria – Globus (6)
Other – Depuy (6); Medtronic Sofamor Danek (6)

Michael P. Steinmetz, MD
Consulting Agreement – Medtronic (2)
Honoraria – Biomet Spine (2)

John K. Stokes, MD
Other – LDR Spine (6)
Royalty – Genesys Orthopedics (6)

Antoine Tohmeh, MD
Consulting Agreement – NuVasive (2)

Vincent C. Traynelis, MD
Consulting Agreement – Medtronic (2); United HealthCare (2)
Other – Globus (6)
Royalty – Medtronic (6)

Eve C. Tsai, MD, PhD, FRCS
Other – BrainLab (6)

Juan S. Uribe, MD
Consulting Agreement – Medtronic (2); NuVasive (2); Orthofix (2)

Alexander R. Vaccaro, MD
Consulting Agreement – Gerson Lehman Group (2); Guidepoint Global (2); Medacorp (2)
Ownership Interest – Advanced Spinal Intellectual Properties (6); Bonovo Orthopaedics (6); Computational Biodynamics (6); Cross Current (6); Cytonics (6); Disc Motion Technology (6); Electrolux (6); Flagship Surgical (6); Flow Pharma (6); Gamma Spine (6); Globus Medical (6); In Vivo (6); K2 Medical (6); Location Based Intelligence (6); Neucore (6); Orthovita (6); Paradigm Spine (6); Progressive Spinal Technologies (6); R.IS (6); Replication Medica (6); Small Bone Innovations (6); Spine Medica (6); Spine (6); Stout Medical (6); Synedicom (6); Vertelex (6)
Royalty – Aesculap (6); Biomet (6); Depuy (6); Globus Medical (6); K2 Medical (6); NuVasive (6); Stryker Spine (6)

Marjorie C. Wang, MD, MPH
Salary – Robert Wood Johnson Physician Faculty Scholars Program (6)

Michael Y. Wang, MD
Consulting Agreement – Aesculap Spine (2); Biomet (2); Depuy Spine (2)
Ownership Interest – NeuroConsulting Specialists, LLC (8)

William Charles Welch, MD, FACS, FICS
Consulting Agreement – Best Doctors (2); Synthes Spine (2); Zimmer Spine (2)
Ownership Interest – Pittsburgh Standard Spine (7); Welch Research and Development (8)

Timothy F. Witham, MD, BS
Honoraria – Globus Medical (6); Stryker Spine (6)
Other – Integra Life Science (6)

Eric J. Woodard, MD
Honoraria – Depuy Spine (2)
Ownership Interest – In Vivo Therapeutics (7)
Royalty – Stryker Spine (2)

Lynda Jun-San Yang, MD, PhD
Other – Spartan Corp. (3)

Sangwook Yoon, MD
Other – AOSNA (6); Biomet (6); OMEGA (6); OREF (6); Phygen (6)
Royalty – Nexgen (6); Stryker (6)
NOTHING TO DISCLOSE

Individuals who have reported they do not have any relationship with commercial companies are listed here.

NOTHING TO DISCLOSE
Disclosures

Mark A. Pichelmann, MD*
Rae Podabinski
David W. Polly, MD*
A. John Popp, MD
Nader Pouratian, MD, PhDF
Gustavo Pradilla, MD*
Matthew R. Quigley, MD*
Shayan Rahnam, MD*
Rajesh Reddy, MBBS, FRACSF
Daniel K. Resnick, MD*
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Alex Riccio, BS*
Daniele Rigmonti, MD*
Gloria E. Rodriguez-Vega, MD*
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Alexander E. Ropper, MD*
Michael K. Rosner, MD*
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Fanor Manuel Saavedra, MD*
Rachel Sarabia-Estrada, DVM, PhD*
Kajana Satkunendrarajah*
Dwight Sault, MD*
Justin K. Scheer*
Terry K. Schiefer, MD*
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J. Sanford Schwartz, MD*
Theodore H. Schwartz, MD, FACS*
David L. Semenoff, MD*
Ericson Sfredlo, MD*
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Antos Shakhbazian*
David Shau, BS*
Jun-Jae Shin, MD, PhD*
Motoi Shoda*
Brenda A. Sides, MA*
Jerry Silver, PhD*
Frederick A. Simeone, MD*
Marcelo S. Simoes, MD*
Laura Ann Snyder, MD*
Robert J. Spinner, MD*
Sherman C. Stein, MD*
James Harris Stephen, MD*
Robert Stetsone*
Geoffrey E. Stoker, BS*
Andrea L. Strayer, BSN*
Gael Strayer, MSc*
Andrea L. Strayer, BSN*

Luncheon Symposium V –
Lateral Retroperitoneal
Interbody Fusion: Technique
and Outcomes
John C. Liu
Jian S. Uribe
Saturday Case Presentations
Aruna Ganju
Oral Platform Presentations II
115: Domagoj Coric
116: Domagoj Coric
Oral Poster Presentations I
226: Warren J. Allain
Oral Poster Presentations II
248: Eric W. Nottmeier
Oral Poster Presentations III
218: Khoi Duc Than
240: Antoine Tohme
243: Daniel Robert Fassett
Oral Poster Presentations IV
245: Maxwell Boakye
252: Reginald J. Davis

Digital Posters
317: Luis M. Tumialan
328: Luis M. Tumialan
334: W.B. Rodgers
341: Ira M. Goldstein
342: John K. Houten
343: Eric W. Nottmeier
348: John G. Stark
351: Mitchell Hardenbrook
364: Kenneth Pettine
368: Kenneth Pettine
370: Kenneth Pettine
372: Mick J. Perez-Cruet
387: Kaveh Khajavi
391: John G. Stark
395: Mick J. Perez-Cruet
399: Robert F. Heary
425: Robert M. Galler
433: Randall W. Porter
439: Kingsley O. Abode-Iyamah

Non-FDA Approved Listing

Scientific Session I – What’s On Your Report Card?
Daryl R. Fournery

Scientific Session III – Complication Avoidance and Management
Praveen V. Mummaneni
Michael Y. Wang

David Cahill Memorial
Controversies II Spine and Peripheral Nerve – Rapid Fire
James S. Harrop
Charles Kuntz, IV

Pediatric Craniocervical Society
Richard C.E. Anderson

Special Course II – Cases and Complications with the Masters
Edward C. Benzel
Christopher I. Shaffrey
Vincent C. Traynelis

Special Course III – Spinal Deformity
Charles Kuntz
Juan S. Uribe

Special Course IV – Advanced MIS Techniques/Managing MIS Complications
Praveen V. Mummaneni
Michael Y. Wang

Special Course VII – Updates on Spine Trauma, Spinal Cord Injury, and Cervical Spine Trauma Guidelines
Michael G. Fehtling

Special Course IX – AOSpine: Aging Spine
Joseph S. Cheng
Theodore J. Choma
Christopher I. Shaffrey
Alexander R. Vaccaro

Luncheon Symposium II – Spine Tumors
Daryl R. Fournery

Luncheon Symposium III – Cranial-Cervical Junction
Ronald I. Apfelbaum
Theodore H. Schwartz

Luncheon Symposium IV – Update of Lumbar Spine Guidelines
Sanjay S. Dhall

Luncheon Symposium V –
Lateral Retroperitoneal
Interbody Fusion: Technique
and Outcomes
John C. Liu
Juan S. Uribe

Saturday Case Presentations
Aruna Ganju
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115: Domagoj Coric
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The AANS/CNS Section on Disorders of the Spine and Peripheral Nerves gratefully acknowledges

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for providing an educational grant in support of the 2012 Annual Meeting.

The AANS/CNS Section on Disorders of the Spine and Peripheral Nerves gratefully acknowledges

NEUROSURGICAL LEADERSHIP AMBASSADOR

Medtronic

for providing an educational grant in support of the 2012 Annual Meeting.
Integrate the new changes in CPT coding.
Identify specific difficult coding scenarios and bring clarity to the coding process.

Learning Objectives: Upon completion of this course, participants should be able to:
- Integrate the newest changes in CPT coding for spine.
- Apply the methodology for correct spine coding.
- Identify specific difficult coding scenarios and bring clarity to the coding process.

1:30 – 1:45 PM
Introduction
Joseph S. Cheng, John J. Knightly

1:45 – 2:15 PM
2012 CPT Coding Update
Joseph S. Cheng

2:15 – 2:45 PM
Revenue Generation: Ancillary Income and Operational Efficiency
Domagoj Coric

2:45 – 3:15 PM
Outcomes Data Collection in the Changing Healthcare Environment: Defining the Quality and Value of your Care Through Practice Data Collection
Matthew McGirt

3:15 – 3:45 PM
Why Building Quality Into Your Practice Is Important to Your Bottom Line
John J. Knightly

3:45 – 4:15 PM
Marketing Your Practice: Techniques to Generate Referrals
Deborah L. Benzil

4:15 – 4:45 PM
Patient Satisfaction: What Really Drives Patient Perception
Michael P. Steinmetz

4:45 – 5:30 PM
Discussion

Learning Objectives: Upon completion of this course, participants should be able to:
- To understand and appreciate the gravity of decisions that lead to complications.
- To understand and appreciate the underlying principles that might be used to minimize complications.
- To develop strategies that can be used to deal with surgical complications.

1:30 – 1:35 PM
Welcome
Edward C. Benzel, Regis W. Haid, Jr.

1:35 – 1:45 PM
Case Presentation: Lumbar Spondylolisthesis – What Is Your Choice of Fusion?
Regis W. Haid, Jr.

1:45 – 2:05 PM
Lumbar Fusion: MIS is the Best Way
Richard G. Fessler

2:05 – 2:30 PM
Lumbar Fusion: Open is the Best Way
Charles Branch

2:30 – 2:40 PM
What Was Done
Regis W. Haid, Jr.

2:40 – 2:50 PM
Perspective on MIS for Lumbar Fusion
Edward C. Benzel

2:50 – 3:00 PM
Questions and Answers

3:00 – 3:25 PM
Lumbar Spondylolisthesis: Complications and Avoidance, Lessons Learned
Robert F. Heary

3:25 – 3:35 PM
Questions and Answers

3:35 – 3:40 PM
Ziya L. Gokaslan
MARCH 7-10, 2012                   WALT DISNEY WORLD SWAN AND DOLPHIN, ORLANDO, FLORIDA

2:00 – 2:15 PM  Questions

2:15 – 2:30 PM  Trauma and Deformity
     James S. Harrop

2:30 – 2:45 PM  PSO and SPO
     Tyler R. Koski

2:45 – 3:00 PM  Questions

3:00 – 3:15 PM  When Is Less Invasive Surgery Acceptable for Spinal Deformity?
     Juan S. Uribe

3:15 – 3:30 PM  When To Extend Fixation to Sacrum and Pelvis
     Robert F. Heary

3:30 – 3:45 PM  Questions

3:45 – 5:30 PM  Case Presentations
     Praveen V. Mummneni, Christopher I. Shaffrey

1:30 – 5:30 PM  Americas Seminar

1:30 – 1:45 PM  Introduction
     Langston T. Holly, Michael Y. Wang

1:45 – 2:15 PM  Advanced Percutaneous Fixation Methods
     Jonathan D. Sherman

2:15 – 2:45 PM  Fusion Options Without Using BMP
     Praveen V. Mummneni

2:45 – 3:15 PM  MIS Surgery and Its Effect on Healthcare Costs and Utilization
     Kevin Scott Cahill

3:15 – 3:30 PM  Break

3:30 – 4:00 PM  Spine Surgery in High Performance Athletes: The Impact of MIS
     Richard G. Fessler

4:00 – 4:30 PM  Minimally Invasive Resection of Metastatic Spinal Column Tumors
     Dean Chou

4:30 – 5:00 PM  The Future of MIS Surgery
     Kevin T. Foley

5:00 – 5:30 PM  Discussion

1:30 – 5:30 PM  Special Course IV

Advanced MIS Techniques/Managing MIS Complications

$200 includes lunch

Course Directors: Langston T. Holly, Michael Y. Wang

Faculty: Kevin Scott Cahill, Dean Chou, Richard G. Fessler, Kevin T. Foley, Praveen V. Mummneni, Jonathan D. Sherman

Course Description: This course will discuss contemporary data and experience through MIS case-based, interactive, didactic presentations. Faculty will discuss their evaluation and treatment algorithms regarding minimally invasive vs. open surgical options to maximize complication avoidance. Focus will be given to cases initially treated minimally invasively with immediate or subsequent necessity for open conversion. Topics include advanced percutaneous fixation methods, fusion options without using BMP, MIS surgery and its effect on healthcare costs and utilization, spine surgery in high performance athletes: the impact of MIS, minimally invasive resection of metastatic spinal cord tumors and the future of MIS surgery.

Learning Objectives: Following completion of this special course, participants should be able to:

- Relate and implement the indications for minimally invasive spinal surgery.
- Distinguish and apply the techniques available for minimally invasive surgery.
- Develop strategies for complication avoidance.

1:30 – 1:45 PM  Introduction
     Langston T. Holly, Michael Y. Wang

1:45 – 2:15 PM  Advanced Percutaneous Fixation Methods
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     Dean Chou

4:30 – 5:00 PM  The Future of MIS Surgery
     Kevin T. Foley

5:00 – 5:30 PM  Discussion

1:30 – 5:30 PM  Americas Seminar
The meeting agenda for the day includes various sessions focusing on pain management and spinal surgery. Participants are expected to gain knowledge and skills in various areas such as pain mechanisms, spinal surgery, and management strategies. The sessions are led by experts in the field, and the agenda also includes special courses on Brazilian Spine Surgery in Brazil and the current status of Brazilian Spinal Surgery.

### Wednesday Agenda

**Meeting Agenda**

**Learning Objectives:** Upon completion of this course, participants should be able to:

- Discuss general postoperative pain issues following spinal surgery
- Analyze the indications for postoperative diagnostic studies in patients with extraordinary pain issues following spinal surgery.
- Review care considerations for postoperative pain remote from the surgical site (e.g., voiding difficulties, constipation, etc.).

**Course Description:**

This course will provide practical, current didactic information on perioperative pain management issues with particular emphasis on up-to-date practical bedside and outpatient management strategies. Interactive case presentations will illustrate treatment and care considerations. Expert advanced practice nurse, physician assistant, and neurosurgeon faculty will explore the challenges of caring for this complex patient population.

**Meeting Agenda:**

- **5:00 – 5:30 PM**
  - Practice Gap Discussion

- **1:30 – 5:30 PM**
  - Asia 4

**Special Course VI**

**Brazil: Spine Surgery in Brazil – in conjunction with the Spine Section of Brazilian Neurosurgical Association**

$200 includes lunch

**Course Directors:** Ricardo Vieira Botelho, Asdrubal Falavigna

**Faculty:** Aluizio Augusto Arantes, Jr., Eduardo Barreto, Ronald de Lucena Farias, Geraldo de Sá Carneiro Filho, Marcos Masini, Marcelo Luís Mudo, Luiz Pimenta, Fernando Luiz Rolemberg Dantas, José Marcus Rotta, Osmar José Santos de Moraes, Ericson Sfreddo, Marcelo Simone Simões, Márcio Vinhal de Carvalho

**Course Description:** This course will involve a debate presentation format. Brazilian spine neurosurgeons experts will argue their perspectives with regard to the management scenarios for spine disorders cases through lectures, interactive case presentations and discussion. This course will provide practical, current didactic information on spine disorders with particular emphasis on surgical approaches, stabilization techniques, complications avoidance and management, surgical and non–surgical decision making and management as well as discussion on future trends.

**Learning Objectives:** Upon completion of this course, participants should be able to:

- Analyze the evolution of spinal surgery in Brazil.
- Recognize some technical nuances of spinal surgery practiced in Brazil.
- Develop strategies for complication avoidance and management.
- Describe the evaluation and appropriate management of a number of spinal pathologies including trauma, degenerative disease and neoplasms.
- List the advantage and disadvantage of spinal surgical techniques.

- **2:40 – 2:50 PM**
  - Posterior Approach for Cervical Myeloradiculopathy
  - Aluizio Augusto Arantes, Jr.

- **2:50 – 3:00 PM**
  - Cervical Facet Dislocations: Anterior or Posterior Approach?
  - Ericson Sfreddo

- **3:00 – 3:15 PM**
  - Break

- **3:15 – 3:35 PM**
  - XLIF for Degenerative Scoliosis
  - Luiz Pimenta

- **3:45 – 3:55 PM**
  - Neuromodulation for Failed Back Surgery
  - Eduardo Barreto

- **3:55 – 4:05 PM**
  - The Role of the Interspinous Device
  - Marcio Vinhal de Carvalho

- **4:05 – 4:20 PM**
  - Break

- **4:20 – 4:30 PM**
  - Treatment and Outcome of Postoperative Deep Wound Infection Following Lumbar Arthrodesis
  - Asdrubal Falavigna

**Courses and Presenters:**

- **Ajit A. Krishnaney, Jennifer Lindstedt, APNP, Gregory R. Trost, Luis Tumialan**

**Course Description:** This course will provide practical, current didactic information on perioperative pain management issues with particular emphasis on up-to-date practical bedside and outpatient management strategies. Interactive case presentations will illustrate treatment and care considerations. Expert advanced practice nurse, physician assistant, and neurosurgeon faculty will explore the challenges of caring for this complex patient population.
THURSDAY

4:30 – 4:40 PM
Evidence in Lumbar Spine Surgery
Osmar José Santos de Moraes

4:40 – 4:50 PM
Thoracoscopic Surgery for Thoracic Disc Herniations
Marcelo Luis Mudo

4:50 – 5:00 PM
Discussion

5:00 – 5:10 PM
Surgical Treatment for Coccygodinya
Ronald de Lucena Farias

5:10 – 5:20 PM
Post-traumatic Deformity Surgery
Marcelo Simone Simões

1:30 – 3:50 PM
Northern Hemisphere A4
Special Course VII
Updates on Spine Trauma, Spinal Cord Injury, and Cervical Spine Trauma Guidelines
$200 includes lunch
Course Directors: James S. Harrop, Michael Fehlings
Faculty: Bizhan Aarabi, Steven Casha, Rajesh Reddy, Christopher I. Shaffrey
Course Description: This course will discuss updated topics on the treatment of spine trauma and spinal cord injury including current clinical trials. Faculty will discuss the current literature and updates on guidelines, and decision-making and treatment of pediatric and geriatric spinal cord injury.
Learning Objectives: Upon completion of this course, participants will be able to discuss the updated treatment of spine trauma and spinal cord injury in the cervical and thoracolumbar spine, and among the pediatric, adult, and geriatric population. Participants will be able to assess the current literature and updated guidelines for treatment of these conditions.

1:30 – 1:40 PM
Introduction
James S. Harrop, Michael Fehlings

1:40 – 2:05 PM
21-Year-Old Male C5 ASIA A: Timing of Treatment
Michael Fehlings

2:05 – 2:30 PM
Occipital-C1 Instability
Steven Casha

2:30 – 2:55 PM
75-Year-Old with Central Cord Injury: When to Operate?
Bizhan Aarabi

2:55 – 3:10 PM
Break

3:10 – 3:35 PM
Pediatric SCI – Are They Just Little Adults?
Rajesh Reddy

3:35 – 4:00 PM
L1 Burst Fracture: Neurointact: Brace or Fusion
Christopher I. Shaffrey

4:00 – 4:25 PM
76-Year-Old with Type II Odontoid Fracture
James S. Harrop

4:25 – 5:30 PM
Case Presentations – Open Forum
All faculty and audience

OPENING RECEPTION
Cabana Deck at the Pool
6:00 – 8:00 PM
Enjoy a lavish array of food and refreshments while reconnecting with colleagues and meeting new contacts at the Opening Reception. Take in the magic and wonder of the reception at the Walt Disney World Swan and Dolphin. Each medical attendee and spouse/guest registered for the meeting will receive one complimentary ticket. Additional tickets available for purchase at the event. Resort casual attire is recommended.

7:00 – 7:12 AM
You’re Being Measured, Whether You Know It or Not
John J. Knights

7:12 – 7:24 AM
Defining Quality in Spine Surgery
Sohail Mirza

7:24 – 7:36 AM
Defining and Achieving Excellence: Cervical Myelopathy
Michael G. Fehlings

MARCH 7-10, 2012 WALT DISNEY WORLD SWAN AND DOLPHIN, ORLANDO, FLORIDA
7:36 – 7:48 AM
Defining and Achieving Excellence: Peripheral Nerve
John E. McGillicuddy

7:48 – 7:54 AM
Questions

7:54 – 8:06 AM
Defining and Achieving Excellence: Spinal Tumors
Ziya L. Gokaslan

8:06 – 8:18 AM
Defining and Achieving Excellence: Spinal Deformity
Christopher I. Shaffrey

8:18 – 8:35 AM
Defining and Achieving Excellence: Spine Trauma – The Cervical Spine Guidelines
Mark N. Hadley

8:35 – 8:45 AM
Announcements

8:45 – 8:50 AM
Introduction of Section Chairman
Daniel K. Resnick

8:50 – 9:05 AM
Presidential Address: My Biases
Christopher E. Wolfla

9:05 – 9:10 AM
Introduction of Meritorious Service Award Recipient Dennis J. Maiman
Joseph S. Cheng

9:10 – 9:25 AM
Meritorious Service Award Presentation: The Role of Biomechanics in Surgical Decision Making
Dennis J. Maiman

9:25 – 9:30 AM
Questions

9:30 – 10:15 AM
Training Break with Exhibitors

10:15 AM – 12:30 PM
Oral Platform Presentations I

10:15 – 10:24 AM
106. The Short-Term Effect of Surgery on Health Related Quality of Life and Functional Outcome in Patients with Metastatic Epidural Spinal Cord Compression (MESCC): Results of the ongoing AOspine North America Prospective Multicenter Study

10:24 – 10:27 AM
Discussant: Iain H. Kalfas

10:27 – 10:36 AM
Isaac Karikari, Jordan Komisarow, Dylan Britt, Ankit Indravadan Mehta, Betsy H. Grunch, Deeptee Jain, Oren N. Gottfried, Carlos A. Bagley

10:36 – 10:39 AM
Discussant: Christopher I. Shaffrey

10:39 – 10:48 AM
101. The Impact of Positive Regional Sagittal Alignment on Outcomes in Posterior Cervical Fusion Surgery
Jessica A. Tang, Justin K. Scheer, Justin S. Smith, Vedat Deviren, Shay Bess, Robert Hart, Virgine Lafage, Christopher I. Shaffrey, Frank Schwab, Christopher P. Ames

10:48 – 10:51 AM
Discussant: Gregory R. Trost

10:51 – 11:00 AM
102. Complications Following Use of rhBMP-2 in Anterior Lumbar Interbody Fusion: An Institutional Cohort Controlled Study
Daniel Lubelski, Kaili G. Abdullah, Matthew D. Alvin, Michael P. Steinmetz, Edward C. Benzol, Thomas Mroz

11:00 – 11:03 AM
Discussant: Daryl R. Fournier

11:03 – 11:16 AM
Discussion

11:16 – 11:25 AM
103. Characterization of Myelination by Skin Derived Precursor Cells
Joey Kevin Grochmal, Rajiv Midha

11:25 – 11:28 AM
Discussant: Eric L. Zager

11:28 – 11:37 AM
104. The Design and Development of the Neuropoint SD Spine Registry for Lumbar Discectomy and Single Level Fusion for Spondylolisthesis

11:37 – 11:40 AM
Discussant: Daniel K. Resnick

11:40 – 11:49 AM
105. Is Surgical Decompression in Patients with Mild Cervical Spondylotic Myelopathy Effective? Results of the Prospective, Controlled, Multicenter AOSpine North America CSM Study

11:49 – 11:52 AM
Discussant: Robert F. Heary
THURSDAY

11:52 AM – 12:01 PM
107. Anterior vs. Posterior Surgical Approaches to Treat Cervical Spondylotic Myelopathy: Outcomes of the Prospective Multicenter AOSSpine North America CSM Study in 278 Patients

12:01 – 12:04 PM
Discussion: Zoher Ghogawala

12:04 – 12:13 PM
108. The Scope and Impact of Wrong-Level Lumbar Spine Surgery: A Survey of the Joint Section on Disorders of the Spine and Peripheral Nerves
Michael W. Greff, Joshua E. Heller, Eric A. Potts, Praveen V. Mummneni, Christopher I. Shaffrey, Justin S. Smith

12:13 – 12:16 PM
Discussion

12:16 – 12:30 PM
12:16 – 12:30 PM
Lunch with Exhibitors

What's New Session II
Moderators: John Chi, D. Kojo Hamilton
1:25 – 1:30 PM
Southern Hemisphere I-III
Meeting Announcements
Marjorie C. Wang

1:30 – 3:00 PM
Scientific Session II
David Cahill Memorial Controversies I: In Depth Debates
Moderators: R. John Hurlbert, Daniel M. Sciubba
Course Description: This Scientific Session will involve in-depth debates on controversial clinical topics. Experts will argue their perspectives with regard to the management scenarios for difficult spine and peripheral nerve cases.
Learning Objectives:
On completion of this course, participants should be able to:

- Analyze the role of surgery in treatment of black disc disease.
- Discuss the risks and benefits of performing a single level anterior cervical disectomy and fusion at a surgery center versus a hospital.
- Distinguish the risks and benefits of cervical spine clearance in the obtunded patient using MRI versus CT imaging.

1:30 – 1:57 PM
Black Disc Disease: Is There a Role for Surgery?
Dennis J. Maiman vs. Charles Branch

1:57 – 2:24 PM
Single Level ACDF: My Surgery Center vs. Your Hospital
Domagoj Coric vs. Joseph S. Cheng

2:24 – 2:51 PM
Cervical Spine Clearance in the Obtunded Patient: MRI vs. CT
David O. Okonkwo vs. Vincent C. Traynelis

2:51 – 3:00 PM
Questions and Discussion

3:00 – 3:45 PM
Northern Hemisphere B-E
Beverage Break with Exhibitors

What’s New Session III
Moderators: Daniel Hoh, Stefan A. Mindea
3:45 – 5:15 PM
Southern Hemisphere I-III
Oral Poster Presentations I

(Concurrent Session)
Moderators: Dean Chou, Jean-Valery Coumans
3:45 – 3:50 PM
219. Impact of Treatment Complications on Outcomes in Geriatric Patients with Type II Odontoid Fracture: Results from the AOSSpine North America Multi-Center GOF Prospective Study
Michael G. Fehlings, Alexander R. Vaccaro, Branko Kopjar, Christopher I. Shaffrey, Jens Chapman, Paul M. Arnold, Ziya L. Gokaslan, Darrel S. Brodke, John France, Sangwook Yoon, Mark B. Dekutoski, Christopher Bono, Rick Sasso

3:50 – 3:55 PM
206. The Fate of Type II Odontoid Fractures After Posterior Atlantoaxial Fusion: Where Does Healing Occur?
Michael Mumert, Marcus D. Mazur, Andrew T. Dailey, Metc H. Schmidt, Erica Fay Bission

3:55 – 4:00 PM
205. Functional Outcome Instruments used for Cervical Spondylotic Myelopathy: Interscale Correlation and Prediction of Preference-based Quality of Life
Dmitry Petrov, Robert G. Whitmore, Zoher Ghogawala, J. Sanford Schwartz, Sherman C. Stein

4:00 – 4:05 PM
217. What Are the Factors That May Predict Regain of Independent Walking After Surgery for Patients with Advanced Cervical Spondylotic Myelopathy?
Ahmed Mustafa Alaqeel, Amro Al Habib, Abdulrahman Aldakkan, Fahad Albadr

4:05 – 4:10 PM
235. Standardized Reporting of Perioperative Complications Following Cervical Corpectomy
Maxwell Boakye, Robert Thomas Arrigo, Ivan Cheng, Stefan A. Mindea, Eugene Carragee, John Park, Todd Alamin

4:10 – 4:15 PM
Discussion

4:15 – 4:20 PM
208. Laminoplasty vs. Laminectomy: Prospective Study in Japan
Tatsushi Inoue, Shigehiko Kuno, Motoi Shoda, Yuichi Hirose

4:20 – 4:25 PM
250. Kyphotic Deformities of the Cervical Spine
Jan Studik, Petr Nesnidal, Jan Kryl, Tomas Vyskocil, Michal Barna

4:25 – 4:30 PM
Shekar N. Kurpad, Brian Schmit, Aditya Vedantam, Marjorie C. Wang, Benjamin M. Ellingson
MEETING AGENDA

THURSDAY

4:30 – 4:35 PM
Spyridon Karadimas, Eun Su Moon, Kajana Satkunendarajah, Michael G. Fehlings

4:35 – 4:40 PM
226. Chondroitinase ABC Treatment and Modest Exposure to Intermittent Hypoxia Restores Hemidiaphragmatic Activity After Cervical Spinal Cord Injury
Warren J. Ailain, Jerry Silver, Megan Clark

4:40 – 4:45 PM
Discussion

4:45 – 4:50 PM
Shekar N. Karpad, Brian Schmit, Benjamin M. Ellingson, Robin Mottackel

4:50 – 4:55 PM
238. Cervical Spine Clearance in the Traumatically Injured Patient: Is CT Scan Sufficient Alone?
Brandon G. Chew, Matthew R. Quigley, Christopher Swartz

4:55 – 5:00 PM
239. The Use of Allograft and Recombinant Human Bone Morphogenetic Protein for Instrumented Atlanto-axial Fusions
Brian James Hood, D. Kojo Hamilton, Justin S. Smith, Marine Dididze, Christopher I. Shaffrey, Allan D. Levi

5:00 – 5:05 PM
227. Incidental Durotomy after Spinal Surgery: A Prospective Study in an Academic Institution
Paul J. McMahon, Marine Dididze, Allan D. Levi

5:05 – 5:10 PM
229. Spinal Ependymomas: An Institutional Experience Over 25 Years in 134 Patients
Phiroz E. Tarapore, Peter Modern, Agne Noujokas, Christopher P. Ames, Dean Chou, Praveen V. Mummamani, Philip R. Weinstein, Tarik Tihan

5:10 – 5:15 PM
Discussion

3:45 – 5:15 PM
Oral Americas Seminar

3:45 – 5:30 PM
Michael W. Groff, Joshua E. Heller, Eric A. Potts, Praveen V. Mummamani, Christopher I. Shaffrey, Justin S. Smith

3:50 – 3:55 PM
D. Kojo Hamilton, Akil Patel, Charles A. Sansur

3:55 – 4:00 PM
225. Repeat Surgery Following Lumbar Decompression for Herniated Disc: The Quality Implications of Hospital and Surgeon Variation
Brook I. Martin

4:00 – 4:05 PM
242. Analysis of Readmission Rates After Spinal Surgery: Do Underfunded Patients Have Higher Readmission Rates After Spinal Surgery?
Daniel Robert Fassett, Yachini Gnanasambantham, Linda Gonia, Huaping Wang, David M. Neils

4:05 – 4:10 PM
Justin S. Smith, Dwight Sallle, Christopher P. Ames, Lawrence Lenke, Steven D. Glassman, Paul A. Broadstone, David W. Polly, Jr., Christopher I. Shaffrey

4:10 – 4:15 PM
Discussion

4:15 – 4:20 PM
201. Radiographic and Clinical Outcomes of Posterior Column Osteotomies in Spinal Deformity Correction: Analysis of 128 Patients
Ian G. Dorward, Lawrence Lenke, Geoffrey E. Stoker, Woojin Cho, Linda A. Koester, Brenda A. Sides

4:20 – 4:25 PM
203. WITHDRAWN

4:25 – 4:30 PM
248. The Effect of RhBMP-2 Dosing on the Complication and Fusion Rate in Posterior Interbody Fusion Using Polyetheretherketone (PEEK) Cages.
Eric W. Nottmeier, Douglas S. Fenton, Cammi Bowman, Zane Thompson, Matthew Hale

4:30 – 4:35 PM
207. Complications with the Use of BMP-2 in Thoracolumbar and Lumbar Spine Fusions: A Nine-Year Institutional Analysis
Daniel Lubelski, Kaili G. Abdullah, Michael P. Steinmez, Matthew D. Alvin, Amy S. Nowacki, Srita Chakka, Edward C. Benzol, Thomas Mroz

4:35 – 4:40 PM
231. Health-Related Quality of Life Outcomes with Minimally Invasive Transforaminal Lumbar Interbody Fusion Based on Long-Term Analysis of 318 Consecutive Patients
Mick J. Perez-Cruet, Namath Syed Hussain, Evan Begun, Joseph John Joshua

4:40 – 4:45 PM
Discussion

4:45 – 4:50 PM
Brian D. Milligan, Terry K. Schiefer, Colen D. Bracken, Jeffrey T. Jacob, William E. Krauss, Mark A. Pichelmann, Michelle J. Clarke

4:50 – 4:55 PM
233. Retrospective, Propensity Score-Matched Cohort Study Examining Timing of Fracture Fixation for Traumatic Thoracolumbar Fractures
Maxwell Boakye, Robert Thomas Arrigo, Melanie Hayden, Corinna Zyguardakis, Shivanand P. Lad

4:55 – 5:00 PM
209.Thoracolumbar Fractures

3:50 – 3:55 PM
212. Incidental Durotomy after Spinal Surgery: A Prospective Study in an Academic Institution
Paul J. McMahon, Marine Dididze, Allan D. Levi

5:00 – 5:05 PM
227. Incidental Durotomy after Spinal Surgery: A Prospective Study in an Academic Institution
Paul J. McMahon, Marine Dididze, Allan D. Levi

5:05 – 5:10 PM
229. Spinal Ependymomas: An Institutional Experience Over 25 Years in 134 Patients
Phiroz E. Tarapore, Peter Modern, Agne Noujokas, Christopher P. Ames, Dean Chou, Praveen V. Mummamani, Philip R. Weinstein, Tarik Tihan
FRIDAY

MARCH 9, 2012

6:30 – 6:55 AM
Southern Hemisphere Foyer
Continental Breakfast

Southern Hemisphere I-III
Case Presentations

Moderators: Eve C. Tsai, Daniel C. Lu

6:55 – 7:00 AM
Meeting Announcements
Marjorie C. Wang

7:00 – 9:00 AM
Southern Hemisphere I-III
Scientific Session III

Complication Avoidance and Management

Moderators: Eric J. Woodard, Michael Y. Wang

Course Description: This course will address complications encountered in spine and nerve surgery using a case-based format. Management techniques and complication avoidance strategies will be discussed. Cases will specifically address ectopic ossification after bone morphogenetic protein use, junctional kyphosis, failure of instrumentation in the osteoporotic spine, complications associated with the lateral approach to the spine, esophageal injury, revision ulnar nerve decompression, and “wrong-level” spine surgery.

Learning Objectives: Upon completion of this course, participants should be able to:

- Identify risk factors associated with complications of spine and nerve surgery.
- Strategize preoperative techniques and planning to help avoid complications.
- Incorporate intraoperative and postoperative management and strategies to help avoid complications and mitigate their effects.

7:00 – 7:03 AM
Ectopic Ossification After rhBMP Use – Case Presentation
D. Kojo Hamilton

7:03 – 7:15 AM
Complication Avoidance and Management: Ectopic Ossification After rhBMP Use
Praveen V. Mummameti

7:15 – 7:18 AM
Junctional Kyphosis – Case Presentation
Justin S. Smith

7:18 – 7:30 AM
Complication Avoidance and Management: Junctional Kyphosis
Tyler Koski

7:30 – 7:33 AM
Failure of Instrumentation in the Osteoporotic Spine – Case Presentation
Daniel Refai

7:33 – 7:45 AM
Complication Avoidance and Management: Failure of Instrumentation in the Osteoporotic Spine
Gregory R. Trost

7:45 – 7:48 AM
Lateral Approach (XLIF/DLIF) – Case Presentation
Khalid M. Abbed

7:48 – 8:00 AM
Complication Avoidance and Management: Lateral Approach (XLIF/DLIF)
Adam S. Kanter

8:00 – 8:05 AM
Discussion

8:05 – 8:08 AM
Esophageal Injury After ACDF – Case Presentation
Srinivas K. Prasad

8:08 – 8:20 AM
Complication Avoidance and Management: Esophageal Injury After ACDF
Daryl R. Fourney

8:20 – 8:23 AM
Revision Ulnar Nerve Decompression – Case Presentation
Amgad Hanna

8:23 – 8:35 AM
Complication Avoidance and Management: Revision Ulnar Nerve Decompression
Eric L. Zager

8:35 – 8:38 AM
“Wrong Level” Spine Surgery – Case Presentation
Eve C. Tsai

5:05 – 5:10 PM
Scott L. Parker, David Shau, Stephen Mendenhall, Ow oicho Adogwa, Joseph S. Cheng, Clinton J. Devin, Matthew McGirt

5:10 – 5:15 PM
Discussion

RECEPTION WITH EXHIBITORS

5:15 – 6:45 PM
Northern Hemisphere B-E

Join us for this special event in the exhibit hall! Interact with colleagues and corporate contacts while enjoying pre-dinner cocktails and hors d’oeuvres. Business casual attire is recommended.
Mayfield Award Presentations

MAYFIELD BASIC SCIENCE AWARD
9:00 – 9:05 AM
118. Human Mesenchymal Stem Cells Seeded in a Polymer Scaffold: A Novel Treatment Approach for Spinal Cord Injury
Alexander E. Ropper, Devang Thakor, Inho Han, Dou Yu, Hariprakash Haragopal, A. John Popp, Yang D. Teng

Mayfield Award Presentations

MAYFIELD CLINICAL SCIENCE AWARD
9:15 – 9:20 AM
119. Decreased Incidence of Venous Thromboembolism After Spine Surgery with Early Aggressive Chemoprophylaxis
Joseph Bridger Cox, Catherine Koepnick, R. Patrick Jacob, Daniel J. Hoh

OUTCOMES COMMITTEE AWARD
9:14 – 9:19 AM
120. The Relevance of Intramedullary High Signal Intensity and Gadolinium (Gd-DTPA) Enhancement to the Clinical Outcome in Cervical Compressive Myelopathy
Jun-Jae Shin, Ji Hae Lee, Woo Ho Cho, Jon Park

9:20 – 9:25 AM
NREF
Regis W. Haid, Jr.

9:25 – 9:30 AM
Discussion

9:30 – 10:15 AM
Northern Hemisphere B-E

Beverage Break with Exhibitors

What’s New Session IV

9:30 – 9:35 AM
Moderators: Langston T. Holly, Frank La Marca
Discussants: Joseph T. Alexander, Peter D. Angevine, Allan J. Belzberg, Erica F. Bisson, Joseph S. Cheng, Shekar Kurpad, Michael K. Rosner, Michael P. Steinmetz, Peter Witt

10:15 – 10:24 AM
109. Radiographic Predictors of Early Failure Following Decompression Without Fusion for Degenerative Grade I Lumbar Spondylolisthesis
Claire Blumenthal, Jill Curran, Edward C. Benzil, Sabu N. Magge, J. Frederick Harrington, Jean-Valery Coumans, Zohar Ghogawala

10:24 – 10:27 AM
Discussant: Michael K. Rosner

10:27 – 10:36 AM
110. Functional and Quality of Life Outcomes in Geriatric Patients with Type II Odontoid Fracture: One Year Results from the AOspine North America Multi-Center GOF Prospective Study
Michael G. Fehlings, Alexander R. Vaccaro, Branko Kopjar, Jens Chapman, Christopher I. Shaffrey, Ziya L. Gokaslan, Paul M. Arnold, Darrel S. Bredder, John France, Sangwook Yoon, Mark B. Dekutoski, Rick Sasso, Christopher Bono

10:36 – 10:39 AM
Discussant: Joseph T. Alexander

10:39 – 10:48 AM
111. Posterior Cervical Foraminotomy for Cervical Radiculopathy: Symptomatic, Functional and Quality of Life Outcomes in 1085 Cases with Long-term Follow-up
Ephraim W. Church, Casey H. Halpern, Ryan Faught, Usha Balnuri, Mark Attiah, Sharon Hayden, Marie Kerr, Eileen Maloney-Wilensky, Janice Bynum, Sherman C. Stein, Stephen J. Dante, William Charles Welch, Frederick A. Simeone

10:48 – 10:51 AM
Discussant: Peter D. Angevine

10:51 – 11:00 AM
112. The Relative Impact of Lumbar Spondylolisthesis on Quality of Life in the United States: A Population Health Perspective
Cyrus Chi-Ho Wong, Scott L. Parker, Marcus J. Gates, Matthew McGirt

11:00 – 11:03 AM
Discussant: Erica F. Bisson

11:03 – 11:09 AM
Discussion

11:09 – 11:18 AM
113. Pitfalls of Calculating Hospital Readmission Rates Based Solely on Nonvalidated Administrative Datasets
Beejal Y. Amin, Urvij Modhia, Keishi Mauro, Lumine Na, Steven Takemoto, Christopher P. Ames, Vedat Devirin, Dean Chou, Sigurd Berven, Praveen V. Mummaneni

11:18 – 11:21 AM
Discussant: Joseph S. Cheng

11:21 – 11:30 AM
114. Modest Systemic Hypothermia in Acute Cervical Spinal Cord Injury: A Prospectve Case Controlled Study
Allan D. Levi, Barth A. Green, Dalton Dietrich, Steven Yanni, Marine Dididze, Michael Y. Wang

11:30 – 11:33 AM
Discussant: Shekar Kurpad

11:33 – 11:42 AM
115. Prospective, Randomized Study of Cervical Arthroplasty and ACD F with Long-Term Follow-up: 76 Patients from a Single Site with Four- to Eight-year Follow-up
Domagoj Coric, Margaret Boltes, Sara James, Judd Heideman

11:42 – 11:45 AM
Discussant: Peter Witt

11:45 – 11:54 AM
116. Prospective Study of Disc Repair with NuQu Injectable Allogeneic Chondrocytes
Domagoj Coric, Kenneth Pettine, Margaret Boltes

11:54 – 11:57 AM
Discussant: Michael P. Steinmetz
FRIDAY

11:57 AM – 12:06 PM
117. Skin-derived Precursor Cells Enhance Functional Outcome Following Nerve Repair
Helene T. Khuong, Aleksandra Ivanovic, Antos Shakhbazan, Ranjan Kumar, Joanne Forden, Hamed Abhari, Rajiv Midha

12:06 – 12:09 PM
Discussion

12:09 – 12:10 PM
Discussion

12:10 – 12:15 PM
NZQD
Zoher Ghogawala

12:15 – 12:30 PM
ANNUAL BUSINESS MEETING
Southern Hemisphere I-III

12:30 – 1:25 PM
Northern Hemisphere B-E
Lunch in the Exhibit Hall

12:30 – 2:30 PM
Northern Hemisphere A4

Luncheon Symposium I

Revision Spine Surgery
$200 includes lunch
Course Directors: Iain H. Kalfas, Michael W. Groff
Faculty: David O. Okonkwo, Timothy C. Ryken
Course Description: This course will provide state-of-the-art information on complication avoidance during revision spine surgery. Faculty will review their clinical experience and lessons learned via interactive case discussions.

Learning Objectives: Upon completion of this course, participants should be able to:

- Explain the management issues unique to revision surgery.
- Appraise the common reasons for spinal instrumentation failure.
- Evaluate the management of recurrent spinal conditions such as restenosis and reherniation and apply to practice.
- Integrate strategies for the management of postoperative deformity and adjacent segment failure.

12:30 – 12:50 PM
Recurrent Lumbar Disc Herniation

12:50 – 1:00 PM
Questions

1:00 – 1:20 PM
Post-laminectomy Cervical Kyphosis
Iain H. Kalfas

1:20 – 1:30 PM
Questions

1:30 – 1:50 PM
Lumbar Adjacent Level Degeneration: Stenosis and Instability
Michael W. Groff

1:50 – 2:00 PM
Questions

2:00 – 2:20 PM
Spinal Instrumentation Failure
Timothy C. Ryken

2:20 – 2:30 PM
Questions

12:30 – 2:30 PM
Northern Hemisphere A3

Luncheon Symposium II

Spine Tumors
$200 includes lunch
Course Directors: Daryl R. Fournery, Laurence D. Rhines
Faculty: Dean Chou, Ziya L. Gokaslan, Ilya Laufer, Daniel M. Sciubba, Frank D. Vrionis
Course Description: This course will review the natural history and management of primary and metastatic spinal tumors. Radiographic imaging, intervention strategies and treatment algorithms will be reviewed. Surgical treatment including approaches will be discussed. Extensive interactive case presentations will illustrate treatment and care considerations and explore the challenges of caring for this complex patient population.

Learning Objectives: Upon completion of this course, participants should be able to:

- Understand the significance of tumor biology in considering management options.
- Discuss the indications and techniques for management of primary and metastatic spinal tumors.
- Discuss surgical approaches and techniques for tumor resection and spinal reconstruction.

12:30 – 12:50 PM
Post-laminectomy Cervical Kyphosis
Iain H. Kalfas

1:00 – 1:20 PM
Questions

1:20 – 1:30 PM
Lumbar Adjacent Level Degeneration: Stenosis and Instability
Michael W. Groff

1:50 – 1:55 PM
Questions

12:35 – 12:55 PM
Unknown Primary with Neuro Deficit
Ilya Laufer

12:55 – 1:05 PM
Mechanical Instability from Tumors: Can We Define It?
Daryl R. Fournery

1:05 – 1:25 PM
Surgical Options: When To Go Anterior, Posterior or Combined
Ziya L. Gokaslan

1:25 – 1:40 PM
Minimally Invasive Options: Is There a Role?
Dean Chou

1:40 – 1:55 PM
When to Consider Kyphoplasty/Radiosurgery
Frank D. Vrionis

1:55 – 2:10 PM
New Frontiers in Metastatic Spine Tumors
Daniel M. Sciubba

2:10 – 2:30 PM
Primary Tumors: En Bloc Surgery Feasibility, Justification?
Laurence D. Rhines

12:30 – 2:30 PM
Northern Hemisphere A2

Luncheon Symposium III

Cranial-Cervical Junction
$200 includes lunch
Course Directors: Michael P. Steinmetz, Jean-Paul Wolinsky
Faculty: Christopher P. Ames, Ronald I. Apfelbaum, Theodore H. Schwartz, Ziya L. Gokaslan
Course Description: This course will discuss contemporary data and experience in treating pathology of the cranial-cervical junction. This course will be in a case-based interactive format with didactic presentations. Faculty will discuss their evaluation and treatment algorithms surrounding pathology of the CCJ. The focus will be on understanding the pathophysiology of various conditions and how treatment strategies have evolved with better understanding of this region.

Learning Objectives: Following completion of this course, participants should be able to:

- Relate how certain pathologic processes...
affect the cranial-cervical junction.
- Distinguish why certain treatment strategies are implemented and understand the basic surgical techniques for specific pathologic processes.
- Develop and design complex reconstructions of the cranial-cervical junction.

Interactive Panel Discussion
Case Presentations and Moderator
Michael P. Steinmetz

Instrumentation and Intraoperative Reduction Techniques
Christopher P. Ames

Trans-Oral Approach
Ronald I. Apfelbaum

Transmandibular Circumglossal Approach
Ziya L. Gokaslan

Endoscopic Endo-nasal Approach
Theodore H. Schwartz

Endoscopic Trans-cervical Approach
Jean-Paul Wolinsky

12:30 – 2:30 PM
Northern Hemisphere A1

Luncheon Symposium IV
Update of Lumbar Spine Guidelines
$200 includes lunch
Course Directors: Michael G. Kaiser, Daniel K. Resnick
Faculty: Sanjay S. Dhall, Zoher Ghogawala, Timothy C. Ryken
Course Description: This course will discuss the current literature and updates on guidelines for the surgical treatment of lumbar spine degenerative conditions.
Learning Objectives: On completion of this course, participants will be able to discuss the updated guidelines, indications, and expected outcomes for surgical treatment of lumbar spine degenerative conditions.

12:30 – 12:45 PM
Introduction to Lumbar Fusion Guidelines, Justification, Methodology, and Use
Timothy Ryken

12:45 – 1:15 PM
Radiographic, Functional and Economic Outcomes in Lumbar Fusion: How To Assess and What Is Expected?
Zoher Ghogawala

1:15 – 1:30 PM
Correlating Radiographic to Clinical Outcome
Sanjay Dhall

1:30 – 2:00 PM
Fusion for Axial Pain, Deformity, and Stenosis: What Is it Justified:
Daniel K. Resnick

2:00 – 2:30 PM
Adjuvants for Fusion: What Works, When, and for Whom?
Michael G. Kaiser

12:30 – 2:30 PM
Americas Seminar
Luncheon Symposium V
Lateral Retroperitoneal Interbody Fusion: Technique and Outcomes
$200 includes lunch
Course Directors: Regis W. Haid, Jr., Praveen V. Mummaneni
Faculty: Juan S. Uribe, Allan D. Levi, John C. Liu, Adam S. Kanter
Course Description: This course will focus on the indications, outcomes and complications of the lateral retroperitoneal transposas fusion technique. Specific lectures will concentrate on anatomy and approach, literature based outcomes, complication avoidance and management, and clinical pearls. Biomechanics of stand-alone versus supplemented techniques will be discussed. Interaction and discussion among participants will be encouraged.
Learning Objectives: Upon completion of this course, participants should be able to:
- Review and discuss indications for lateral thoracolumbar interbody approaches and surgery.
- Discuss the complications and their avoidance in these procedures.
- Review the clinical and radiographic results in lateral thoracolumbar interbody fusion procedures.

12:30 – 12:50 PM
Anatomic Overview and Approach
Allen D. Levi

12:50 – 1:10 PM
Complications: Incidence and Avoidance
John C. Liu

1:10 – 1:30 PM
Stand Alone or Anterior – Posterior: How I Choose
Adam S. Kanter

1:30 – 1:50 PM
Deformity Correction with Stand Alone
Juan S. Uribe

1:50 – 2:10 PM
Deformity Correction with Anterior – Posterior
Praveen V. Mummaneni

2:10 – 2:30 PM
Discussion

1:30 – 5:30 PM
Asia 3

Special Course VIII
Peripheral Nerve Exposures and Nerve Repair Techniques (Complimentary to Residents)
$200 includes lunch
Course Directors: Robert J. Spinner, Linda Jun-San Yang
Faculty: Allan J. Belzberg, Marie-Noelle Hebert-Blouin, Line Jacques, Michel Kloti, Rajiv Midha, Nader Pouratian, Eric L. Zager
Course Description: This course will demonstrate the common exposures to peripheral nerves in the upper extremity and common techniques used for peripheral nerve reconstruction. It is targeted to practicing surgeons, senior residents and fellows.
Learning Objectives: Upon completion of this course, participants should be able to:
- Synthesize the pertinent and practical surgical anatomy of the brachial plexus and peripheral nerves in the upper limb as related to common nerve injuries, nerve entrapments, and other nerve disorders.
- Distinguish common techniques utilized in the reconstruction of peripheral nerves (direct repair, grafting, nerve transfers, and nerve conduits).

This course will prepare residents for written board examinations and young neurosurgeons for oral board examinations.

This course will be presented in an interactive, round-robin format to facilitate small group teaching of peripheral nerve anatomy and exposures as well as nerve repair techniques.

Nerve Repair Techniques (Direct Repair, Grafting, Nerve Transfers, Conduits)
Rajiv Midha

Median and Ulnar Nerves
Robert J. Spinner

Radial and Musculocutaneous Nerves
Line Jacques
**Suprascapular and Axillary Nerves**
Marie-Noelle Hebert-Blouin

**Exposures to Nerves in Hip and Thigh (e.g., Sciatic, Femoral, Lateral Femoral Cutaneous)**
Nader Pouratian

**Exposures to Nerves in Leg (Knee and Below—e.g., Tibial Nerve, Peroneal Nerve)**
Michel Kliot

**Brachial Plexus (Supra and Infraclavicular)**
Allan J. Belzberg, Linda Jun-San Yang

**Common Nerve Transfers**
Eric L. Zager

1:30 – 5:30 PM
Asia 4

### Special Course IX

**AOSpine: Aging Spine**
$200 includes lunch

**Course Directors:** Darrel S. Brodke, Roger Hartl

**Faculty:** Eugene Carragee, Jens R. Chapman, Joseph S. Cheng, Theodore J. Choma, Michael G. Fehlings, Christopher I. Shaffrey, Alexander R. Vaccaro, Luis M. Vialle

**Course Description:** This course will discuss contemporary data and experience in treatment of the aging spine. Faculty will discuss decision-making and treatment options for odontoid fractures, cervical myelopathy, degenerative scoliosis, osteoporosis, minimally invasive approaches in the aging spine, and surgery trends and healthcare costs in the elderly.

**Learning Objectives:** Upon completion of this course, participants should be able to:

- The participant should understand the different types of odontoid fractures and the treatment options with predicted fusion rates based on recent clinical trials.
- The participant should understand the rationale for surgical treatment of cervical spinal stenosis and myelopathy with pros and cons of anterior vs. posterior and combined approaches.
- The participant should understand the special risks of surgical treatment of spinal disorders in the elderly population and their avoidance and management.
- The participant should understand the treatment options for degenerative lumbar scoliosis in elderly patients with pros and cons.
- The participant should understand current trends in the surgical treatment of spinal disorders in the elderly population and be able to discuss underlying reasons and implications.

1:30 – 1:35 PM

**Introduction**
Darrel S. Brodke, Roger Hartl

1:35 – 1:45 PM

**What is AOSpine?**
Jens R. Chapman

1:45 – 1:50 PM

**Geriatric Cervical Spine**
Case Presentation
Roger Hartl

1:50 – 2:05 PM

**Decision-making: Surgical vs. Non-operative Management of Odontoid Fractures**
Joseph S. Cheng

2:05 – 2:20 PM

**The AOSpine Multicenter GOF Study**
Alexander R. Vaccaro

2:20 – 2:35 PM

**Cervical Myelopathy: Clinical Trials and Evidence-based Management**
Michael G. Fehlings

2:35 – 2:50 PM

**Case Resolution / Questions / Discussion**

### Thoracolumbar Degeneration / Deformity

3:05 – 4:05 PM

**Management of Thoracolumbar Deformity in the Elderly**
Darrel S. Brodke

4:05 – 4:20 PM

**Minimally Invasive Approaches in the Aging Spine: Pros and Cons**
Roger Hartl

4:20 – 4:35 PM

**Questions/Discussion**

### Surgery Trends and Health Care Costs in the Elderly

4:35 – 4:55 PM

**Increasing Complexity of Surgeries in the Elderly: Are We Operating Too Much?**
Eugene Carragee

4:55 – 5:15 PM

**Response: The Role of Surgery in Elderly Patients**
Christopher I. Shaffrey

5:15 – 5:30 PM

**Questions / Discussion**

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**YOU NG NEUROSURGEONS’ DINNER**

6:30 PM

**Southern Hemisphere V**

All residents, fellows and young neurosurgeons are encouraged to attend this event with a special presentation from Dr. Gerald E. Rodts, Jr. RSVP to DePuy Spine, Booth #207.
221. The Impact of Different Surgical Strategies in Achieving Satisfactory Post-Operative Sagittal Alignment

7:20 AM – 7:25 AM
Discussion

230. Does Single Dose Preemptive Amitriptyline or Gabapentin Reduce Remaining Leg Pain After Single Level Lumbar Discectomy? A Randomised Clinical Trial with Placebo Control
Payman Vahedi, Zahra Mohajernejadfard

7:53 – 7:57 AM
Discussion

231. Modulation of Spinal Cord Reflex Circuity by Spinal DC Stimulation in Humans
Maxwell Boakye, Robert Thomas Arrigo, Chris Ho, Jean-Charles Lamy

8:02 AM – 8:07 AM

237. Characterization of a Novel Metastatic Human Breast Adenocarcinoma Rat Model Using Intracardiac Injection and Bioluminescence

8:07 AM – 8:12 AM

241. W ITHDRAW N

8:12 AM – 8:17 AM

209. The Distribution of Body Mass as a Significant Risk Factor for Lumbar Spinal Fusion Postoperative Infections
Ankit Mehta, Ranjith Babu, Isaac Karikari, Betsy H. Grunch, Vijay Agarwal, Timothy Ryan Owens, Allan H. Friedman, Carlos A. Bagley, Oren N. Gottfried

8:17 – 8:20 AM

Discussion
Understand the risks and benefits of treatment of an asymptomatic unstable geriatric dens fracture.

8:20 – 8:45 AM  
Asymptomatic Cervical Stenosis with Cord Signal Changes

8:20 – 8:22 AM  
Case Presentation  
Charles Sansur

8:22 – 8:30 AM  
Richard G. Fessler

8:30 – 8:38 AM  
Edward C. Benzel

8:38 – 8:45 AM  
Discussion

8:45 – 9:10 AM  
Asymptomatic Schwannoma: Peripheral Nerve

8:45 – 8:47 AM  
Case Presentation  
Olawale Sulaiman

8:47 – 8:55 AM  
Robert J. Spinner

8:55 – 9:03 AM  
Lynda J.S. Yang

9:03 – 9:10 AM  
Discussion

9:10 – 9:35 AM  
Neurologically Intact Patient with Thoracic Epidural Abscess and Cord Compression

9:10 – 9:12 AM  
Case Presentation  
Charles Sansur

9:12 – 9:20 AM  
Gerald E. Rodts, Jr.

9:20 – 9:28 AM  
Robert F. Heary

9:28 – 9:35 AM  
Discussion

9:35 – 10:00 AM  
Asymptomatic Unstable Geriatric Dens Fracture

9:35 – 9:37 AM  
Case Presentation  
Charles Sansur

9:37 – 9:45 AM  
Regis W. Haid, Jr.

9:45 – 9:53 AM  
Michael G. Fehlings

9:53 – 10:00 AM  
Discussion

10:00 – 10:10 AM  
Questions

10:10 – 10:40 AM  
Southern Hemisphere I-III  
Beverage Break

10:40 – 10:45 AM  
Southern Hemisphere I-III  
Fellowship Awards and Updates  
Zoher Ghogawala, Adam S. Kanter,  
Daniel M. Sciubba

10:45 – 11:00 AM  
Southern Hemisphere I-III  
Clinical Trial Award Updates

10:45 – 10:50 AM  
Minimally Invasive vs. Open TLIF for Spondylolisthesis  
Khalid M. Abbed

10:50 – 10:55 AM  
CSM – Can Outcome Be Predicted by Diffusion Tensor Imaging?  
Marjorie C. Wang

10:55 – 11:00 AM  
A Web-based Registry for Comparative Effectiveness Research for Back Pain in the Wisconsin Population  
Daniel K. Resnick

11:00 AM – 12:30 PM  
Southern Hemisphere I-III  
Oral Poster Presentations IV  
Moderators: Michael D. Martin,  
Shekar N. Kurpad

11:00 – 11:05 AM  
244. Anterior vs. Posterior Interbody Fusion: A Comparison of Outcomes  
Mark Mahan, Samuel Kalb,  
Juan Christian Ribas Nijkerk,  
Laura Ann Snyder, Udaya K. Kakarla,  
Nicholas Theodore

11:05 – 11:10 AM  
245. Utility of Clavien-Dindo and Accordion Classification Systems for Postoperative Complications Following Spinal Metastasis Surgery  
Maxwell Boakye, Pui Tran,  
Robert Thomas Arrigo, Ivan Cheng,  
Stefan A. Mindeu, Eugene Carragee,  
John Park, Todd Alamin

11:10 – 11:15 AM  
246. Cost-utility and Comparative Effectiveness Analyses of Laminectomy vs. Comprehensive Medical Management for Lumbar Stenosis  
Scott L. Parker, Scott Zuckerman,  
David Shau, Stephen Mendenhall,  
Joseph S. Cheng, Clinton J. Devin,  
Matthew McGirt

11:15 – 11:20 AM  
228. Cost-utility and Comparative Effectiveness Analyses of Trans-foraminal Lumbar Interbody Fusion (TLIF) vs. Comprehensive Medical Management for Lumbar Spondylolisthesis  
Scott L. Parker, Scott Zuckerman,  
David Shau, Stephen Mendenhall,  
Joseph S. Cheng, Clinton J. Devin,  
Matthew McGirt

11:20 – 11:25 AM  
247. Long-term Outcome of Minimally Invasive Transforaminal Lumbar Interbody Fusion: 5 Years Post-op and Beyond  
Hamid M. Shah, Kevin T. Foley

11:25 – 11:28 AM  
Discussion

11:28 – 11:33 AM  
224. Pedicle Subtraction Osteotomy with Extension of Fusion to the Pelvis: Does Anterior Interbody Support at L5-S1 Improve Sagittal and Pelvic Parameters?  
Justin S. Smith, Christopher P. Ames,  
Munish Gupta, Eric Klineberg,  
Virginie Lafage, Shav Bess, Frank Schwab,  
Oheneba Bouchie-Adjei, Khaleed Kebaish,  
Kirkham Wood, Behroz A. Akbarinia,  
Gregory Mundis, Michael F. O’Brien,  
Richard A. Hostin, Christopher I. Shaffrey
MEETING AGENDA

SATURDAY

11:33 – 11:38 AM
222. How the Assessment of Pelvic Tilt, Pelvic Incidence/Lumbar Lordosis Mismatch and Sagittal Vertical Axis Predicts Disability in Adult Spinal Deformity: A Prospective Analysis

11:53 – 11:56 AM
Discussion

11:56 AM – 12:01 PM
251. Predictors of Outcome Following Traumatic Spinal Cord Injury
Daniel Yavin, Steven Casha, Amro Al-Habib, R. John Hurlbert

12:01 – 12:06 PM
249. Diffusion Tensor Imaging Correlates with Spinal Somatosensory Evoked Potentials After Spinal Cord Injury
Shekar N. Kurpad, Brian Schmit, Michael Jirjis

12:06 – 12:11 PM
200. Acute Adrenal Insufficiency in Cervical Spinal Cord Injury
Emil Antonio Pastrana Ramirez, Fanor Manuel Saavedra, Samuel Estronza-Ojeda, Gisela Murray, John David Rolston, Gloria E. Rodriguez-Vega

12:11 – 12:16 PM
255. Early Stabilization of Thoracolumbar Injuries in Polytraumatized Patients
Timothy A. Moore, Michael P. Steinmetz, Heather Vallier

12:16 – 12:21 PM
252. Functional Improvement After Total Disc Arthroplasty at 1 and 2 Levels of the Cervical Spine: 36 Month Follow-Up of an FDA IDE Clinical Trial
Reginald J. Davis, Steven E. Gaede, Michael S. Hisey, Kee Duk Kim, Pierce D. Nunley, Daniel L. Peterson, John K. Stokes

12:21 – 12:26 PM
204. Short-term Complications Associated with Surgery for High-grade Spondylolisthesis in Adults and Pediatric Patients: A Report from the Scoliosis Research Society Morbidity and Mortality Database
Manish K. Kasliwal, Justin S. Smith, Christopher I. Shaffrey, Dwight Saulle, Lawrence Lenke, David W. Polly, Jr., Christopher P. Ames, Joseph Perra

12:26 – 12:30 PM
Discussion

12:30 PM
Adjourn

The following companies have provided an educational grant in support of the 2012 Annual Meeting:
Biomet Spine
DePuy Spine
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NuVasive
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The AANS/CNS Section on Disorders of the Spine and Peripheral Nerves gratefully acknowledges

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for providing an educational grant in support of the 2012 Annual Meeting.
EXHIBITOR INFORMATION

EXHIBIT HALL
NORTHERN HEMISPHERE B-E

The Exhibit Hall, located in the Northern Hemisphere B-E, will feature:
More than 60 exhibiting companies displaying the latest neurosurgical technology and equipment, products and services.

Lunch in the Exhibit Hall*: Enjoy a complimentary lunch on Thursday and Friday while mingling with your corporate contacts.

Reception with the Exhibitors: Join us Thursday evening for another great networking opportunity! Take the time to browse the aisles of the Exhibit Hall and visit with your corporate colleagues while enjoying cocktails and hors d’oeuvres.

E-mail Café: Stay in touch with home and the office through this complimentary attendee service.

Digital Posters: Browse over 240 abstracts enhanced by photos and video. The digital format also makes it easy to search for abstracts by author or topic.

What’s New Sessions: Join the crowd during daily breaks and Thursday lunch as speakers share the latest in cutting-edge research and technology.

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**Exhibit Hall Hours**
Thursday, March 8: 9:00 AM – 7:00 PM
Friday, March 9: 9:00 AM – 2:00 PM

**Beverage Break and What’s New Session Hours**
Thursday, March 8: 9:30 – 10:15 AM
12:30 – 1:25 PM*
3:00 – 3:45 PM
Friday, March 9: 9:30 – 10:15 AM
12:30 – 1:25 PM*

*Lunch in the Exhibit Hall is complimentary to all medical attendees and guests ages 18 and older.

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AAN/S/CNS SECTION ON DISORDERS OF THE SPINE AND PERIPHERAL NERVES
<table>
<thead>
<tr>
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### EXHIBITOR INFORMATION

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**THURSDAY, MARCH 8**

**9:30 – 10:15 AM**

- Aesculap
- DePuy
- Medtronic
- Nuvasive
- LDR
- Nuvasive
- SpineView
- Zimmer Spine

**12:30 – 1:25 PM**

- Aesculap
- DePuy
- Medtronic
- Nuvasive
- LDR
- Nuvasive
- SpineView
- Zimmer Spine

**3:15 – 4:00 PM**

- Aesculap
- DePuy
- Medtronic
- Nuvasive
- LDR
- Nuvasive
- SpineView
- Zimmer Spine

**FRIDAY, MARCH 9**

**9:30 – 10:15 AM**

- Aesculap
- DePuy
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Isaac Karikari, Jordan Komisarow, Dylan Britt, Ankit Indravadan Mehta, Betsy H. Grunch, Deepette Jain, Oren N. Gottfried, Carlos A. Bagley

Introduction: The emergence of new spine techniques combined with an aging population has resulted in an increased number of complex spine instrumentations. The specific complications in patients undergoing long segment instrumentations are under reported.

Methods: A retrospective review was performed on 160 consecutive adult patients who underwent thoracolumbar pelvic fixation for deformity between 2004 and 2011. A binary logistic regression model was created to determine the variables that are associated with increased perioperative complications. The primary endpoints were overall complications, major, and minor complications. The variables studied included age, sex, levels of fusion, comorbidity index, fusion to pelvis and estimated blood loss.

Results: The mean age was 54.7 years. There were 54 males and 106 females. The mean follow-up was 13.9 months. The mean length of stay was 7.2 days. The mean number of levels fused was 9.2. The average estimated blood loss (EBL) was 1735 ml. The overall rate of complications was 51.9% (i.e. 83 patients had at least 1 complication). We observed 4 deaths in this study. A binary logistic regression analysis revealed fusion to pelvis (P = 0.009) and prolonged length of stay (P = 0.039) to be associated with increased perioperative complication. Age, sex, comorbidity index, levels of fusion, osteotomy and EBL did not show a statistically significant association with increased complications (P = 0.55, 0.48, 0.24, 0.52, 0.45, 0.61, respectively). The overall complication rate was 62% and 47.3% in the elderly and younger groups, respectively (P = 0.39). Of all the complications, respiratory failure, myocardial infarction and intraoperative CSF leak were found to be significantly higher in the elderly group (P = 0.043, 0.033, 0.04 respectively).

Conclusion: Complication rates in elderly patients undergoing complex spinal fusions remain high. A continued assessment of perioperative complications and factors predictive of complications are necessary to ensure safe and favorable outcomes.

The Impact of Positive Regional Sagittal Alignment on Outcomes in Posterior Cervical Fusion Surgery

Jessica A. Tang, Justin K. Scheer, Justin S. Smith, Vedat Deviren, Shay Bess, Robert Hart, Virginie Lafage, Christopher I. Shaffrey, Frank Schwab, Christopher P. Ames

Introduction: Positive spinal sagittal malalignment has repeatedly shown to correlate with pain and disability in thoracolumbar fusion. This study evaluated the relationship between cervical sagittal alignment and postoperative outcomes for patients receiving multi-level cervical fusion.

Methods: From 2006-2010, 113 patients received multi-level cervical fusion for cervical stenosis, myelopathy, and kyphosis. Radiographic measurements at intermediate follow-up included: (1) C1-C2 lordosis, (2) C2-C7 lordosis, (3) C2-C7 sagittal vertical axis (C2-C7 SVA), (4) Center of gravity of head SVA (CGH-C7 SVA), and (5) C1-C7 SVA. Health related quality of life measures (HRQOL) included neck disability index (NDI), visual analog pain scale (VAS), and SF-36 physical component (PCS) scores. Pearson product-moment correlation coefficients were calculated between pairs of radiographic measures and HRQOL scores. Improvement in NDI scores following surgery were evaluated by categorizing scores into standard intervals: no disability (0-4), mild (5-14), moderate (15-24), severe (35-34), and complete (>34).

Results: 80% of patients experienced an improvement of NDI scores or remained the same compared to preop. PCS scores improved by 22.0 ± 37.5%. Both C2-C7 SVA and CGH-C7 SVA negatively correlated with PCS (r = 0.43, P < 0.001 and r = 0.36, P = 0.005, respectively). C2-C7 SVA positively correlated with NDI scores (r = 0.20, P = 0.036). C1-C2 lordosis constituted 76.0 ± 15.8% of total cervical lordosis (sum of C1-C2 and C2-C7 lordosis). C2-C7 SVA positively correlated with C1-C2 lordosis (r = 0.33, P = 0.0003). For significant correlations between C2-C7 SVA and NDI scores, regression models predicted a threshold C2-C7 SVA value of approximately 40mm, beyond which correlations were most significant.

Conclusion: Positive cervical sagittal malalignment, measured by C2-C7 SVA, negatively affects HRQOL scores following multi-level cervical fusion at intermediate follow-up. This is the first study to examine the impact that regional SVA in the cervical spine has upon HRQOL following multi-level cervical fusion. Our findings demonstrate that, similar to the thoracolumbar spine, the severity of disability increases with positive sagittal malalignment following surgical reconstruction.

Complications Following Use of rhBMP-2 in Anterior Lumbar Interbody Fusion: An Institutional Cohort Controlled Study

Daniel Lubelski, Kaili G. Abdullah, Matthew D. Alvin, Michael P. Steinmetz, Edward C. Benzel, Thomas Mroz

Introduction: Recombinant human bone morphogenetic protein-2 (rhBMP-2) has been increasingly used in spinal fusions. While initial studies extolled the product’s improvement of patients’ outcomes, recent investigations have revealed increased rates of urological complications, as well as wound infection, pseudoarthrosis, and reoperation, relative to the standard ALIF procedure.

Methods: Using the institutional electronic medical records, we retrospectively reviewed all patients who underwent ALIF with and without rhBMP-2 between January 2002 and August 2010. Patient demographic, operative, and outcome/complication information was collected.

Results: Of the 267 ALIF patients that fit our inclusion criteria, 144 included the use of rhBMP-2 and 123 did not and served as the control cohort. The mean follow-up was 20.2 months for the rhBMP-2 group and 32.5 months for the control group. No difference was found regarding the
number of urological complications in the rhBMP-2 group vs. the control group (8% vs. 7%, respectively). Only one case of retrograde ejaculation was identified in the rhBMP-2 group, none were found in the control group. The rates of pseudoarthrosis, radiculitis, and reoperation were significantly higher in the rhBMP-2 group relative to the control (17% vs. 5%, 23% vs. 2%, and 22% vs. 5%, respectively).

**Conclusion:** Urological complications and retrograde ejaculation may not be as prevalent as previously reported following ALIF procedures with rhBMP-2. The higher rate of pseudoarthrosis, radiculitis, and reoperation confirm previous reports and should be considered by patient and surgeon before proceeding to operations with rhBMP-2.

**103 Characterization of Myelination by Skin Derived Precursor Cells**

**Joey Kevin Grochmal, Rajiv Midha**

**Introduction:** Skin derived precursor cells (SKPs) can mimic the phenotypic appearance of Schwann cells when predifferentiated in vitro (SKP-SCs). Our hypothesis is that SKP-SCs can produce morphologically and electrophysiologically functional myelin as they ensheath axons.

**Methods:** We unilaterally injected 500,000 DiI positive, GFP producing SKP-SCs into the tibial nerves of 10 adult Lewis rats, while the contralateral tibial nerve received media injection. This was done one week after a demyelinating bilateral tibial nerve lesion was created using a 30ul injection of 12.5ug/ml Adriamycin(1). All animals were followed for compound motor action potentials (CMAPs) every three days until 60 days post-adriamycin. A parallel series of animals also included a cohort that instead received GFP labeled Schwann cells (500,000), all of which were sacrificed at day 33 post-adriamycin injury (n = 5/group). These animals were analyzed for EPON morphometry, teased fibre immunohistochemistry (NaV1.6), as well as confocal analysis of 8μm frozen sections for axial morphology.

**Results:** The cohort of animals that were followed until day 60 demonstrated no significant difference between their respective return to electrophysiological normalcy. At day 33, however, SKP-SCs promoted a significantly lower G-ratio (P < 0.05) when analyzed against either media or Schwann cell injection in this model (Epon morphometry, N = 5/group). Teased fibre analysis and spectral confocal analysis demonstrated strong evidence of myelination by SKP-SCs. These cells formed compact myelin and participated in mature Node of Ranvier formation.

**Conclusion:** SKP-SCs graft improves tibial nerve remyelination within this adriamycin injury model. The effect is robust enough to produce a morphometric difference in the G-ratios between the treatment groups at day 33, with the SKP-SC group measuring closest to a normal G-ratio. One plausible mechanism for the improved morphology is the direct, compact myelination of axons by SKP-SCs, which was conclusively demonstrated.

**104 The Design and Development of the Neuropoint SD Spine Registry for Lumbar Discectomy and Single Level Fusion for Spondylolisthesis**


**Introduction:** The goal of this project was to establish a multi-center collaborative research group to demonstrate the feasibility of developing a registry to assess the efficacy of common lumbar spinal procedures in actual practice. Before proceeding with comparative effectiveness projects, it is critical to develop an infrastructure with personnel that can reliably collect health-related patient-reported outcomes data over 1 year.

**Methods:** A prospective, 13-site registry study collected data from unselected patients undergoing lumbar discectomy or single-level fusion for spondylolisthesis. Funding was obtained to enroll 200 patients. Subjects completed SF-36 and ODI questionnaires pre-operatively, and at 3, 6, and 12 months post-operatively. All patient data were entered into a secure HIPAA compliant internet-based data management platform developed by the Neuropoint Alliance in conjunction with the AANS.

**Results:** Three investigator meetings were held. IRB approval and contracts were required at all sites. 211 patients were enrolled from 13 academic and community sites (mean 16 patients/site) over 1 year (Figure 1). Mean age: 46.0 years (48% female) for lumbar discectomy (N = 156), 58.3 years (60% female) for lumbar spondylolisthesis (N = 48). Eleven sites met enrollment goals (Figure 2). Baseline data was collected in 99.5% of cases. Complications were assessed at 30 days (96.6% compliance) with 11 (5.4%) reported. Outcomes assessment compliance was 90.3% and 88.4% at 3 and 6 months, respectively. Overall, there was 88% compliance with patient-reported outcomes data collection. At 3 months, lumbar discectomy and single-level fusion procedures were associated with significant improvements in ODI and SF-36 scores (P < 0.001).

**Conclusion:** It is feasible to build a national spine registry for the collection of high-quality prospective data to demonstrate the effectiveness of spinal procedures in actual practice. Thirteen sites achieved 88% compliance with the collection of patient-reported outcomes data over 1 year.

**105 Is Surgical Decompression in Patients with Mild Cervical Spondylotic Myelopathy Effective? Results of the Prospective, Controlled, Multicenter AO Spine North America CSM Study**


**Introduction:** Surgical decompression is standard for patients with moderate and severe cervical spondylotic myelopathy (CSM), however, the role of surgery in cases of mild CSM remains questioned. We aimed to evaluate the efficacy and safety of surgical decompression in patients with mild CSM.

**Methods:** 189 subjects with mild CSM, modified Japanese Orthopaedic Association (mJOA) score 12-17, and 79 control subjects with moderate CSM, mJOA score 7-11, were enrolled in this prospective, multi-center study. The outcome measures used were mJOA, Nurick Score, Neck Disability Index (NDI), and SF36v2. Measurements were taken during preoperative and 12 month post-surgery assessments. The mild cohort outcomes were compared to the moderate
control group. Complications were assessed prospectively.

Results: Following surgery, patients with mild and moderate CSM showed significant improvement in all outcomes. The degree of improvement on the Nurick, NDI, and SF36v2 was comparable in patients with mild and moderate CSM. Subjects in the mild group showed less absolute improvement in their mJOA scores (mean: 2.07, 95% confidence interval: 1.67-2.46) than subjects with moderate CSM (mean: 4.80, 95% confidence interval: 4.11-5.48). The rate of perioperative neurological complications was comparable in the mild (3.7%) and moderate (3.8%) groups and largely reflected transient nerve root dysfunction. Of note, only one patient (0.4%) experienced permanent decline in spinal cord function.

Conclusion: Surgical decompression improves outcomes in subjects with mild CSM to an extent comparable to individuals with moderate CSM. This data provides support for surgical intervention in cases of mild CSM.

106 The Short-Term Effect of Surgery on Health Related Quality of Life and Functional Outcome in Patients with Metastatic Epidural Spinal Cord Compression (MESC): Results of the Ongoing AO Spine North America Prospective Multicenter Study


Introduction: Studies have provided evidence that in selected patients combined surgery and radiotherapy provides the optimal neurological recovery in MESC patients. However, patients with MESC have relatively short life-expectancy and face numerous health challenges. The impact of surgery on improving quality of life outcomes in the setting of MESC is unknown.

Methods: 111 surgical patients were enrolled in a prospective multi-center, cohort study involving 10 sites in North America. Outcomes were assessed using the pain assessments, ASIA scale, SF-36v2, and EQ-5D.

Results: Average age was 58 years, 59 percent were males. Common primary sites were lungs (24 percent), prostate (12 percent), breast (13 percent), and kidney (12 percent). 67 percent survived three months, only 33 percent survived 12 months. The survival was associated with site of primary cancer. In survivors, the average improvement at 3 month was for .23 for EQSD (P < .01), 19.2 for ODI (P < .01), 2.1 for VAS Pain (P < .01). Also, there was a significant improvement in ASIA Impairment grade (P < .01). The changes in SF36 PCS and MCS were not significant.

Conclusion: Surgically treated patients with MESC are a diverse group of patients with different prognoses. The surviving patients experience clinically relevant symptoms improvement and gains in function and utility. Individuals with less than three month life expectancy may be less than ideal candidates for surgical intervention.

107 Anterior vs. Posterior Surgical Approaches to Treat Cervical Spondylotic Myelopathy: Outcomes of the Prospective Multicenter AOSpine North America CSM Study in 278 Patients


Introduction: The optimal surgical approach to treat cervical spondylotic myelopathy (CSM) remains debated with varying opinions favoring anterior vs. posterior surgical approaches. We present an analysis of a prospective observational multicenter study examining outcomes of surgical treatment for CSM.

Methods: 278 subjects from 12 clinical sites in NA received anterior/posterior or combined surgery at the discretion of the surgeon. This study focused on subjects who had either anterior or posterior surgery (n = 264, 87% follow-up rate). Outcome measures included the Modified Japanese Orthopedic Assessment Scale (mJOA), the Nurick scale, the Neck Disability Index (NDI) and the SF36v2 Physical (PCS) and Mental (MCS) Component Scores.

Results: 169 patients were treated using anteriorly (discectomy/foraminotomy with instrumented fusion) 95 received posteriorly (either laminectomy (86%) and fusion or laminoplasty (14%)), 42% were female. Anterior surgery cases were younger (53 ± 11 vs. 63 ± 11 years), had less severe myelopathy as assessed by mJOA and Nurick scores. There were no baseline differences in NDI or SF36 between the anterior and posterior cases. Anterior cases had on average 3.1 vertebral levels operated on compared to 5.1 levels in the posterior group (P < .0001). Improvement in the mJOA was significantly lower in the anterior group when compared to posterior group (2.47 vs. 3.62, respectively, P < .01), although the groups started at different levels of baseline impairment. The extent of improvement in the Nurick, NDI, SF36v2 PCS, SF36v2 MCS scores did not differ between the anterior and the posterior groups.

Conclusion: Patients with CSM show significant improvements in generic and disease specific health related outcome measures with anterior or posterior surgery. Importantly, patients treated with anterior techniques were younger, with less severe impairment and more focal pathology. While there was a greater improvement in mJOA scores in posterior cases, this difference could be accounted for by differences in baseline characteristics.

108 The Scope and Impact of Wrong-Level Lumbar Spine Surgery: A Survey of the Joint Section on Disorders of the Spine and Peripheral Nerves

Michael W. Groff, Joshua E. Heller, Eric A. Potts, Praveen V. Mummaneni, Christopher I. Shaffrey, Justin S. Smith

Introduction: Wrong-level spine surgery continues despite national efforts by regulators and professional societies. The authors surveyed the membership of the Joint Section of Spinal Disorders and Peripheral Nerve Diseases (Spine Section) to better understand the scope and impact of wrong-level lumbar spine surgery.

Methods: A Spine Section task force developed a survey on single-level lumbar spine decompression surgery, including questions regarding wrong-level lumbar spine surgery. Invitations to complete the web-based survey were sent to all members of the Spine Section. Respondents were assured of confidentiality.

Results: There were 569 responses from 1,045 requests (54%). Almost 50% of reporting surgeons have performed wrong-level lumbar spine surgery at least once, and more than 10% have performed...
wrong-side lumbar spine surgery at least once (see figure). Nearly 20% of responding surgeons have been the subject of at least one medical malpractice case relating to these errors. In 68% of cases in which wrong-level or wrong-side surgery was performed, this error was discovered at the time of surgery, and the surgeon proceeded with the correct level/side surgery. The error was discovered immediately following the procedure in 5% of cases and sometime >24 hours after the procedure in 27% of cases. In addition, almost 90% of surgeons reported at least one “close call” with regard to wrong-level or wrong-side lumbar spine surgery, including wrong level exposed but no bony removal (65%), wrong side exposed but no bony removal (3%), or both of these events (20%).

**Conclusion:** Existing safety protocols may not be preventing wrong-level spine surgery to the extent previously thought. These findings argue for additional study of wrong-level spine surgery, including development of a standardized approach for level confirmation that can at least be used to facilitate a multi-institutional effort to further investigate and mitigate these errors.

**109 Radiographic Predictors of Early Failure Following Decompression Without Fusion for Degenerative Grade I Lumbar Spondylolisthesis**

Claire Blumenthal, Jill Curran, Edward C. Benzil, Suhu N. Magge, J. Frederick Harrington, Jean-Valery Cournand, Zoher Ghogawala

**Introduction:** Determining specific radiographic traits that predict early failure following decompression surgery might guide clinical decision making regarding the utility of upfront fusion in patients with degenerative grade I spondylolisthesis.

**Methods:** Patients with grade I degenerative lumbar spondylolisthesis (3-14 mm) with symptomatic stenosis were prospectively enrolled from 5 sites from May 2002 to September 2009 and treated with decompressive laminectomy without fusion and 42/58 patients with complete radiographic data sets were available for analysis. Re-operation rate was 15/42 (35.71%) with mean follow-up of 3 years. Re-operation was performed for pain caused by instability at the index level in all 15 cases. Using multivariate stepwise logistic regression with a threshold p-value of 0.35, motion at spondylolisthesis, disc height, and facet angle were predictors of reoperation following surgery (Table 1). Facet angle > 50 degrees was associated with a 37% rate of re-operation. Disc height > 6.5 mm was associated with a 45% rate of re-operation. Patients with 3 risk factors for instability had a 75% rate of re-operation, while patients with no risk factors instability had a 0% rate of re-operation (P < 0.05) (Figure 1).

**Conclusion:** Patients with motion at spondylolisthesis, disc height > 6.5 mm, and facet angle > 50 degrees are more likely to experience instability following decompression surgery for grade I lumbar spondylolisthesis. Identification of key significant risk factors for instability might improve outcomes following decompression without fusion surgery.

**110 Functional and Quality of Life Outcomes in Geriatric Patients with Type II Odontoid Fracture: One Year Results from the AO Spine North America Multi-Center GOF Prospective Study**

Michael G. Feilings, Alexander R. Vaccaro, Branko Kopjar, Jens Chapman, Christopher I. Shaffrey, Ziya L. Gokaslan, Paul M. Arnold, Darrel S. Brodkne, John France, Sangwook Yoon, Mark B. Dekutoski, Rick Sasso, Christopher Boni

**Introduction:** Odontoid fractures commonly occur in the elderly and represent a management challenge. It is unclear whether surgery or conservative management is the best treatment option. There is a paucity of information regarding treatment outcomes.

**Methods:** We conducted a prospective multi-center cohort study of subjects > 65 years old with Type II odontoid fracture at 11 sites in North America. Patients received nonoperative or surgical treatment at the discretion of the surgical team and were followed for 12 months.

**Results:** There were no differences in Neck Disability Index (NDI) outcomes between the surgical cases and the conservatively treated group. The decline in NDI among the surgically and the conservatively treated group (P = 0.019) was 14.7 points in the conservatively treated surgical group, though the possibility of selection bias needs to be carefully considered.
patients treated at one center with long-term follow-up. **Methods:** We retrospectively examined charts of patients who underwent a total 1085 FORs in 1990-2009. A large cohort of these patients participated in a structured telephone interview designed to assess improvement in symptoms and function. We assessed post-operative quality of life (QOL) using the EQ-5D. A total 338 interviews were completed with a mean follow-up of 10 years. **Results:** Approximately 90 percent of interviewees reported improved pain, weakness or function following FOR, and outcomes significantly correlated with improved QOL scores (P < 0.0001). Such symptomatic relief allowed 93 percent of patients to return to work. The overall complication rate was 3.3 percent and the rate of recurrent radiculopathy requiring surgery was 6.2 percent. Neither rate of complications nor that of additional surgery correlated with QOL at long-term follow-up. Soft disc subtypes were compared to osteophyte disease by operative report and were associated with significantly improved pain, weakness and function. The operative report of these pathologic subtypes was significantly associated with the preoperative MRI interpretation (P < 0.0001). **Conclusion:** These results suggest that FOR is a highly effective surgical treatment for cervical radiculopathy with a low incidence of complications. Radiculopathy due to soft disc subtypes may be associated with a better prognosis compared to osteophytic disease. These common etiologies for radiculopathy may be differentiated on preoperative MRI scans, providing an opportunity for surgeons to predict outcome.

112 **The Relative Impact of Lumbar Spondylosis on Quality of Life in the United States: A Population Health Perspective**

Cyrus Chi-Ho Wong, Scott L. Parker, Marcus J. Gates, Matthew McGirt

**Introduction:** Current cost of healthcare is unsustainable. To improve efficiency, payers are aiming to preferentially support higher value care and decrease spending on disease states with less impact on population health. The relative impact common disease states have on quality of life is poorly understood. In a systematic literature review, we determined mean quality-adjusted life year (QALY) of lumbar spondylosis vs. other common chronic disease states and utilize U.S. prevalence rates to determine the relative impact (annual U.S. population QALYs lost) these common diseases states have on U.S. population health. **Methods:** Systematic literature review was conducted for studies utilizing health state instrument (EQ-5D). Studies examining ten common disease states (both surgical and non-surgical) were included, Table 1. Baseline health state for each disease state was recorded from the literature. Mean health state per disease state was multiplied by Center for Disease Control reported disease prevalence rates to determine overall annual QALY lost per disease state in U.S. **Results:** 137 studies (135,106 patients) met inclusion criteria, Table 1. Lumbar spondylosis patients had cumulative mean EQ-5D of 0.39, Table 2, the lowest QALY among all disease states examined, Figure 1. Lumbar spondylosis, knee osteoarthritis, COPD, and diabetes mellitus were the most prevalent disease states, Table 3. Estimated total annual QALY’s lost in the U.S. was greatest for lumbar spondylosis (18,391,456 QALY’s), 1.34-fold greater than knee osteoarthritis, 2.6-fold greater than COPD and diabetes, 4.34-fold greater than degenerative hip disease, Table 3. **Conclusion:** Lumbar spondylosis was associated with the lowest QALY health state compared to other common disease states. Overall impact on QALY’s lost for U.S. population is significantly higher for lumbar spondylosis than disease states studied, suggesting degenerative lumbar spinal disorders have a large and detrimental impact on U.S. population’s health and quality of life. Healthcare reform initiatives should allocate appropriate resources and spending to address this high-impact disease process.

113 **Pitfalls of Calculating Hospital Readmission Rates Based Solely on Nonvalidated Administrative Datasets**

Beejal Y. Amin, Urvij Mordhia, Keishi Mauro, Lumine Na, Steven Takemoto, Christopher P. Ames, Vedat Deviren, Dean Chou, Sigurd Berven, Praveen V Munnameni

**Introduction:** Administrative databases are increasingly being used to establish benchmarks for quality of care and to compare performance across peer hospitals. As proposals for Accountable Care Organization are being developed, readmission rates will be increasingly scrutinized. The purpose of this study is to assess the accuracy of administrative datasets and identify independent predictors of readmission. **Methods:** Data for 5,854 consecutive spine admissions to UCSF Medical Center from July 2007-June 2011 was abstracted from the University Health-System Consortium (UHC) using the Clinical Database/Resource Manager. Of these admissions, 320 cases (5.8%) were rehospitalized within 30 days of the initial discharge date. We performed an independent chart review to determine reasons for readmission and extracted hospital administrative data to calculate total and direct costs. Logistic regression analysis was used to test the odds of readmission on categorical variables. The two-sample t-test was used to test the difference of total and direct cost between readmission and non-readmission. **Results:** The main reasons for readmission were infection (46.1%), planned, staged surgery (11.6%), and nonoperative management (9.8%). The UHC database overestimated the readmission rate. Based on our chart review, 50 cases (of the 320 total readmissions) were misclassified. Thirty-seven cases (11.6%) were planned, staged procedures and 13 cases (4.1%) were unrelated to the initial admission. When planned, staged readmission cases are excluded, the total cost of readmission is reduced by 18.2% (P = 0.005). The cost variance is in excess of one million dollars. Predictors of readmission were admission status (P < 0.0001), length of stay (P = 0.0001), risk of mortality (P < 0.0001), and age (P = 0.021). **Conclusion:** Our findings uncover the potential pitfalls of calculating hospital readmission rates based solely on nonvalidated administrative datasets. Benchmarking algorithms for defining a hospital’s readmission rate must take into account planned, staged surgery and eliminate unrelated reasons for readmission. Current tools overestimate the true readmission rate and cost.

114 **Modest Systemic Hypothermia in Acute Cervical Spinal Cord Injury: A Prospective Case Controlled Study**

Allan D. Levi, Barth A. Green, Dalton Dietrich, Steven Vanni, Marine Dididze, Michael Y. Wang

**Introduction:** Systemic hypothermia continues to show promise in select CNS injury conditions. We have previously
reported our experience (n = 14 pts)[1,2] with modest intravascular hypothermia (T-33 OC) after spinal cord injury (SCI). We describe our extended single center experience that now spans over 6 years. Methods: We prospectively acquired data on 32 patients (mean age 36 years, range 18-65) with acute cervical SCI who received intravascular hypothermia with target temperature (33 OC) maintained for 48 hours. Clinical outcome was assessed by American Spinal injury Association International Medical Society of Paraplegia Impairment Scale (AIS). All patients initially were complete AIS A on admission but two converted to AIS B in <12 hours. The majority of patients had C5-6 lesion (14 and 10 respectively), while 6 had C4 and 2 - C7. 62% of injuries were related to motor vehicle accident or fall. Results: The mean (SEM) time from injury to initiation of hypothermia was 5.95 (0.48) hours (after excluding four cases due to delayed admission). Thirteen of 32 patients (41%) improved at latest follow-up (average 11 months): 5 converted to AIS B, 3 - to AIS C, 2 to AIS D and 1 to AIS E. Complications were mainly respiratory. Five thromboembolic complications (15%) were noted - one in an arm vein, one femoral vein, one IVC clot unrelated to the catheter and two patients developed subsegmental pulmonary embolus, well managed with anticoagulants. Two deaths (2 and 12 months post-treatment) were seen in patients age 55 and 62 respectively. Conclusion: The AIS conversion rate of 41% in 32 complete (AIS A) cervical SCI patients compares favorably with previously published data regarding AIS conversion rates in cervical SCI. The incidence of complications corresponds to control SCI treated in our institution supporting concept that systemic cooling after SCI warrants larger, controlled prospective, randomized study.

115 Prospective, Randomized Study of Cervical Arthroplasty and ACDF with Long-Term Follow-up: 76 Patients from a Single Site with Four- to Eight-year Follow-up
Domagoj Coric, Margaret Boltes, Sara James, Judd Heideman
Introduction: The purpose of this study is to evaluate the long-term clinical results of cervical total disc replacement (cTD R) and anterior cervical disectomy and fusion (ACDF) in the treatment of single level cervical radiculopathy. Methods: The results of two separate prospective, randomized US Food and Drug Administration (FDA) Investigational Device Exemptions (IDE) pivotal trials (Bryan Disc and Kineflex|C) from a single investigational site were combined to evaluate outcomes at long-term follow-up. The primary clinical outcome measures included the Neck Disability Index (NDI), visual analog scales (VAS), and neurologic exam. Patients were randomized to cTD R or ACDF in two separate studies using the Bryan Disc or Kineflex|C artificial discs vs. ACDF using structural allograft and an anterior plate. Results: Results: A total of 76 patients were enrolled and randomly assigned to either cTD R (n = 42) or to ACDF (n = 34). A total of 63 patients (83%) were available for minimum four-year follow-up (cTD R = 88%, ACDF = 77%). Average follow-up was 6 years (72 months) with a range from 48-96 months. Clinical success: In both the cTD R and ACDF groups, the mean NDI and VAS scores improved significantly by 6 weeks after surgery and remained significantly improved throughout the minimum 48-month follow-up (P < 0.0001). Radiographic success: The range of motion (ROM) in the cTD R group remained significantly greater than the pre-op mean while the ROM in the ACDF group was significantly reduced. Reoperation: The adjacent level reoperation rate in the cTD R group (4.8%) was not statistically significantly different than the ACDF group (5.9%). The index level reoperation rate in the cTD R group (2.4%) was not statistically different than the ACDF group (0%). Conclusion: Both cTD R and ACDF groups showed excellent clinical outcomes that were maintained over long-term follow-up. Both groups showed low index level and adjacent level reoperation rates. Both cTD R and ACDF appear to be viable options for the treatment of single level cervical radiculopathy.

116 Prospective Study of Disc Repair with NuQu Injectable Allogeneic Chondrocytes
Domagoj Coric, Kenneth Pettine, Margaret Boltes
Introduction: The purpose of the study was to evaluate the safety and initial efficacy of the NuQu allogeneic juvenile chondrocyte injection. The NuQu phase I feasibility study is a single arm, prospective study of disc repair using a single, outpatient injection of allogeneic chondrocytes for the treatment of patients with mechanical low back pain (LBP) with single level spondylosis (Pfirrmann grade III-IV) L3-S1. Methods: Patients were evaluated pre-operatively and post-operatively at 1, 3, 6 and 12 months. Evaluations included routine neurological examinations, MRI, the Oswestry Disability Index (ODI) and patient self-report visual analog scale pain assessments (VAS). Results: Fifteen patients (6 female, 9 male) were enrolled at 2 sites with a mean age of 40 years (range 21-48). All 15 (100%) were evaluated at one year follow-up. Levels: L3-4=2, L4-5=1, L5-S1=11. Each injection consisted of 1-2 cc (mean injection=1.4cc) of juvenile chondrocytes (~ 4-5 million chondrocyte cells/cc) with fibrin glue carrier. Mean injection peak pressure=86.5 psi. The mean ODI (baseline = 53, 6 months = 28, P = 0.0005), VAS (baseline=6, 6 months=4, P = 0.02) and SF-36 Physical scores (baseline = 35, 6 months = 43, P = 0.005) all improved significantly from baseline. Patient self-report of pain: improved = 8, unchanged = 6, worse = 1. MRI: Nine (60%) of 15 patients showed improvements in MRI imaging. High intensity zones (HIZ) consistent with posterior annular tears were present at baseline in nine patients, eight (89%) showed improvements in MR imaging. No patients experienced neurological deterioration. There were no serious and no unexpected adverse events. There were no observed immunological response to the chondrocyte injection. Two patients (13%) underwent total disc replacement by 12 month follow-up due to persistent LBP. Conclusion: This is the first report of the clinical and radiographic results of cell-based disc repair therapy (injectable juvenile chondrocytes) in the treatment of lumbar spondylosis with mechanical LBP. The results of this prospective cohort are promising and warrant further investigation with a prospective, randomized, double-blinded, placebo-controlled study.
Skin-derived Precursor Cells Enhance Functional Outcome Following Nerve Repair

Helene T. Khuong, Aleksandra Ivanovic, Antos Shakhbazau, Ranjan Kumar, Joanne Forden, Hamed Abhari, Rajiv Midha

Introduction: Although peripheral nerves are known for the capacity to regenerate, outcome following injury remains poor. Previous work has shown that delivery of skin-derived precursors predifferentiated into Schwann cells (SKP-SC) can improve some measures of axonal regeneration in a chronically denervated model of nerve injury. There is no published data showing functional outcome from such a therapy in a model of acute nerve injury.

Methods: Eighteen adult male Lewis rats were trained prior to surgical intervention to cross a previously validated ladder with rungs placed at variable distance. A right tibial nerve section was performed and immediately repaired in a direct (end-to-end) fashion. One group (n = 5) also received injection of SKP-SCs (5 X 10^5 cells) 3 mm distally to the repair site while another group (n = 5) received injection of carrier medium at the same site. One group (n = 5) underwent sham surgery and one last group (n = 3) had a nerve injury without repair (see Figure 1). All rats were tested at defined timepoints over the 20 weeks following surgery. A slip ratio was calculated after gait analysis of 5 runs per rat at each timepoint.

Results: A baseline slip ratio was similar across all groups. Immediately after surgery, the slip ratio rose similarly among all injured animals. Animals in both positive and negative control groups performed as expected. Four weeks after surgery, animals treated with SKP-SCs showed dramatic improvement with a mean slip ratio that stayed low for the rest of the study. The animals with media injection showed a slower improvement that never matched the level of the treated group. The difference between those two groups at weeks 5 and 9 was statistically significant. (See Figure 2.)

Conclusion: SKP-SCs improve functional outcome in an animal model of immediate repair following nerve injury, with faster recovery and better performance on gait analysis.

**MAYFIELD BASIC SCIENCE AWARD 118**

Human Mesenchymal Stem Cells Seeded in a Polymer Scaffold: A Novel Treatment Approach for Spinal Cord Injury

Alexander E. Ropper, Devang Thakor, Inho Han, Dong Yu, Hariprakash Haragopal, A. John Popp, Yang D. Teng

Introduction: We investigated the effects of human mesenchymal stem cell (hMSCs) seeded in poly-lactic-co-glycolic acid (PLGA) scaffold on neurorehabilitation in rats undergoing thoracic segmental hemisection spinal cord injury (SCI). We hypothesized that this treatment, which utilizes both developmental trophic and homeostatic properties of hMSCs as well as the structural stabilization of a PLGA scaffold, would improve sensorimotor recovery in SCI rats.

Methods: Female SD rats received a unilateral T9-10 segmental midline hemisection. In addition to a lesion control group, biocompatible and biodegradable PLGA scaffold seeded with bone marrow-derived hMSCs, hMSCs alone or scaffold alone was implanted into the injury epicenter immediately following SCI (n=7/group). Standardized behavioral tests were performed at day one post-injury and weekly thereafter, which was followed by analyses of histopathology and cellular/molecular biology.

Results: The scaffold+hMSCs treatment group demonstrated significantly improved hind limb locomotion, coordination and spinal reflexes at 4 weeks relative to all of the controls. Histochemical evaluation revealed a larger volume of spared gray and white matter in the scaffold+hMSCs treated spinal cords. Immunocytochemistry of transverse sections at and adjacent to the injury epicenter showed the least scale of reactive astrogliosis (i.e. GFAP immunoreactivity) in the treated tissue, indicating that scaffold+hMSCs implantation engendered a pro-repair environment in the lesioned parenchyma. Moreover, the treatment reduced levels of both chronic inflammation as evidenced by diminished numbers of CD68 and CD11b positive cells around the injury site and reduced immunoreactivity against nitrotyrosine, a marker of oxidative injury.

Conclusion: We have demonstrated the effectiveness of a PLGA scaffold-hMSCs based treatment in improving sensorimotor function after experimental SCI. The clinical findings were substantiated by histopathologic and cellular/molecular evidence that validates our hypothesis. Importantly, our data suggests that the autologous feasibility of hMSCs plus the biocompatibility of PLGA may help render CNS trauma operable under neurosurgical regimens based on regenerative medicine principles.

**MAYFIELD CLINICAL SCIENCE AWARD 119**

Decreased Incidence of Venous Thrombo-Embolism After Spine Surgery with Early Aggressive Chemoprophylaxis

Joseph Bridger Cox, Catherine Koepnick, R. Patrick Jacob, Daniel J. Hoh

Introduction: Venous thrombo-embolism (VTE) can be a significant complication after spine surgery with rates reported as high as 2-4%. Institutional practices for VTE prophylaxis are highly variable. In 2008, we instituted an aggressive protocol for early VTE prophylaxis consisting of combined compressive devices and subcutaneous heparin initiated either preoperatively or the day of surgery. In this study, we compare our incidence of VTE in spine surgery patients before and after initiating this protocol.

Methods: An IRB-approved retrospective review of spine surgery patients for 2 years prior to protocol initiation and for 2 years thereafter was conducted. Inclusion criteria were spine surgery patients ≥18 years old and admitted for ≥ 1 day. VTE prophylaxis since 2008 consisted of a uniform protocol of heparin 5000 units subcutaneously three-times daily, except those >75 years old or <50 kg who underwent twice-daily dosing. All patients had sequential compression devices. VTE prophylaxis was administered starting either preoperatively or the same day of surgery and continued throughout hospitalization. Prior to 2008, VTE prophylaxis was variable and provider dependent without any uniform protocol. VTE incidence was identified by ICD-9 codes for deep vein thrombosis (DVT).
and pulmonary embolus (PE). Secondary bleeding complications related to anticoagulation were evaluated by CPT code for postoperative epidural hematoma (EDH) requiring evacuation.

**Results:** Prior to protocol initiation, 1002 patients met inclusion criteria: 25 had DVT (2.50%), 6 had PE (0.60%), 6 had postoperative EDH (0.60%). After protocol initiation, 1071 patients met criteria: 10 had DVT (0.93%), 5 had PE (0.47%), 4 had postoperative EDH (0.37%). This reduction in DVT was statistically significant (P = .006). Despite early aggressive prophylaxis, there was no increased incidence of postoperative EDH, and compared favorably to published literature.

**Conclusion:** At a high volume tertiary center, an aggressive protocol for early VTE prophylaxis after spine surgery decreases VTE incidence without associated increased morbidity.

**OUTCOMES COMMITTEE AWARD 120**

**The Relevance of Intramedullary High Signal Intensity and Gadolinium (Gd-DTPA) Enhancement to the Clinical Outcome in Cervical Compressive Myelopathy**

**Jun-Jae Shin, Ji Hae Lee, Woo Ho Cho, Jon Park**

**Introduction:** We prospectively investigated whether high intramedullary signal intensity (SI) and contrast (gadolinium-diethylene-triamine-pentaacetic acid [Gd-DTPA]) enhancement in MRI are associated with postoperative prognosis in cervical compressive myelopathy (CCM) patients. Additionally, we investigate the usefulness of contrast-enhanced MRI in patients with cervical myelopathy.

**Methods:** Seventy-four patients with ventral cord compression underwent anterior cervical discectomy and fusion (ACDF) for CCM between March 2006 and June 2009. The mean follow-up period was 39.7 months (range, 12.7-55.7 months). The clinical outcomes were measured using Japanese Orthopedic Association (JOA) scores. Patients were classified into three groups based on the SI change in T2-weighted images (T2WI), T1-weighted images (T1WI), and contrast (Gd-DTPA) enhancement. Group A displayed normal intensity on both T2WI and T1WI, group B displayed no intramedullary signal intensity abnormalities on T1WI and high SI on T2WI, and group C displayed no intramedullary SI abnormalities on T1WI, high SI on T2WI, and an enhanced contrast(Gd-DTPA) image. By comparing the preoperative and postoperative signal change on T2WI, patients with high SI before surgery were classified into two groups after the surgery: reversible group (those whose SI had decreased) and stationary group (those whose SI was unchanged).

**Results:** The respective postoperative JOA scores and recovery ratios were 16.2 ± 0.8/82.4 ± 16.7% for group A, 14.6 ± 2.5/69.1 ± 20.8% for group B, and 13.9 ± 1.7/57.5 ± 14.0% for group C (P < 0.05). The mean recovery ratio of the reversible group was 75.9 ± 14.3%, which was better than that of the stationary group (59.0 ± 19.7%) (P <0.05).

**Conclusion:** We found that intramedullary SI change is a poor prognostic factor and the intramedullary contrast enhancement on preoperative MRI should be viewed as the worst predictor of surgical outcomes in cervical myelopathy. The regression of signal changes in patients with intramedullary high SI before surgery reflects improved neurological outcomes after surgery. We consider contrast enhancement and postoperative MRI are useful for identifying the prognosis of patients with poor neurological recovery.
201 Radiographic and Clinical Outcomes of Posterior Column Osteotomies in Spinal Deformity Correction: Analysis of 128 Patients
Ian G. Dorward, Lawrence Lenke, Geoffrey E. Stoker, Woojin Cho, Linda A. Koester, Brenda A. Sides

Introduction: Though posterior column osteotomies (PCOs Smith-Petersen or Ponté) are common, few studies have evaluated their radiographic and clinical outcomes. We present the largest reported series of patients with PCOs for spinal deformity correction.

Methods: 128 consecutive adult and pediatric patients underwent PSF with PCOs (75 primary surgeries and 53 revisions) with minimum 2-year follow-up. We excluded those with concomitant PSO, VCR, or anterior release/fusion at PCO levels.

Results: 128 patients aged 37.6 ± 21 years underwent 518 PCOs (mean 4.0 ± 2.2) with 14.4 ± 3 levels of instrumentation, with 3-year (range 2-6.8) mean follow-up. PCOs were used for kyphosis correction in 49%, scoliosis correction at the apex of a curve in 13%, and both in 38%. Kyphosis correction per PCO averaged 8.8° ± 7.2, varying with patient age (10.2° for <21 vs. 7.7° for ≥21, P < 0.0001) and spinal region: TL 11.6° > L 9.4° > MT 7.2° > PT 3.6°. Sagittal Cobb for PCO segments decreased from 30° ± 30 to 8.6° ± 22 (<0.0001). With PCOs at a curve apex, max coronal Cobb decreased from 66° ± 21 to 31° ± 14 (P < 0.0001). EBL averaged 1419 ± 887mL, correlating with greater age (P < 0.0001) and more instrumented levels (P < 0.0001), but not number of PCOs (P = 0.32).

Complications occurred in 31 (24.2%) patients, including 4 radiculopathies (none attributable to PCOs), 5 implant failures, and 4 pseudarthroses (1 at a PCO level). Complications did not correlate with number of PCOs (P = 0.5). 6 patients failed an intraoperative wake-up test or lost motor evoked potentials (MEPs) due to overcorrection with PCOs, but no postoperative deficits occurred. ODI scores improved pre vs. postop (34.4 ± 17 vs. 23.6 ± 18, P < 0.0001), as did normalized SRS-30 scores (63.7 ± 13 vs. 76.4 ± 15, P < 0.0001).

Conclusion: PCO is a safe and effective technique for posterior spinal deformity correction. The number of PCOs did not correlate with EBL or complications. The main technical concern with PCOs was overcorrection, but intraoperative MEPS and wakeup tests prevented neurologic deficits.

202 Factors Influencing Two-year Healthcare Costs in Patients Undergoing Revision Lumbar Fusion Procedures: A Guide to Where We Should Target Our Cost and Quality Improvement Initiatives
Scott L. Parker, David Shaw, Stephen Mendenhall, Matthew McGirt

Introduction: Failed back surgery syndrome (FBSS) is technically challenging to treat and can be associated with tremendous healthcare resource utilization and cost. There is minimal data regarding specific factors that significantly contribute to excessive cost of care. Therefore, we set out to identify independent risk factors predictive of increasing two-year healthcare costs after revision lumbar fusion procedures.

Methods: One hundred fifty patients undergoing revision neural decompression and instrumented fusion for adjacent segment disease (n = 50), pseudarthrosis (n = 47), or same-level recurrent stenosis (n = 53) were included in this study.

Patient demographics, comorbidities, preoperative health states, and peri-operative complications were collected and analyzed. Two-year back-related medical resource utilization and direct healthcare costs were assessed. The independent association of all variables to increasing cost was assessed using multivariate linear regression analysis.

Results: There was a wide range ($24,935-$63,769) in overall two-year costs for patients undergoing revision lumbar fusion (mean: $32,915 ± 8,344), Figure 1.

Pre-operative variables independently associated with two-year direct healthcare costs are shown in Table 1. There was a 1.1 to 1.2-fold increase in cost for patients in the greatest vs. lowest quartiles for these variables, Table 2. Surgical site infection (SSI), return to the operating room, and spine-related hospital re-admission during the 90-day global health period were independently associated with two-year cost, Table 1. Patients in the greatest vs. lowest quartiles had a 1.7 to 1.9-fold increase in cost for these variables, Table 2.

Conclusion: Costs of revision lumbar fusion can vary widely between patients. While co-morbidities and pre-operative severity of disease states contribute to cost of care, the primary drivers of excess cost include peri-operative complications such as surgical site infection, return to the OR, and re-admission during the global health period. Measures focused on health service improvement will be most successful in reducing the cost of care for patients undergoing revision lumbar fusion.

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neurological deficits in both adults and pediatric groups ($P = 0.02$ and 0.012 respectively). Though most of the new neurological deficits improved over follow-up, there was a 10% chance of a deficit being permanent.

**Conclusion:** Awareness of incidence of overall complications with influence of surgical procedure as shown in this study can help surgeons select the optimal approach for HGS.

**205 Functional Outcome Instruments Used for Cervical Spondylotic Myelopathy: Interscale Correlation and Prediction of Preference-based Quality of Life**

Dmitriy Petrov, Robert G. Whitmore, Zohar Ghogawala, J. Sanford Schwartz, Sherman C. Stein

**Introduction:** Cervical myelopathy is a debilitating disease, greatly impacting the quality of life of the patient. We aim to determine the correlation between different functional outcome measures used in cervical spondylotic myelopathy (CSM) patient assessment and their ability to predict preference-based quality of life.

**Methods:** CSM patients from seven centers undergoing either anterior or posterior surgery were prospectively followed with five different functional outcome measures over one year. Correlations among scales were tested using the Spearman’s rank correlation test. The sensitivity and specificity of each scale for predicting the global index of the EuroQol-5D (EQ-5D) was determined, and receiver operating characteristic (ROC) analysis was used to compare each scale’s ability to discriminate quality of life (QOL).

**Results:** 106 patients were initially enrolled, 103 were operated upon for cervical spondylotic myelopathy and followed for one year. Their ages ranged from 40 to 82 years (mean 61.9), and 61.3% were male. Correlations among the various functional outcome instruments were all highly significant ($P < 0.001$), but the degree of correlation varied greatly. Correlation between the EQ-5D scale and the Nurick Scale was the least (Spearman’s rho 0.5539), correlation was the highest with the Oswestry NDI (Spearman’s rho 0.8306). The Oswestry NDI also had the greatest ability to discriminate favorable from adverse QOL compared to the other outcome instruments ($P = 0.023$).

**Conclusion:** Preference-based quality of life instruments, such as the EQ-5D, are important measures for studying spinal disorders. Among the various commonly used outcome instruments for CSM, the Oswestry NDI is most predictive of preference-based QOL.

**206 The Fate of Type II Odontoid Fractures After Posterior Atlantoaxial Fusion: Where Does Healing Occur?**

Michael Muntert, Marcus D. Mazur, Andrew T. Dailey, Meic H. Schmidt, Erica Fay Bisson

**Introduction:** Odontoid fractures are the most common injury associated with the axis and account for up to 1/5 of all fractures in the cervical spine. Anderson and D’Alonzo Type II odontoid fractures, the least stable of the three proposed types, often require surgical intervention. Range-of-motion sparing treatments are a priority at this level because of its significant impact on rotational motion. The goal of this study was to understand the pattern of healing in patients who had posterior C1-2 fusion for Type II odontoid fracture.

**Methods:** We retrospectively identified patients who had undergone posterior screw fixation and fusion surgery at the atlantoaxial complex for a Type II odontoid fracture at the University of Utah between 1987 and 2011. Techniques for fusion included posterior bone graft with either a transarticular screw, a C1 lateral mass/C2 pars construct, or a combination of the two techniques. We collected data on fusion patterns in patients who had more than three months’ follow-up.

**Results:** Sixty-four patients were identified that had posterior cervical instrumentation and fusion for Type II odontoid fractures. Eleven of these patients had fusion evaluation by computed tomography scan more than three months postoperatively. Ten of eleven patients had fusion across the fracture site. Two patients showed fusion across the C1/2 joint and nine at the posterior graft site. All eleven patients had at least one site of fusion.

**Conclusion:** Fusion across the fracture site of a Type II odontoid fracture was achieved in 91% of patients after internal stabilization via a posterior approach. This would leave the possibility for theoretical preservation of rotational movement after instrumentation removal if no posterior bone graft is placed. However, a subset of patients does not heal and would best be treated with a combination fixation and posterior fusion.

**207 Complications with the Use of BMP-2 in Thoracolumbar and Lumbar Spine Fusions: A Nine-Year Institutional Analysis**

Daniel Lubelski, Kalil G. Abdullah, Michael P. Steinmetz, Matthew D. Alvin, Amy S. Nowacki, Srita Chakka, Edward C. Benzil, Thomas Mroz

**Introduction:** Bone Morphogenetic Protein (BMP) has been increasingly used in spinal fusions over the past decade. Early studies reported that the use of BMP is associated decreased operative time, blood loss, and pain scores, as well as improved fusion rates. Recent investigations have shown BMP to be associated with various complications occurring at incidences ranging from 0 to 100%.

**Methods:** Using the institutional electronic medical records, we retrospectively reviewed all patients between January 2002 and September 2010 that underwent thoracolumbar and lumbar spine fusion. Patient demographic, operative, and outcome/compliation information was collected.

**Results:** Five hundred forty-seven patient charts were reviewed with a mean follow-up time of 17 months. Mean age was 58 years and mean BMI was 29. Forty-one percent of patients had undergone previous spine surgery, 36% were taking antidepressants, 61% opioid analgesics, and 35% were current smokers. Eight percent had PLIF operations, 32% TLIF, 27% ALIF, and 29% PLF procedures. No clinically relevant differences in the patient characteristics and complications were identified between the various surgical approaches. Adverse outcomes included 6% urological complications, 9% wound infections, 10% pseudoarthrosis, 19% radiculitis, 15% reoperation, and 1% death. Having undergone a previous spine surgery was associated with increased incidence of radiculitis, reoperation, and pseudoarthrosis ($P = 0.005$, $P = 0.0008$, $P = 0.05$, respectively). Being a current smoker at the time of operation was associated with increased rate of radiculitis ($P = 0.03$).

**Conclusion:** The use of BMP is associated with high incidence of radiculitis, pseudoarthrosis, and reoperation. Complications do not differ by surgical approach, but are more likely in current smokers and those with history of spine surgery. Patients undergoing lumbar spine fusion with BMP have high incidence of antidepressant use, current smoking status, and previous spine surgery and as
such have relatively high complication rates. Familiarity with possible complications and improved surgical patient selection should be prerequisites to proceed with spine fusions with BMP.

208 Laminoplasty vs. Laminectomy: Prospective Study in Japan
Tatsushi Inoue, Shigehiko Kuno, Motoi Shoda, Yaichi Hirose
Introduction: In 2003, Ratliff reported that there is no evidence suggesting for laminoplasty to overcome laminectomy (J Neurosurg (Spine) 3 vol. 98). In response to his report, guideline committee for cervical spondylotic myelopathy by Japanese orthopedic association concluded that there had been no quality-certified evidence-based paper suggesting significant difference between laminoplasty and laminectomy because every study before was retrospective one. The objective of the present study is to compare cervical laminectomy with laminoplasty prospectively regarding neuroradiological findings.

Methods: Between 2007 and 2010, 57 cases of laminectomy (Group A, M:F = 15:42, mean age 68.7) and 26 cases of laminoplasty (Group B, M:F = 9:17, mean age 61.6) were done at our institution. The two methods for operation were assigned by the day when the patients visited our hospital without bias for selection. Outpatient clinic opened three times every week. One day was for ELAP, the other two days were for laminectomy when posterior decompression was indicated for cervical spondylotic/disc herniation, canal stenosis and OPLL. In laminoplasty, care was taken to preserve and reconstruct posterior element including spinous process and supra- and interspinous ligament. Radiological follow-up parameters (pre- and postoperative lordotic curve [C2-C7 angle, a] in flexion, neutral and extension positions) were collected prospectively in a database.

Results: Mean postop neutral a was 5.8° and 5.3° in group A and B respectively (P = 0.93). Mean postop flexion a was -16.0° and -0.1° (P = 0.11), mean a loss (preop neutral a postop neutral a) was 8.1° and -0.3° (P = 0.22), mean postop ROM was 36.4° and 19.9° (P = 0.057) in group A and B, respectively. Progressive kyphosis over -20° in postop neutral a was noted in 3 cases (5.2%) of group A.

Conclusion: There was no significant difference between laminoplasty and laminectomy in pre- and postop cervical alignment, though adequate reconstruction of cervical posterior element following posterior decompression may help to prevent progressive kyphosis.

209 The Distribution of Body Mass as a Significant Risk Factor for Lumbar Spinal Fusion Postoperative Infections
Ankit Mehta, Ranjith Babu, Isaac Karikari, Betsy H. Grunich, Vijay Agarwal, Timothy Ryan Owens, Allan H. Friedman, Carlos A. Bagley, Oren N. Gottfried
Introduction: Surgical site infection (SSI) after lumbar spine surgery remains a significant cause of morbidity. The literature demonstrates an increased risk of postoperative infections associated with obesity, diabetes, and multilevel surgeries. The purpose of this study was to determine the role in body habitus and weight distribution on developing a surgical site infection.

Methods: A retrospective review was performed on a consecutive cohort of 298 adult patients who underwent lumbar spine surgeries between 2006 and 2008 at the Duke University Medical Center. Previously identified risk factors (i.e., number of levels, diabetes, body mass index) were collected, as well as the horizontal distance from the lamina to the skin surface (measured at L4) and thickness of subcutaneous fat at the surgical site.

Results: Among the 298 patients, 24 (8%) had postoperative infections. Of the previously identified risk factors, number of levels (P = 0.0078) was found to be significantly associated with infections whereas body mass index (P = 0.16) and diabetes (P = 0.13) were found to not be statistically significant. Obesity (BMI > = 30) (P = 0.025), skin to lamina distance (P = 0.046) and thickness of the subcutaneous fat (P = 0.035) were found to be significant risk factors for SSI.

Conclusion: Our findings suggest that in obese patients, the distribution of body mass is more predictive of SSI than the absolute BMI and deserves attention in preoperative evaluation.

210 Fractures of the Ankylosed Spine: A Single Institution Experience
Brian D. Milligan, Terry K. Schieber, Colten D. Bracken, Jeffrey T. Jacob, William E. Krauss, Mark A. Pichelmann, Michelle J. Clarke
Introduction: Vertebreal fractures in the setting of spinal ankylosis may occur following relatively minor trauma and be associated with significant neurologic morbidity and/or mortality.

Methods: We retrospectively reviewed 72 fractures in 65 patients with either diffuse idiopathic skeletal hyperostosis (DISH, 30%) or ankylosing spondylitis (AS, 70%) who presented between 1994 and 2010. We recorded demographics, comorbidities, and fracture/treatment characteristics. Neurologic presentation and outcomes were categorized using ASIA grades and the modified Rankin Scale. We utilized univariate analysis to identify risk factors for neurologic deterioration or poor outcome (mRS 4-6).

Results: Most fractures (66%) occurred after falls of standing height or less and involved the cervical (40%), thoracic (40%), and/or lumbosacral (20%) regions. 3-column injuries were identified in 83%. Presentation and diagnosis were each delayed by about 1 week in 47% and 21% of patients, respectively. Most fractures were extension (57%) and/or distraction (71%) injuries. Median SLIC (subaxial cervical fractures) and TLIS (thoracolumbar fractures) scores were 5 (IQR 4.5-7) and 6 (IQR 6-8), respectively. Treatment included operative fusion (67%), percutaneous instrumentation (18%) or external orthosis (32%, of whom 55% required subsequent fusion). Neurologic deterioration to a complete spinal cord injury (ASIA-A) occurred in 5 patients (7%). The presence and severity of neurologic symptoms at presentation, but not age, obesity, polytrauma or fracture treatment choice was predictive of poor outcome at 1 year (or last follow-up, P < 0.001). Thirteen patients died within one year of injury (18%).

Conclusion: Spinal fractures in the setting of DISH or AS are frequent after low-energy trauma mechanisms and frequently result in unstable fractures that often fail nonoperative treatment. Neurologic deterioration during the initial hospitalization is not uncommon and mortality within 1 year of the initial injury is high. Treating physicians and patients should be aware that mortality and poor outcomes might be more common than in the general trauma population.
Cost per Quality-adjusted Life Year Gained of Revision Lumbar Surgery for Adjacent Segment Disease, Pseudoarthrosis, and Same-level Recurrent Stenosis: Defining the Value of Surgical Intervention
Scott L. Parker, David Shau, Stephen Mendenhall, Owoicho Adogwa, Joseph S. Cheng, Clinton J. Devin, Matthew McGirt

Introduction: Failed back surgery syndrome (FBSS) is distressing to patients and spinal surgeons. While there are several studies reporting mixed long-term outcomes of surgical management of FBSS, cost-effectiveness of surgery in this population remains unclear. We set out to assess the cost-effectiveness of revision surgery for adjacent segment disease (ASD), pseudoarthrosis, and same-level recurrent stenosis over a two-year follow-up period.

Methods: 150 patients undergoing revision neural decompression and instrumented fusion for ASD (n = 50), pseudoarthrosis (n = 47), or same-level recurrent stenosis (n = 53) were included. Two-year total back-related medical resource utilization, missed work, and health-state values [quality adjusted life years (QALYs)] were assessed. Two-year resource use was multiplied by unit costs based on Medicare national allowable payment amounts (direct cost), patient and caregiver work-day losses were multiplied by the self-reported gross-of-tax wage rate (indirect cost). Total two-year cost per QALY gained after revision surgery was assessed.

Results: Baseline characteristics provided in Table 1. Pre-operative EQ-5D for patients with ASD, pseudoarthrosis, and same-level recurrent stenosis was 0.30 ± 0.28, 0.37 ± 0.17, and 0.18 ± 0.22, respectively. Mean cumulative two-year health-state gain for these 3 cohorts following surgery was 0.76, 0.35, and 0.84 QALYs, respectively, Figure 1. Mean±SD total (direct+indirect) two-year cost of surgery following ASD, pseudoarthrosis, and same-level stenosis was $47,846 ± 32,712, $41,631 ± $9,691, and $49,431 ± 7,583, respectively. Cost-components specified in Table 2. Revision surgery for ASD, pseudoarthrosis, and same-level stenosis was associated with mean two-year cost per QALY gained of $62,955, $118,945, and $58,846.

Conclusion: Revision fusion for FBSS was associated with significant improvement in quality of life at two years. Surgical management of ASD and same-level recurrent stenosis were cost-effective at $62,955 and $58,846 per QALY gained, respectively. Surgery for pseudoarthrosis was poorly cost-effective at $118,945 per QALY gained. Our results suggest that revision neural decompression and fusion for FBSS is a valuable treatment option.

Preoperative Zung Depression Scale Predicts Patient Satisfaction Independent of Extent of Improvement After Revision Lumbar Surgery
Scott L. Parker, Owoicho Adogwa, David Shau, Stephen Mendenhall, Matthew McGirt

Introduction: Patient satisfaction ratings are increasingly used in healthcare as a proxy for quality and are becoming the focal point for several quality improvement initiatives. Affective disorders, such as depression, have been shown to influence patient reported outcomes and self-interpretation of health status. We hypothesize that patient psychiatric profiles influence reported satisfaction with care, independent of surgical effectiveness. We assessed the predictive value of pre-operative depression on patient satisfaction following revision surgery for same-level recurrent stenosis.

Methods: Fifty-three patients undergoing revision neural decompression and instrumented fusion for same-level recurrent stenosis-associated back and leg pain were included. Pre-operative Zung-self reported depression score (ZDS), education status, co-morbidities, and postoperative satisfaction with surgical care and outcome was assessed for all patients. Baseline and two-year VAS-LP, VAS-BP, Oswestry Disability Index (ODI), SF-12 PCS and MCS, as well as health-state utility [EuroQol (EQ-5D)] were assessed. Factors associated with patient satisfaction after surgery was assessed via multivariate logistic regression analysis.

Results: Baseline characteristics presented in Table 1. Two years after surgery, a significant improvement was reported in all outcome measures, Table 2. Independent of post-operative improvement in pain and disability (surgical effectiveness), increasing pre-operative Zung depression score was significantly associated with patient dissatisfaction two-years after revision lumbar surgery (OR=0.67 [CI: 0.38-0.87], P < 0.001), Table 3. Patients in bottom quartile (least depressed) vs. patients in top quartile (most depressed) of pre-operative Zung scores reported greater satisfaction with surgical outcome and overall care experience (94% vs. 6%). Patients with higher levels of education (college graduate or higher) also reported greater satisfaction levels (95% vs. 33%) following surgery, Figure 1.

Conclusion: Our study suggests that independent of surgical effectiveness, the extent of pre-operative depression influence reported patient satisfaction after revision lumbar surgery. Quality improvement initiatives using patient satisfaction as a proxy for quality should account for patients’ baseline depression as potential confounders.

Extent of Preoperative Depression Predicts Outcome After Revision Lumbar Surgery for Adjacent Segment Disease, Recurrent Stenosis, and Pseudoarthrosis
Scott L. Parker, David Shau, Stephen Mendenhall, Owoicho Adogwa, Clinton J. Devin, Matthew McGirt

Introduction: Revision surgery for failed back surgery syndrome is technically challenging and has been reported to yield unpredictable outcomes. Recently, affective disorders, such as depression and anxiety, have been considered potential predictors of surgical outcomes across many disease states of chronic pain. There remains a paucity of studies assessing the predictive value of baseline depression on outcomes in the setting of revision spine surgery. We assessed the predictive value of pre-operative depression on two-year post-operative outcome.

Methods: 150 patients undergoing revision neural decompression and instrumented fusion for adjacent segment disease (ASD, n = 50), pseudoarthrosis (n = 47), or same-level recurrent stenosis (n = 53) were included. Pre-operative Zung-self reported depression score (ZDS) was assessed for all patients. Pre-operative and two-year post-operative back and leg pain (VAS-LP, VAS-BP) and Oswestry Disability Index (ODI) were assessed. Association between pre-operative Zung depression score and two-year improvement in disability was assessed via multivariate regression analysis.

Results: Baseline characteristics presented in Table 1. All patient-reported outcomes assessed were significantly improved at two-years post-operatively for all 3
cohorts, Table 2. Independent of age, BMI, symptom duration, smoking, comorbidities, and level of pre-operative pain and disability, increasing pre-operative Zung depression score was significantly associated with less two-year improvement in disability (ODI) after revision surgery for ASD, pseudoarthrosis, and recurrent stenosis, Table 3. Patients in the top quartile (most depressed) vs. bottom quartile (least depressed) of pre-operative Zung scores experienced 4-fold less mean improvement in ODI two-years after surgery for ASD (P = 0.001), two-fold less mean improvement in ODI for pseudoarthrosis (P = 0.001), and 1.8-fold less mean improvement in ODI for same-level recurrent stenosis (P = 0.001), Figure 1.

Conclusion: Extent of pre-operative depression is an independent predictor of functional outcome after revision lumbar surgery for ASD, pseudoarthrosis, and recurrent stenosis. Future comparative effectiveness studies assessing outcomes after revision lumbar surgery should account for depression as a potential confounder. Zung depression questionnaire may help risk stratify patients presenting for revision lumbar surgery.

Spyridon Karadimas, Eun Su Moon, Kajana Satkunendrarajah, Michael G. Fehlings

Introduction: In order to validate potential neuroprotective and neuroregenerative strategies for cervical spondylotic myelopathy (CSM), we have developed a novel translationally relevant rat model of CSM.

Methods: Following posterior exposure of the cervical spine, the ligamentum flavum is opened at C5-6, C6-7 and progressive compression (over 10 weeks) was achieved by introducing a piece of aromatic polyether with absorbant properties under the C6 lamina in 10 Sprague-Dawley rats. Sham operation was performed on 8 animals (controls). The extent of compression was evaluated using MRI. Gait patterns were evaluated using the automated gait analysis system. Demyelination was assessed by H-E and Luxol Fast. The loss of interneuronal cells at the site of compression and at the lumbarosacral enlargement were measured by En1(+) and Chx10 (+) immunohistochemistry. Moreover, retrograde labelling of the long descending propriospinal tract was performed by injecting fluorogold bilaterally at the lumbarosacral enlargement (L2-L5). At 10 weeks, the animals were subjected to in vivo somatosensory and motor evoked potential recordings (SSEPs and MEPs). ANOVAs were used for the statistical analysis.

Results: MRI quantification at 10 weeks revealed 50.2% ± 4.8 compression ratio in the compression group. There was a statistically significant decrease in stride length, swing speed. Furthermore, statistically significant increases were observed in running time, stance phase, four-limb% support, number of steps and base of support. The normalized gray matter area at the compression epicentre was decreased compared to controls (5.15 ± 0.25 vs. 32.04 ± 0.17). Moreover, the normalized glial scar tissue area at the compression epicentre was 54.2 ± 1.33. The chronic compression led to decreases in both SSEP and MEP peak amplitudes and to a decrease in axonal conduction compared.

Conclusion: This model reproduces the neurobehavioural abnormalities, gait deficits and the neuropathological features of human CSM and hence has the potential to facilitate discovery of novel clinical translational therapeutic targets.

Michael W. Groff, Joshua E. Heller, Eric A. Potts, Praveen V. Mummaneni, Christopher I. Shaffrey, Justin S. Smith

Introduction: Methods used by surgeons for localization of spinal level have not been well studied or standardized. The authors surveyed the membership of the Joint Section of Spinal Disorders and Peripheral Nerve Diseases (Spine Section) to better understand current practices for intraoperative localization of lumbar spinal levels.

Methods: The Spine Section developed a survey on single-level lumbar spine decompression surgery, including questions regarding methods to localize the spinal level. Invitations to complete the web-based survey were sent to all Spine Section members. Respondents were assured of confidentiality.

Results: There were 569 responses from 1,045 requests (54%). Most surgeons either routinely (74%) or sometimes (11%) obtain preoperative x-ray imaging before incision. Approximately one half (56%) of those obtaining preoperative imaging for localization do so with a radiopaque marker inserted through the skin. Others use a radiopaque marker at the patient’s side (16%), overlaying the planned incision (14%), or depressed into the patient’s back without violating the skin (19%). The majority of surgeons indicated that post-incision imaging for localization is obtained either routinely prior to bone removal (73%) or most frequently prior to bone removal but occasionally after (16%). The most common technique for such imaging was to place a Penfield #4 or a similar instrument beneath the lamina (42%) (see figure). Others use a towel clamp or similar instrument attached to a spinal process (10%) or place a Penfield #4 or similar instrument in the midportion of the incision but not beneath the lamina (10%). The remaining surgeons use a combination of the above or use other methods.

Conclusion: Survey of the Spine Section membership demonstrates that there is substantial heterogeneity in approaches used to localize operative levels in the lumbar spine. Development of standardized approaches for level confirmation could facilitate a multi-institutional effort to further investigate optimal methods for level localization.

Justin S. Smith, Dwight Saulle, Christopher P. Ames, Lawrence Lenke, Steven D. Glassman, Paul A. Broadstone, David W. Polly, Jr., Christopher I. Shaffrey

Introduction: Despite the best of care, all surgical procedures have inherent risks of complications, including mortality. Defining these risks is important for patient counseling and quality improvement. The objectives of this study were to assess rates and causes of mortality associated with spine surgery based on a large prospectively collected, multicenter database.

Methods: The Scoliosis Research Society Morbidity and Mortality database was queried for spinal surgery cases
complicated by death from 2004-2007, including pediatric (<21 years) and adult (>21 years) patients. Deaths occurring within 60 days and complications within 60 days of surgery that resulted in death were assessed.

**Results:** 197 mortalities were reported among 108,419 cases (1.82 deaths/1,000 cases). Based on age (provided for 107,517 cases), rates of death/1,000 cases were: 1.99 for degenerative (n = 47,393), 1.82 for scoliosis (n = 26,421), 0.88 for spondylolisthesis (n = 11,421), 5.67 for fracture (n = 6,706), 4.44 for kyphosis (n = 3,600), and 3.29 for other (n = 12,455). The most common causes of mortality included: respiratory/pulmonary (n = 83, including respiratory failure [n = 23], presumed/confirmed pulmonary embolism [n = 20], and pneumonia [n = 9]), cardiac (n = 41, including myocardial infarction [n = 16] and cardiac arrest [n = 13]), sepsis (n = 35), stroke (n = 15), and intraoperative blood loss (n = 8) (Table). Death occurred prior to hospital discharge for 109 (79%) of 138 deaths for which this information was reported. The specific post-operative day (POD) of death relative to surgery was reported for 94 (48%) cases, and included POD#0 (n = 23), POD#1-3 (n = 17), POD#4-14 (n = 30), and POD#15+ (n = 24).

**Conclusion:** This study provides rates and causes of mortality associated with spine surgery for a broad range of diagnoses and includes assessments for adult and pediatric patients. These findings may prove valuable for patient counseling and efforts to improve the safety of patient care.

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What Are the Factors That May Predict Regain of Independent Walking After Surgery for Patients with Advanced Cervical Spondylotic Myelopathy?

Ahmed Mustafa Aleaqel, Amro Al Habib, Abdulrahman AlDakkan, Fahad Albodr

**Introduction:** Cervical spondylotic myelopathy (CSM) is a common spine disease that can be associated with devastating consequences, one of which is impairment of walking. Factors that may predict the ability of walking following surgery are not well defined. Studying potential predictors of independent walking in patients with advanced CSM was our goal. This information is important in counseling patients and their families and planning appropriate resources for rehabilitation.

**Methods:** Retrospective review of CSM patients with inability to walk independently (Nurick 4 and 5) who underwent surgery from 2003-2010. A neuroradiologist who was blinded to the clinical status reviewed all MRI studies. 38% of patients were contacted to update their follow-up status.

**Results:** Forty-eight patients were included (males 83%) with a mean follow-up of 24.7 months. Patients with a better preoperative neurological status had a significantly better chance of walking after surgery (83.33% for Nurick 4 vs. 33.33% for Nurick 5, P < 0.01). Independent walking after surgery was less likely in patients with longer signal change on T2WI MRI study (20.5 mm vs. 7.5 mm, P < 0.001) as well as when stratified to Nurick 4 (12.8 mm vs. 7.3 mm, P<0.05) and Nurick 5 (22.4 mm vs. 8.1 mm, P = 0.0001). Additionally, narrow spinal canal width was a predictor for independent walking (6.3 mm vs. 7.5 mm, P < 0.05) as well as for Nurick 4 alone (4.88 mm vs. 7.53 mm, P < 0.05). Other factors including age, sex, duration of difficulty walking, type of surgical approach and the presence of comorbidities did not predict independent walking regardless of preoperative neurological status.

**Conclusion:** In patients with advanced CSM, the better the baseline walking, the less the signal change on MRI, and the wider the spinal canal the better their ability to walk following surgery. Surgery should be recommended before patients progress into advanced stage where recovery is less and the need for resources is large.

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Intradiscal Injection of Simvastatin for Disc Regeneration in a Rat Model of Degenerative Disc Disease

Khoi Duc Than, Shuyan Rahman, Kwaku A. Kyere, Lin Wang, Tracey T. Than, Adam Khan, Yoon-Shin Park, Ki Park, Victor C. Yang, Frank La Marca, Paul Park, Huina Zhang, Chia-Ying Lin

**Introduction:** Degenerative disc disease (DDD) is a common etiology of back pain, and conservative management options are limited. Bone morphogenetic protein-2 (BMP-2) plays an important role in the physiology of the intervertebral disc (IVD), and the drug simvastatin is known to up-regulate the expression of BMP-2. We hypothesized that injection of simvastatin into degenerated rat IVDs reverses the process of disc degeneration.

**Methods:** Disc injury was induced in 224 rats by needle puncture. After 6 weeks, discs were treated with 2 microliters of: simvastatin (5 mg/ml) in a collagen-based hydrogel, simvastatin (15 mg/ml) in hydrogel or saline, saline only, or hydrogel only. Rats were sacrificed after 2, 4, 8, 12, and 24 weeks. Outcomes measures were radiologic, histologic, or genetic. Magnetic resonance imaging (MRI) was used to calculate the MRI index. Discs were graded histologically according to the appearance of the annulus fibrosus (AF), border between the AF and nucleus pulposus (NP), cellularity of the NP, and matrix of the NP. Real-time polymerase chain reaction was used to quantify gene expression of BMP-2, collagen types I and II, aggrecan, matrix metalloproteinases-3 and -13, and aggrecan.

**Results:** Radiographic data suggested that discs treated with simvastatin at 5 mg/ml in hydrogel maintained a normal MRI index at 2, 4, and 8-week time points, whereas other treatment groups did not. Histologic data revealed that this group also had the best microscopic appearance at 2 weeks, although this was neither statistically significant nor sustained. Genetic data is pending.

**Conclusion:** In a rat model of DDD, simvastatin injected intradiscially in a hydrogel carrier at 5 mg/ml resulted in a normal MRI appearance on MRI through 8 weeks. Further data is pending. Simvastatin may result in regeneration of injured IVDs via up-regulation of BMP-2, although further work is necessary to identify the ideal delivery vehicle and dose.

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Impact of Treatment Complications on Outcomes in Geriatric Patients with Type II Odontoid Fracture: Results from the AMERICAN MULTI-CENTER GOF Prospective Study

Michael G. Fehlings, Alexander R. Vaccaro, Branko Kopjar, Christopher I. Shaffrey, Jens Chapman, Paul M. Arnold, Ziva L. Gokaslan, Darrel S. Brodke, John France, Sangwook Yoon, Mark B. Dekutoski, Christopher Bono, Rick Sasso

**Introduction:** Purpose of this study was to assess the impact of treatment complications on outcomes in geriatric...
patients with type II odontoid fractures.

Methods: 159 subjects enrolled 65 years and older with a Type II odontoid fracture in a prospective multi-center cohort study at 13 sites in North America. Treatment complications were prospectively followed using a list of 19 anticipated complications associated with the treatment of odontoid fractures. Complications not on the list were also recorded. Reported events were adjudicated by a study Adverse Event Committee. The events were categorized as treatment complications and treatment-unrelated events.

Results: 64.2% of patients were treated operatively and 35.8% nonoperatively. 89 treatment-related complications reported among the 159 subjects. There was a tendency towards higher proportion of subjects with any complication in the nonoperative cohort compared to the operative cohort (36.8% and 29.4%, respectively, \( P = 0.1661 \)). Common complications were dysphagia (11 cases, 10.8% in the surgical group and 3 cases, 5.3% in the nonoperative group), pneumonia (4 cases, 3.9% in the operative and 2 cases, 3.5% in the nonoperative group), acute airway compromise (5 cases (4.9%) in the operative and 4 cases (7.0%) in the nonoperative group). Nonunions occurred in 12 subjects (21.1%) in the nonoperative arm compared with 5 cases in the operative arm (4.9%) (Fisher Exact Test \( P = .0026 \)). 3 cases of treatment-related deaths, 2 (1.96%) in the operative cohort and 1 case (1.75%) in the nonoperatively group. Analysis is currently underway to evaluate the impact of complications on SF-36 and Neck Disability Index and will be available at the time of the congress.

Conclusion: Treatment complications are common in geriatric patients with type II odontoid fractures. There is no evidence that operative treatment is associated with an increased risk of complications.

value of screening ultrasonography for earlier detection of DVT in spinal patients and the subsequent prevention of pulmonary complications remains unclear. This is especially true when evaluating DVT in asymptomatic patients undergoing spine surgery, who though non-plegic or paretic, but due to pain and/or deconditioning, have not been very mobile preoperatively. The goal of this study was to determine possible patterns, incidence and risk factors in acquiring DVT in asymptomatic hospitalized spine surgery patients who underwent, routine on admission, and weekly, ultrasound screening for DVT.

Methods: A retrospective review of 587 consecutive adult spinal patients who underwent admission and weekly ultrasound screening at a university hospital center, over 1 year, was conducted. All patients included received standard mechanical and chemical prophylaxis. We reviewed patient demographics and high risk groups.

Results: There was a 1.9% overall incidence of DVT in this population. Patients undergoing complex spinal surgery had a higher subgroup incidence with further pulmonary complications. Overall, 91% were diagnosed with a DVT within 7 days of hospital stay, 0% diagnosed within 8-14 days, and the rest were (9%) diagnosed after 14 days (\( p \)-value <0.05).

Conclusion: The effectiveness of routine ultrasonography screening for DVT may be most maximized if screening includes an initial admission and immediate post-op study in particularly high risk patients, followed by studies on only symptomatic patients.

The Impact of Different Surgical Strategies in Achieving Satisfactory Post-Operative Sagittal Alignment


Introduction: Adult spinal deformity (ASD) presents a wide range of deformity and clinical patterns. When non-operative care fails, surgical realignment using osteotomies is often pursued to achieve improved alignment and function. Reports have identified key radiographic spinopelvic parameters associated with outcomes, including Sagittal Vertical Axis (SVA, <50mm), Pelvic Tilt (PT, <20°) and Pelvic Incidence-Lumbar Lordosis (PI-LL, >10°). While objectives of correction have been previously described, different methods to reach them have not been reported. This study evaluated if different strategies for realignment can lead to satisfactory post-operative radiographic sagittal alignment.

Methods: A multicenter, retrospective radiographic analysis of 77 consecutively enrolled ASD patients, who underwent pedicle subtraction osteotomy (PSO) and fusion at three different sites. Baseline and post-operative coronal and lateral full-length radiographic data were obtained. Only patients that underwent a lumbar PSO with a postoperative SVA<50mm were included in this study. This population was analyzed for pre-operative differences, surgical parameters (degree and level of PSO resection, and numbers of levels fused) and changes in post-operative radiographic parameters.

Results: There were no significant differences in terms of pre-operative radiographic parameters, and in terms of primary and revision patients. For the surgical procedures, site 3 performed larger PSO resections, 31° vs. 20°, exhibited an increase in thoracic kyphosis (TK) and used shorter fusions than the other sites (UIV=T9 vs. T5). The patients from site 3 were also 10 years older. There was no difference in terms of LL change beyond the PSO resection.

Conclusion: Different surgical strategies can lead to a satisfactory SVA. One strategy employed a smaller PSO resection with conservation of TK and a higher UIV. Another strategy used a larger PSO resection and a shorter fusion, with a significant increase in TK. Long-term analysis will be performed to investigate the impact of different strategies on incidence of proximal TK.
**Introduction:** Sagittal spinal malalignment (SSM) is commonly defined by increased sagittal vertical axis (SVA), however, SVA alone may underestimate the severity of SSM. Spino-pelvic parameters provide a more complete assessment of SSM. Little data has correlated spino-pelvic parameters with disability. Purpose: evaluate correlations between sagittal spino-pelvic parameters and health related quality of life (HRQOL) scores.

**Methods:** Demographic, radiographic, and HRQOL data were obtained from patients consecutively enrolled into a multi-center, prospective study evaluating operative (OP) vs. nonoperative (NON) treatment for adult spinal deformity (ASD). Inclusion criteria: age >18 years and radiographic diagnosis of ASD (scoliosis >20°, or SVA >5cm, or pelvic tilt >25°, or thoracic kyphosis >60°). Radiographic evaluation: frontal and lateral spino-pelvic measurements. HRQOL questionnaires: Oswestry Disability Index (ODI), Scoliosis Research Society Questionnaire (SRS-22r). Radiographic parameters demonstrating highest correlation with HRQOL values were evaluated to determine a disability threshold of ODI=40.

**Results:** 492 consecutive ASD patients (mean age 51.9 years, SD 16.8) were enrolled. Patients treated OP (n = 178) were older (55 vs. 50.1 years, P < 0.05), had greater SVA (5.5 vs. 1.7cm, P < 0.05), greater pelvic tilt (PT, 22° vs. 11°, P < 0.05) and greater pelvic incidence/lumbar lordosis mismatch (PI-LL, 12.2 vs. 4.3, P < 0.05) than NON (n = 314). OP demonstrated greater disability on all HRQOL measures compared to NON (ODI =41.4 vs. 23.9, P < 0.05, SRS total = 2.9 vs. 3.5, P < 0.05). Pearson analysis demonstrated PT, SVA, and PI-LL correlated most strongly with disability for both OP and NON patients (P < 0.001). Linear regression models demonstrated threshold radiographic spino-pelvic parameters for ODI = 40 included: PT = 22° (r = 0.38), SVA = 46 mm (r = 0.47), PI-LL = 11 (r = 0.45).

**Conclusion:** SSM is a disabling condition. Prospective analysis of consecutively enrolled ASD patients demonstrated PT and PI-LL combined with SVA predict patient disability and provide a guide for patient assessment. Threshold values for severe disability included: PT = 22°, SVA = 46mm, and PI-LL = 11°.

**223 Correction of Sagittal Malalignment Following Pedicle Subtraction Osteotomy Improves Cervical Lordosis**


**Introduction:** Numerous methods exist that predict spinal alignment following pedicle subtraction osteotomy (PSO). Alignment within fused spinal segments is controllable by the surgeon, however, alignment changes in segments outside the fusion (reciprocal changes) are unpredictable and can negatively impact postoperative alignment. Reciprocal changes have been reported for the thoracic and lumbar spine. Cervical reciprocal changes have not been defined.

**Methods:** Adult spinal deformity (ASD) patients treated with PSO for sagittal spinal malalignment (SSM) were evaluated using a multicenter PSO database. Inclusion criteria: age >18 years, preoperative sagittal vertical axis (SVA) >50mm, cervical lordosis (CL, C2-C7 Cobb) >15°. Radiographic measures included regional and global spino-pelvic parameters. Regional measures of spinal inclination (cervical, thoracic, lumbar) were based on best-fit linear approximation of the vertebral body centroids.

**Results:** 29 patients treated with 29 PSOs (26 lumbar, 3 thoracic) met inclusion criteria. PSO levels ranged from T7-L5 (most common level = L3, n = 12). Mean correction at PSO site was 26.5°, mean SVA improved from 134mm to 50mm (P < 0.001). CL decreased (29.1° to 21.4°, P < 0.001) and thoracic inclination (TI) decreased (23.7° to 11.0°, P < 0.001) following PSO. Cervical inclination remained unchanged (preoperative = 13.3°, postoperative = 14.3°, P = 0.554). TI slope decreased following PSO (-36.9° to -31.8°, P = 0.006). Pearson correlation analysis demonstrated strong correlation between postoperative changes in SVA and TI (r = 0.82, P < 0.001) and moderate correlation between postoperative changes in TI and cervical lordosis (r = 0.39, P = 0.042). Postoperative change in CL did not correlate with change in SVA (r = 0.18, P = 0.342).

**Conclusion:** Cervical hyperlordosis is a compensatory mechanism utilized by patients with SSM to maintain horizontal gaze. SSM correction following PSO generates spontaneous decrease and relaxation of CL. Favorable reciprocal changes in cervical alignment following PSO correlated with change in TI. TI alignment changes following PSO correlated strongly with SVA.

**224 Pedicle Subtraction Osteotomy with Extension of Fusion to the Pelvis: Does Anterior Interbody Support at L5-S1 Improve Sagittal and Pelvic Parameters?**


**Introduction:** Lumbar pedicle subtraction osteotomy (LPSO) improves lumbar lordosis (LL), sagittal vertical axis (SVA), and spino-pelvic alignment (SPA). Reports have indicated that interbody fusion at the L5-S1 improves arthrodesis rates at the lumbosacral junction, however, the contribution of L5-S1 interbody procedure toward sagittal alignment correction when performing LPSO is unknown.

**Methods:** Multi-center, retrospective, radiographic analysis of adult spinal deformity (ASD) patients undergoing LPSO with fusion to the sacro-pelvis for sagittal spinal malalignment (SSM) using a prospective collected database. Inclusion criteria: age >18 years, pre and postoperative spine radiographs permitting spino-pelvic parameter measurement. Exclusion criteria: post-traumatic, infectious, neuromuscular or tumor associated spinal deformities. Patients evaluated according to type of interbody fusion performed at L5-S1 (anterior approach= ALIF, posterior approach= TPLIF, no interbody= NONE). ALIF patients divided into timing of the ALIF procedure: prior to (ALIFpre) or after (ALIFpost) the LPSO procedure. Radiographic analysis included coronal and sagittal spino-pelvic parameters and degree of focal PSO correction.

**Results:** 105 patients were treated with LPSO with fusion to the sacro-pelvis, of which 77 patients met inclusion criteria. Interbody procedures included: NONE, n = 32, T/P LIF, n = 15, ALIFpre, n = 19, ALIFpost, n = 11. Mean preoperative radiographic parameters, correction of and postoperative values for SVA, L5-S1
angle, lumbar lordosis and PSO angle were similar for all treatment groups (ANOVA<0.05). T/PILF had greater postoperative pelvic tilt (PT) than ALIFpost (29.4° vs. 17.1° and P = 0.014), however PT correction was similar for all groups.

**Conclusion:** Anterior interbody graft at L5-S1 has been reported to enhance fusion rates at the lumbosacral junction despite higher reported complication rates. There was, however, no added benefit of ALIF vs. TLIF with respect to sagittal SPA correction when performing LPSO and fusion to the sacro-pelvis. Further research is needed to evaluate long-term outcomes to determine the ideal interbody approach at L5-S1 when performing LPSO.

### 225 Spinal Epidural Abscess: Clinical Features and Surgical Outcomes

Amish Gaurav Amin, George Austin Crabill, Gustavo Pradilla, Amit Jain, Michael Lim, Daniele Rigamonti, Wesley Hsu

**Introduction:** We reviewed our institution’s experience with spinal epidural abscess (SEA) to assess the clinical presentation and surgical outcomes of SEA.

**Methods:** Medical records were reviewed for 42 patients who were admitted with a diagnosis of SEA and underwent surgical decompression at the Johns Hopkins Hospital between 1997 and 2009.

**Results:** The median patient age was 53 (range, 39-82). Thirty-three (79%) patients were male. The most prevalent comorbidities were: diabetes (18, 43%), IV drug use (15, 36%), and obesity (10, 24%). Eleven (26%) patients had previous spine surgery. Three (7%) patients were on dialysis. Only two (5%) patients had no identifiable risk factor or etiology. The most prevalent presenting symptoms were: back pain (40, 95%), motor deficit (30, 71%), fever (14, 33%), urinary/bowel incontinence (15, 36%), and sensory deficit (13, 31%). The SEA was located: 14 (33%) cervical, 17 (40%) thoracic, 15 (36%) lumbar, and 1 (2%) sacral. SEA was located anteriorly in 27 (64%) cases, posteriorly in 14 (33%) cases, and circumferential in 1 (2%) case.

**Conclusion:** Surgical evacuation and instrumentation for spinal epidural abscesses can result in symptomatic recovery with minimal recurrence or morbidity. Spontaneous epidural abscess requiring surgical intervention in patients without an identifiable risk factor or etiology was rare in this series.

### 226 Chondroitinase ABC Treatment and Modest Exposure to Intermittent Hypoxia Restores Hemidiaphragmatic Activity After Cervical Spinal Cord Injury

Warren J. Alilain, Jerry Silver, Megan Clark

**Introduction:** Most spinal cord injuries (SCI) occur at the cervical level. This is devastating because the phrenic motor neurons, which innervate the diaphragm, are located at this level. As a result, those afflicted with a cervical SCI usually have complications in breathing and can be dependent on a mechanical ventilator in order to survive. To study these complications and ways to restore respiratory motor activity, our laboratory utilizes the lateral C2 hemisection (C2H) model of SCI. C2H severs the bulbospinal inputs to the phrenic nucleus and paralyses the ipsilateral hemidiaphragm while sparing the crossed phrenic pathway, which serves as a potential anatomical substratum for respiratory plasticity. Following C2H, there is a dramatic up regulation of the chondroitin sulfate proteoglycan (CSPG) containing perineuronal net (PNN) around the ipsilateral phrenic motor neurons. CSPGs and the PNN severely inhibit plasticity and axonal regeneration, and thereby the means to restore function. Chondroitinase ABC (ChABC) can digest these inhibitory matrix molecules and we have shown that with enzyme administration alone, there is a modest return of hemidiaphragm activity after C2H. In other models of SCI, combining ChABC treatment with task-specific training can profoundly improve limb function. We hypothesized that combining ChABC treatment with a modest exposure to intermittent hypoxia (IH), which can strongly drive respiratory motor function after C2H, will further promote recovery.

**Methods:** Rats received a C2H along with ChABC or vehicle control. One week later, these animals were exposed to IH for one hour per day for five days. On the last day of exposure, diaphragm activity was assessed.

**Results:** We show that this combination treatment of ChABC and modest IH exposure can induce robust respiratory motor function after C2H. Animals that received IH with no ChABC displayed little to no recovery.

**Conclusion:** Taken together, these results show that ChABC treatment combined with an IH regimen that is far more tolerable to the animal can strongly augment recovery of respiratory motor function after SCI.

### 227 Incidental Durotomy After Spinal Surgery: A Prospective Study in an Academic Institution

Paul J. McMahon, Marine Dididze, Allan D. Levi

**Introduction:** Incidental durotomies (IDs) are an unfortunate but anticipated potential complication of spinal surgery. We prospectively surveyed the frequency of IDs of a single spine surgeon and analyzed major risk factors as well as the impact on long term patient outcomes.

**Methods:** We conducted a prospective review of elective spinal surgery over a 15-year period. Any surgery involving peripheral nerve only, intradural procedures or dural tears due to trauma were excluded. The incidence was categorized by surgery type including primary surgery, revision surgery, etc. Incidence was also examined in the context of years of physician experience and training. Furthermore, the incidence and type of sequelae were examined for those patients experiencing an ID.

**Results:** Out of 3,000 total elective spinal surgery cases, 3.5% (104) experienced an ID. The incidence of IDs (3.3%) during minimally invasive procedures was similar, but no patients experienced long term sequelae. The incidence during revision surgery was higher (6.5%). There was marked difference in incidence between cervical (1.3%) and thoracolumbar (5.1%) cases.
incidence was lower for cases involving instrumentation (2.4%). When physician training was examined, residents accounted for 49% of all IDs, while fellows accounted for 26% and the attending 25%. Of all the cases that involved an ID, 7.7% of patients went on to experience a neurologic deficit, and 6.8% experienced a failure of dural repair. The risk of failed dural repair increased 3x in the setting of revision surgery.

Conclusion: We established a baseline incidence for durotomy after spine surgery including procedure type, clarified contributing factors and examined the long-term effects on patient outcomes.

228 Cost-utility and Comparative Effectiveness Analyses of Transforaminal Lumbar Interbody Fusion (TLIF) vs. Comprehensive Medical Management for Lumbar Spondylolisthesis
Scott L. Parker, Scott Zuckerman, David Shau, Stephen Mendenhall, Joseph S. Cheng, Clinton J. Devin, Matthew McGirt

Introduction: The SPORT trial suggested that lumbar fusion was efficacious but NOT cost-effective for the treatment of lumbar spondylolisthesis. However, such randomized controlled trials inherently control and standardize medical resource utilization and cost. Furthermore, mid-trial crossover of medicine non-responders significantly inflates the utility of medical management, further biasing cost-utility analysis (CUA). We performed a comparative effectiveness and CUA of TLIF vs. medical management for lumbar spondylolisthesis utilizing a prospective single-center multidisciplinary spine center registry in a real-world practice setting.

Methods: Eighty patients with degenerative lumbar spondylolisthesis managed at a single institution’s Multidisciplinary Spine Center were entered into a prospective registry. Surgical management consisted of trans-foraminal lumbar interbody fusion (TLIF), while comprehensive medical management included spinal steroid injections, physical therapy, oral medications, and various other therapies. Two-year patient-reported outcomes (PRO), back-related medical resource utilization, and work-day losses were prospectively assessed via phone interview and used to calculate Medicare fee-based direct cost and indirect costs from occupation loss. Difference in mean total two-year cost per QALY gained was assessed as incremental cost-effectiveness ratio (ICER).

Results: Baseline characteristics of each cohort presented in Table 1. TLIF resulted in significant (P < 0.001) two-year improvement in all outcome measures, while comprehensive medical management failed to provide significant improvement, Figure 1. Two-year gain in QALY was significantly greater after TLIF (0.43 QALY gained) vs. medical management (0.06 QALY gained), Figure 2. Total two-year cost was significantly greater for TLIF ($36,836) vs. medical management ($8,762), Table 2. The cost per QALY gained for surgery vs. medical management (ICER) was $75,876, Figure 3.

Conclusion: In this prospective multidisciplinary registry, lumbar fusion vs. medical management was shown to be cost-effective and provide greater two-year improvement in pain, disability, and quality of life. The findings from this real-world practice setting may more accurately reflect the true value and effectiveness of surgical vs. medical care for degenerative spondylolisthesis.

229 Spinal Ependymomas: An Institutional Experience Over 25 Years in 134 Patients
Phiroz E. Tarapore, Peter Modera, Agne Noujokas, Christopher P. Ames, Dean Chou, Praveen V. Mummaneni, Philip R. Weinstein, Tarik Tihan

Introduction: Ependymomas of all grades comprise approximately 40% of primary intraspinal tumors. This study examines whether progression free survival (PFS) is influenced by histological grade or extent of resection, and analyzes usage and effectiveness of postoperative adjuvant radiotherapy.

Methods: We have performed a retrospective review of 352 consecutive intraspinal tumors treated at our institution between 1985 and 2010. All patients with sufficient pathology material and clinical information were included in the study, 134 patients with ependymomas were identified.

Results: There were 85 male and 49 female patients with ages from 10 to 79 (median 41) years at the time of surgery. Thirty were grade I, 101 were grade II, and 3 were grade III. Follow-up ranged from 3 months to 20 years. Kaplan Meier analysis of PFS demonstrated a mean of 6 years for grade I, 14.9 years for grade II, and 3.7 years for grade III (P < .001). The rate of gross total resection was 77% for grade I tumors, 68% for grade II tumors, and 33% for grade III tumors. In grade I ependymomas, mean PFS was 6.8 years with subtotal resection and 6.3 years with gross total resection (P < .74). In grade II ependymomas, mean PFS was 11.2 years with subtotal resection and 17.8 years with gross total resection (P < .01). Adjuvant radiotherapy was given in 29% of cases overall (79% of patients who had subtotal resection, and 14% of patients who underwent gross total resection (P < .001)). PFS of patients undergoing subtotal resection of grade I or II disease was not significantly changed by adjuvant radiotherapy (P < .36).

Conclusion: There appears to be a shorter PFS in grade I ependymoma than in grade II. Extent of resection does not appear to affect PFS in grade I ependymoma, but it does in grade II.

230 Does Single Dose Preemptive Amitriptyline or Gabapentin Reduce Remaining Leg Pain After Single Level Lumbar Discectomy? A Randomised Clinical Trial with Placebo Control
Payman Vahedi, Zahra Mohajernejadfard

Introduction: Remaining leg pain makes the outcome in lumbar discectomy unfavorable. Long time sciatica facilitates central sensitization, which is responsible for the maintenance of pain even after the optimal surgery. Pre-emptive drugs effective on neuropathic pain might interrupt this process via their possible synergy with opioids. The aim of present study was to assess the effect of amitriptyline and gabapentin to reduce postoperative pain scores and morphine consumption after single level lumbar laminectomy and discectomy.

Methods: Over one year, patients with a decision for single level lumbar laminectomy and discectomy were randomly assigned into three groups, each received similar capsules containing amitriptyline, gabapentin or matching placebo 2 hours before surgery. Same anesthetic protocol was performed. Only patients with postoperative leg pain remained in the study. Visual analogue scale and morphine consumption were compared at 6 hours intervals up to 24 hours. The results were analyzed by SPSS V.13 and Chi Square and Independent Ttest were used for the statistical analysis. The groups were revealed after the accomplishment of the
statistical analysis.

**Results:** Pain was significantly reduced in each group at each time intervals (P value < 0.001). In comparison to the placebo, the amitriptyline group had a significantly lower pain score by the end of 24 hours (P Value = 0.047), however the gabapentin group showed no statistically significant difference (P Value = 0.190). Morphine consumption was not different statistically between the groups (P Value = 0.132, 0.087 respectively).

**Conclusion:** The treatment of remaining leg pain should be considered prior to the surgery. While preemptive amitriptyline is effective to reduce remaining leg pain after lumbar discectomies, gabapentin works no better than placebo.

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**231 Health-Related Quality of Life Outcomes with Minimally Invasive Transformaminal Lumbar Interbody Fusion Based on Long-Term Analysis of 318 Consecutive Patients**

Mick J. Perez-Cruet, Namath Syed Hussain, Evan Begun, Joseph John Joshua

**Introduction:** Long-term prospective outcomes in patients undergoing minimally-invasive spinal fusion for debilitating back pain has not been well-studied.

**Methods:** 318 patients (mean age 63 years, range 19-94) who underwent MITLIF were followed for 7 years. Patients presented with spondylolisthesis (n = 236, 74%), and degenerative disc disease (n = 82, 26%). Health care quality of life measures studied were Visual Analog Scale (VAS), Oswestry Disability Index (ODI), and Short Form-36 (SF36). Other outcomes analyzed included pre-operative co-morbidities, age, bone quality, and complications.

**Results:** 196 females and 122 males were treated. Levels fused included L1-2 (n = 3, 1%), L2-3 (n = 19, 6%), L3-4 (n = 34, 11%), L4-5 (n = 163, 51%), L5-S1 (n = 89, 28%), or multi-level instrumentation (n = 10, 3%). Estimated blood loss and hospital stay were 128.4 mL and 4.37 days. VAS scores decreased significantly starting at 6 weeks post-op. ODI scores declined from 44.1 preoperatively to 28.1 (P < .05) at one year, and 30.4 (P < .05) at 2-7 year period. SF36 physical component scores (PCS) increased from 30.3 preoperatively to 39.6 (P < .05) at one year, and 38.7 (P < .05) at 2-7 year period. SF36 mental component scores (MCS) increased from 43.7 preoperatively to 48.5 (P < .05) at one year, and 49.1 (P < .05) at 2-7 year period. Re-operation rate for adjacent level disease was less than 2% over the 7 year period.

**Conclusion:** This study presents a large long-term prospective outcomes analysis of MITLIF revealing statistically significant outcome improvements out to seven years. MITLIF resulted in a high rate of spinal fusion and very low rate of adjacent segment disease requiring re-operation. These results highlight the importance of focused surgery and attention to proper indications when selecting patients.

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**232 Modulation of Spinal Cord Reflex Circuitry by Spinal DC Stimulation in Humans**

Maxwell Boakye, Robert Thomas Arrigo, Chris Ho, Jean-Charles Lamy

**Introduction:** Transcranial direct current stimulation (tDCS) of the human motor cortex induces changes in excitability within cortical and spinal circuits which occur during and after the stimulation. Recently, transcutaneous spinal direct current stimulation (tsDCS) has been shown to modulate spinal conduction properties, as assessed by somatosensory-evoked potentials, and trans-synaptic properties of the spinal neurons. The goal of this project is to examine the ability of spinal direct current stimulation to induce plasticity of spinal H-reflexes.

**Methods:** To further explore tsDCS-induced plastic changes in spinal excitability, we examined, in a double-blind crossover randomized study, the stimulus-response curves of the Soleus H reflex before, during, at current offset and 15 minutes after anodal, cathodal and sham tsDCS delivered at Th11 level (2.5mA, 15min, 0.071mA/cm2, 0.064C/cm2) in 17 healthy subjects.

**Results:** Anodal tsDCS induced a progressive leftward shift of the recruitment curve of the soleus H reflex during the stimulation, the effects persisted for at least 15 minutes after current offset. In contrast, both cathodal and sham tsDCS had no significant effects. Our results confirm that tsDCS can be a useful, non-invasive tool to induce long-lasting plastic changes in spinal circuitry.

**Conclusion:** Increased spinal excitability after anodal tsDCS may have potential for spinal neuromodulation in patients with central nervous system pain or injury.
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Minimally-invasive vs. Open Thoracolumbar Fusion: A Hospital-based Microcosting Analysis
Daniel R. Kramer, Robert G. Whitmore, James Harris Stephen, Robert Stetson, Angus McWilliams, Sherman C. Stein, Sean Doerfler

Introduction: To compare upfront, downstream, and total costs of minimally-invasive thoracolumbar spinal fusion (MIS) compared to open spine techniques (OS) from a hospital-based perspective.

Methods: Patients underwent either OS or MIS thoracolumbar fusion for degenerative spinal pathology at our institution. Actual costs for each component of the index hospitalization (upfront) and for 9 months postoperatively (downstream) were collected from the health system financial databases by cost center. A multivariable regression was performed with cost as the dependent variable and the following as independent variables: number of levels operated on, OR time, length of stay (LOS), estimated blood loss (EBL), age, gender, and ethnicity.

Results: 79 patients were included in the analysis: 66 for OS and 13 for MIS. MIS patients had a significantly shorter LOS (4.7 days, ± SD 3.6 days vs. 7.3 days, ± SD 5.1 days, P = 0.035) and less intraoperative EBL (381.7 ml, ± SD 290.8 mL vs. 722.3 ml, ± SD 844.8 ml, P = 0.012) compared to OS patients. MIS procedures were associated with significantly less upfront costs than OS procedures ($32,119.86, ± SD $11,802.25 vs. $43,047.98, ± SD $20504.35, P = 0.966) and P = 0.240 respectively. Regression analysis showed that MIS upfront costs, when corrected for all independent variables, were still significantly less than OS surgery (P = 0.05).

Conclusion: Upfront total costs for MIS are significantly less than those for OS thoracolumbar fusion, despite the greater actual cost of surgical implants. The largest driver of cost savings for MIS procedures is a shortened LOS. However, the 9-month downstream and total costs were not significantly different between the two types of surgery.

235 Standardized Reporting of Perioperative Complications Following Cervical Corpectomy
Maxwell Boakye, Robert Thomas Arrigo, Ivan Cheng, Stefan A. Mindea, Eugene Caragase, John Park, Todd Alanin

Introduction: Corpectomy with fusion is routinely used to decompress and stabilize the degenerative cervical spine but carries with it significant perioperative complication risk. Non-standardized complications reporting in the literature has made comparison of cervical corpectomy with alternative procedures difficult. This study is the first to present the 30-day complication rate following cervical corpectomy for degenerative spine disorders using standardized complications reporting systems.

Methods: Chart review was performed on sixty-two patients receiving corpectomy for degenerative cervical spine disease at Stanford Hospital between 2003 and 2010. Two competing complications severity grading systems (Clavien-Dindo, Table 1, Accordion2, Table 2) were applied.

Results: The mean (SD) age at surgery was 61 (±13) years. Within 30 days of surgery, 18 patients (29.0%) developed one or more complications regardless of the grading system used. Both assigned nine patients (14.5%) the lowest possible grade, and three out of four patients the second lowest grade, with the fourth patient having been treated in an ICU (Clavien-Dindo Grade IV) for pneumonia (Accordion Grade 2. Moderate Complication). A single death (1.6%) was treated similarly in both systems. The remaining four patients with more severe complications were sorted differently (Tables 3 and 4). Finally, three patients (4.8%) had a permanent disability (two cases of dysphagia, one chronic pain) following surgery.

Conclusion: The literature on anterior cervical corpectomy cites a significant morbidity burden but comparing results across studies or against competing procedures is complicated by a lack of reliability, bias, and missing severity data. Routine use of a standardized complication severity grading system will improve surgical outcomes reporting which in-turn supports evidence-based medicine, facilitates comparisons within and between studies, and may improve surgical decision making and informed consent. While both standardized systems have their advantages, the Accordion system has a built-in intuitive set of quantitative descriptions of categories as well as a better means of handling disability, an important outcome following spine surgery.

236 Prediction of Reciprocal Changes in Cervical Spine Lordosis After Corrective Thoracolumbar Deformity Surgery
Yoon Ha, Vedat Deviren, Christopher P. Ames

Introduction: To document changes in values for parameters of cervical sagittal spine balance in before and after deformity surgery and find the preoperative parameters affecting the postoperative cervical spine alignment.

Methods: The study included 49 adult patients treated for thoracolumbar spinal deformity. Full-length standing films were available for all subjects. Position of C7 plumb line relative to sacrum was assessed as C7 sagittal vertical axis (SVA). This study was divided into two parts. First, to identify the reciprocal changes postoperatively, we compare cervical spine parameters in two distinct groups. Low C7 SVA (n = 21) group includes patient’s C7 SVA below 6Cm and high C7 SVA group (n = 21) is defined C7 SVA over 9Cm. Comparisons on the basis of C7 SVA were performed using student t-test. Second, to predict postoperative cervical lordosis, we studied correlation between postoperative cervical lordosis with preoperative spine and pelvic parameters. Multilinear models with a stepwise condition were used to assess the relationship between postoperative cervical lordosis and preoperative parameters including sagittal spinal parameters and surgical plans (C7 SVA to 0 Cm, PT to 25 degrees).

Results: In high C7 SVA group, compare to low C7 SVA group, demonstrated higher preoperative cervical lordosis angles (T1, C0-2, C1-2 angles). In low C7 SVA group, mean preoperative C0-C1, C1-C2 and C2-C7 angles were significantly increased after thoracic/lumbar deformity correction. On the other hand, high C7 SVA group decreased T1 and C2-7 angles postoperatively. Multiple linear regression analysis led to formula for the relationship between postoperative cervical lordosis and preoperative parameters (R = 0.808, adjust R2 = 0.619, parameters using preop pelvic tilt plan, preop C7 SVA plan, preop C2-7 angle and preopT1 angle).
Conclusion: This study provides the evidence that cervical lordosis has reciprocal changes accommodating the shifting of global spine balance. Preoperative parameters in global spine balance and surgical plans could predict postoperative cervical spine sagittal alignment.

237 Characterization of a Novel Metastatic Human Breast Adenocarcinoma Rat Model Using Intracardiac Injection and Bioluminescence

Introduction: Previous animal models of metastatic spine disease rely on placement of tumor directly into the spine followed by functional and histological assessment. In order to more accurately reflect human pathophysiology, we developed a rat model of human breast adenocarcinoma that reliably metastasizes to the spine following intracardiac injection of tumor cells. In addition, by tagging the cells with Luciferase and GFP, tumor growth can be imaged non-invasively.

Methods: Six four-week-old female athymic nude rats were injected with 100,000 HTB-26 cells (ATCC) into the left ventricle. Bioluminescence imaging was performed at day 3, 11 and 34. Group 1 was submitted for CT imaging. Group 2 was sacrificed and the spine dissected for histology. Group 3 had spine tumor cells dissociated for cell culture. Fluorescence microscopy was performed to analyze GFP signal.

Results: Bioluminescence/CT Imaging. By day 34, the rats demonstrated bioluminescence signals in the spine (Figure 1). Small animal CT imaging confirmed the presence of an osteolytic lesion (Figure 2). Clinical signs of neurologic compromise. On day 38, all bioluminescence positive rats demonstrated paresis. Dissection revealed osteolytic bone lesions as shown on CT (Figure 3 a,b). Cell culture. Osteolytic tumor was removed from the vertebral body and posterior elements and plated for culture. On day 3, cells exhibited GFP signaling, confirming their identity as HTB-26 cells (Figure 4).

Conclusion: We have created a reliable animal model of metastasis of a human breast cancer line to the spine with subsequent characterization of the lesion via bioluminescence, CT imaging and histology. We were able to recover the original cells from a metastatic spine lesion, as evidenced by GFP expression in our metastatic lesion. This novel model more accurately represents the human condition, and thus experimental therapies may transfer more readily to the patient with metastatic spine disease.

238 Cervical Spine Clearance in the Traumatically Injured Patient: Is CT Scan Sufficient Alone
Brandon G. Chew, Matthew R. Quigley, Christopher Swartz

Introduction: Clearance of the cervical spine in the trauma patient remains a contentious issue. Although some have advocated for the use of CT scanning alone, this has been criticized, among other things, for the absence of a gold-standard comparator-namely MRI.

Methods: A retrospective review of a prospectively collected trauma database for all patients admitted January 2004 – January 2011 to a level one trauma center who had a cervical CT interpreted by a board certified radiologist, as being without evidence of acute traumatic injury and a cervical MR obtained during the same hospital admission.

Results: There were 1004 patients reviewed, of which 614 were male, average age overall of 47 years. Thirty-nine patients ultimately underwent (29 anterior/10 posterior) cervical surgical procedures (5 delayed), for central cord syndrome (21), quadraparesis (9) or discogenic radicular pain (9). None had an unstable cervical spine. The MR was interpreted as normal in 645, evidencing ligamentous injury alone in 125 and showing non-specific degenerative changes in the rest. Of the 125 ligamentous injuries, 59 had documentation of clearance (22 clinical, 37 with F/E X-rays), 5 died prior to clearance and one was transferred to another facility prior to clearance. No patient with ligamentous injury on MR was documented to require any surgical procedure nor orthosis.

Conclusion: In this large population of traumatically injured patients with normal cervical CT scans, MR was useful solely to guide surgical procedures already determined by clinical presentation. The appearance of ligamentous injury alone on MR was a common occurrence (12.5%) but never predicted occult cervical instability.

239 The Use of Allograft and Recombinant Human Bone Morphogenetic Protein for Instrumented Atlanto-axial Fusions
Brian James Hood, D. Kojo Hamilton, Justin S. Smith, Marine Dididze, Christopher I. Shaffrey, Allan D. Levi

Introduction: Fusing the atlantoaxial complex has long been a challenge to surgeons. Iliac crest is the historical gold standard for bone grafting but is associated with significant patient morbidity. Hillard et al. reported a fusion rate of 88.9% using iliac crest allograft vs. 96.7% using autologous iliac crest bone for C1-2 fusion.

Methods: We reviewed our experience using allograft bone, rhBMP2 and rigid screw fixation of C1-2. A retrospective chart and film review of a senior surgeon was performed at the University of Miami (24 patients) and University of Virginia, Charlottesville (28 patients) between 2004 and 2011 and examined for fusion rates and complications. In 28 patients, corticocancellous allograft pieces were laid along decorticated bone after a C2 neurectomy. In 24 patients uncortical iliac crest allograft was precision cut to fit between the C1 lamina and C2 spinous process. The mean amount of rhBMP used for all cases was 4.5 mg (2.2 mg-12 mg).

Results: There were 25 female and 27 male patients ranging in age from 6 to 92 years with a mean age of 65.8 years. Operative indications include trauma (56%), degenerative (23%), rheumatoid arthritis (15%), congenital (4%), and synovial cyst (2%). The mean follow-up was 22.5 months (range 1-55 months). 52 fusions were performed. 46 patients achieved a minimum 3 month follow-up. 100% achieved fusion: 41/46 Lenke A, 5/46 Lenke B. Patients not reaching 3 months all appeared to be progressing to fusion. Complications including sustained tachycardia, pneumonia, DVT, shock/respiratory failure, and bilateral hand numbness occurred in 5 patients (9.6%) and were unrelated to the use of rhBMP2.

Conclusion: The use of small amounts of rhBMP2 added to allograft in addition to rigid screw fixation is safe and highly effective means of promoting a solid fusion of the atlantoaxial complex and spares the patient the morbidity of iliac crest harvest.
Minimally Invasive Treatment of Adult Scoliosis with XLIF: Radiographic Outcomes and Predictors from a Prospective Multicenter Study

Antoine Toehme, Frank Phillips, W.B. Rodgers

Introduction: This report summarizes the early radiographic outcomes of XLIF for the treatment of adult scoliosis.

Methods: 107 patients were treated for adult scoliosis with XLIF. Radiographs and clinical outcomes were collected preoperatively and at 0.5, 3, 6, 12, and 24 months. This report details results up to 3 months as the study progresses. Radiographic measures include lumbar lordosis (L1-S1), Cobb, device subsidence/migration, anterior/posterior disc height, listhesis, and coronal/sagittal balance. To minimize radiographic magnification all linear measures were collected as a ratio of a reference endplate or vertebral body height, and reported as a percentage change.

Results: Measures were collected from 93 patients (74.2% female, 11.1% smokers) 48-87 years old treated at 280 levels from T11-L5. Up to 6 levels were treated. Supplemental fixation included: bilateral pedicle screws (59.3%), unilateral pedicle screws (23.3%), and anterolateral plating (4.4%). 16.1% of levels were stand-alone. Radiographic measures are reported in Table 1. At baseline, 42 patients were hypolordotic (>40°) with an average lumbar lordosis of -24.74° (range: 0 to -40°). Hypolordosis in these patients was corrected to an average of -38.2° at post-op (P < 0.001). Cobb angle was corrected by 40% from baseline to post-op (P < 0.001). Spondylo-retrolisthesis was reduced from an average baseline magnitude of 7.3% to a post-op magnitude of 6.0% (P = 0.002). All corrections were maintained at 3 months (P > 0.05). Coronal Cobb correction was affected by supplemental fixation (P = 0.002), with the greatest corrections achieved in patients with bilateral pedicle fixation and the least achieved in patients with no supplemental fixation (11.7° vs. <1°). Subsidence was 26.2% at 3 months with the highest rate of subsidence in segments with no supplemental fixation (55.6%). No segments required revision for subsidence. There were no reports of migration.

Conclusion: XLIF in the treatment of adult scoliosis, reduces coronal and sagittal plane deformity. Supplemental fixation optimized deformity correction and reduced subsidence.
equivalent surgical procedures between surgeons. This is largely explained with the indiscriminate use of biologics and bone graft substitutes. In our current health care economic environment, procedural costs should be scrutinized. Our analysis underscores the need for protocol development for the use of biologics and bone graft substitutes.

244 Anterior vs. Posterior Interbody Fusion: A Comparison of Outcomes
Mark Mahan, Samuel Kalb, Juan Christian Ribas Nijkerk, Laura Ann Snyder, Udaya K. Kakarla, Nicholas Theodore

Introduction: Choosing the most appropriate approach for lumbar fusion depends on individual symptoms and anatomy. Multiple studies have demonstrated good results with both ALIF and PLIF procedures independently. This study compares outcome between patients who received ALIF and PLIF.

Methods: 775 patients who underwent lumbar fusion using either ALIF or PLIF techniques were reviewed. 37 cases were lost to follow up. 500 patients received PLIF and 238 received ALIF. Patient surgical outcomes were evaluated based on complications, symptomatic improvement, hospitalized days and Prolo outcome scores.

Results: The average length of follow-up for PLIF patients was similar to that of ALIF patients: 11.8 months and 11.5 months, respectively. ALIF patients had a 12.1% (29/238) rate of cumulative complications. The average economical, functional and total Prolo scores for this group were 4.26, 3.66, and 7.92. PLIF patients had a 5% (25/500) rate of cumulative complications. The average economical, functional and total Prolo scores for PLIF were 4.07, 4.04, and 8.11. Patients with L3 to L5 disc disease were more likely to undergo PLIF (P = <0.001). Post-operative complications was significantly higher in ALIF group (P = <0.001). Hospital stay was longer in the PLIF group compared to ALIF (P = 0.005). PLIF patients showed better symptomatic improvement at 3 months follow-up (P = <0.001) and Prolo functional score (P = <0.001). No statistical difference was seen in Prolo total score between ALIF and PLIF patients. PLIF showed superior overall outcomes only at L3-L4 level when compared to ALIF (P = 0.008).

Conclusion: ALIF and PLIF have shown to be safe treatment procedures with low complications rates. PLIF appears to have better short term symptomatic outcome and fewer complications compared to anterior approach. Overall outcomes were similar between them. It seems that PLIF is more suitable in L3 to L5 cases, possibly secondary to increased difficulty in performing anterior surgery in superior levels.

245 Utility of Clavien-Dindo and Accordion Classification Systems for Postoperative Complications Following Spinal Metastasis Surgery
Maxwell Boulkya, Pela Tran, Robert Thomas Arrigo, Ivan Cheng, Stefan A. Mindea, Eugene Carragee, John Park, Todd Alamin

Introduction: Surgical intervention for spinal metastases is an extensive procedure with extended recovery times and high rate of morbidity. Yet, a consistent method of classification and quantification of complications does not exist. In this study, we analyzed the applicability of the Clavien-Dindo and Contracted Accordion classification system on a cohort of 200 patients operated on for spinal metastases at Stanford Hospital between 1999 and 2009.

Methods: Stanford’s STRIDE database was used to perform a retrospective chart analysis on 200 patients who had been operated on for spinal metastases between 1999 and 2009 at Stanford. 30-day complications were graded by level of intervention required, per the Clavien-Dindo and Accordion classification system, 74 patients (37.0% ) experienced minor complications and 28 patients (14.0%) had major complication. Under the Accordion System, minor complications were reported in 58 patients (29.0%), and major complications in 28 patients (14.0%). Of the major complications, 8 (4.0%) led to death. Correlation between complication grade under the Accordion system and length of stay was 0.24, vs. 0.22 for the Clavien-Dindo system.

Conclusion: Analysis of 30-day spinal metastasis surgery complications classified via the Accordion and Clavien-Dindo systems provided increased resolution for complication reporting, and could be broken down to analyze complication severity distribution between several patient subpopulations. Excluding blood transfusions, the overall complication rate was 37.0%, in line with reported complication rates of 15-39%. Classification under the Accordion System was more closely correlated to length of stay than under Clavien-Dindo. Additionally, overall complication rate reported by the Accordion system more closely followed those previously reported in literature. The use of the Clavien-Dindo or Accordion system for classification of complications is easily applicable to surgery for spinal metastases and enables more precise reporting and analysis of complications.

246 Cost-utility and Comparative Effectiveness Analyses of Laminctomy vs. Comprehensive Medical Management for Lumbar Stenosis
Scott L. Parker, Scott Zuckerman, David Shau, Stephen Mendenhall, Joseph S. Cheng, Clinton J. Devin, Matthew McGirt

Introduction: The SPORT trial suggested that lumbar laminectomy was efficacious but only moderately cost-effective for the treatment of lumbar stenosis. However, such randomized controlled trials inherently control and standardize medical resource utilization and cost. Furthermore, mid-trial crossover of medicine non-responders significantly inflates the utility of medical management, further biasing cost-utility analysis (CUA). We performed a comparative effectiveness and CUA of laminectomy vs. medical management for lumbar stenosis utilizing a prospective single-center multidisciplinary spine center registry in a real-world practice setting.

Methods: Ninety-four patients with lumbar spinal stenosis managed at a single institution’s Multidisciplinary Spine Center were entered into a prospective registry. Surgical management consisted of laminectomy, while comprehensive medical management included spinal steroid injections, physical therapy, oral medications, and various other therapies. Two-year patient-reported outcomes (PRO), back-related medical resource utilization, and work-day losses were prospectively assessed via phone interview and used to calculate Medicare fee-based direct cost and indirect costs from occupation loss. Difference in mean
total cost per QALY gained was assessed as incremental cost-effectiveness ratio (ICER).

**Results:** Baseline characteristics of each cohort are presented in Table 1. Laminectomy resulted in significant \( P < 0.01 \) two-year improvement in all outcome measures, while comprehensive medical management failed to provide significant effectiveness, Figure 1. Two-year gain in QALY was significantly greater after laminectomy (0.36 QALY gained) vs. medical management (0.10 QALY gained), Figure 2. Total two-year cost was significantly greater for laminectomy ($24,264) vs. medical management ($9,550), Table 2. The cost per QALY gained for surgery vs. medical management (ICER) was $56,592, Figure 3.

**Conclusion:** In this prospective multidisciplinary registry, lumbar laminectomy vs. medical management was shown to be cost-effective and provide greater two-year improvement in pain, disability, and quality of life. The findings from this real-world practice setting may more accurately reflect the true value and effectiveness of surgical vs. medical care for lumbar stenosis.

**247 Long-term Outcome of Minimally Invasive Transforaminal Lumbar Interbody Fusion: 5 Years Post-op and Beyond**

*Hamid M. Shah, Kevin T. Foley*

**Introduction:** Several reports have described the efficacy of minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF), but none have documented the long-term outcomes of patients undergoing this procedure. The purpose of this study was to quantify patient-derived outcomes for MIS-TLIF patients who were 5 years or more postoperative.

**Methods:** A chart review was performed after obtaining IRB approval. All patients who had undergone a single-level MIS-TLIF 5 or more years prior for lumbar spondylolisthesis or spondylosis and for whom preoperative Oswestry Disability Index (ODI) and visual analog pain scale (VAS) data had been collected were included. These patients were contacted by phone and mail. After informed consent, they filled out ODI and VAS forms and returned them to the investigators. The current outcome data were compared to the preoperatively derived measures.

**Results:** 55 patients had undergone MIS-TLIF within the specified time frame [mean 72.6 months (60-90)] and had preoperative baseline ODI and VAS scores. Of these, 39 (19 male/20 female) patients were successfully contacted and returned current ODI and VAS scores. The mean cohort age was 63 years (37-80). The mean baseline ODI was 53 (30-100) and mean baseline VAS back and VAS leg were 50 (0-99) and 56 (0-98), respectively. The mean scores at the time of inquiry for ODI, VAS back, and VAS leg were 17(0-60), 12 (0-62), and 16 (0-77), respectively, represent a decrease of 36, 38, and 40 points from baseline.

**Conclusion:** Multiple reports have documented patient-derived outcome data following MIS-TLIF, none have done so for patients 5 or more years beyond their index procedure. The significant improvements in disability, back pain, and leg pain seen in the present study imply that MIS-TLIF is capable of producing sustained relief of symptoms and improvement in patient function. This has positive implications for the cost-effectiveness of this procedure.

**248 The Effect of RhBMP-2 Dosing on the Complication and Fusion Rate in Posterior Interbody Fusion Using Polyetheretherketone (PEEK) Cages**

*Eric W. Nottmeier, Douglas S. Fenton, Cammi Bowman, Zane Thompson, Matthew Hale*

**Introduction:** Excellent fusion rates, as well as complications, have been reported with the off-label use of rhBMP-2 in posterior lumbar interbody fusion procedures. The authors report the fusion and complication rates in a large cohort of patients undergoing posterior interbody fusion using rhBMP-2 at three different dosages.

**Methods:** The charts of 177 consecutive patients undergoing PLIF or TLIF using PEEK cages and rhBMP-2 at 234 interbody levels were retrospectively reviewed. Delivery of rhBMP-2 was via absorbable collagen sponges (ACS) in all patients. All patients had contralateral posterolateral fusion with rhBMP-2 and morcelized allograft/local autograft. Demineralized bone matrix (DBM) was used in some patients at the discretion of the surgeon. The rhBMP-2 dose used in the interspace was adjusted twice in this 4 cohort secondary to complications observed from rhBMP-2 (Table 1). All patients were scheduled for thin-cut computed tomographic (CT) scans, which were graded for fusion by an independent radiologist.

**Results:** Mean follow-up in this study was 19 months. Twelve patients undergoing interbody fusion at 13 levels in this study were lost to follow-up and no CT was available leaving 221 interbody levels in 165 patients to be evaluated. Complications of rhBMP-2 included cyst formation behind the cage causing radiculopathy and/or vertebral osteolysis (Fig. 1). The per-level fusion rates in Groups 1, 2, and 3 were 93%, 94%, and 93%, respectively. The per-level complication rates in Groups 1, 2, and 3 were 17.1%, 9.4%, and 3.4%, respectively.

**Conclusion:** Complications resulting from the use of rhBMP-2 in posterior interbody fusion can be decreased by decreasing the dose of rhBMP-2. In this study, a total dose of 1.1mg of rhBMP-2 in the interspace decreased the complication rate without a decrease in fusion rate when compared to higher doses of rhBMP-2 used in the interspace.

**249 Diffusion Tensor Imaging Correlates with Spinal Somatosensory Evoked Potentials After Spinal Cord Injury**

*Shekar N. Kurpad, Brian Schmit, Michael Jirjis*

**Introduction:** Diffusion Tensor Imaging (DTI) is a promising novel MRI-based technique for spinal cord tractography. Spinal somatosensory evoked potentials (SpSEPs) have previously been shown to detect and characterize different latency components associated with specific spinal pathways. We have correlated DTI Index FA and SpSEP in the spinal cord after varying injury severity.

**Methods:** DTI (FA) and SpSEPs were collected on 40 female Sprague-Dawley rats 10 weeks post-injury. 4 groups were included: sham, mild, moderate, and severe thoracic SCI derived from an NYU impactor. Animals were imaged in vivo using a 9.4T magnet, and axial diffusion weighted images were collected at a b-value of 500 seconds/mm². Average FA values were calculated in axial sections of the cervical spinal cord with five slices representing C2-3/C3-4/C4-5/C5-6 and C6-7 respectively. For SpSEPs, stimulation was applied to the sciatic nerve and recording electrodes were placed rostral to T5 and T11.

**Results:** In all three injury groups, average FA values showed a progressive decreasing trend in a cephalocaudal
direction ranging from 0.69 to 0.59 mm²/s in FA and correlated with SpSEP amplitude. Severely injured rats showed the greatest reduction in FA and SpSEP values (average of 0.9 decrease in FA) with moderate and mild injured animals showing slightly lesser reduction (average of 0.6 and 0.4 mm²/s decrease in FA respectively). FA and SpSEP values in the severe injury group were significantly different (analysis of variance [ANOVA], P > 0.05) than the other two groups. No significant difference was observed between the mild and moderate groups. **Conclusion:** We have demonstrated that DTI biomarker FA correlates with SpSEPs after SCI rendering FA a suitable biomarker for estimating functional changes in the spinal cord after varying injury severity.

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**Kyphotic Deformities of the Cervical Spine**

Jan Stulik, Petr Nesnidal, Jan Kryl, Tomas Vyskocil, Michal Barna

**Introduction:** The development of a cervical kyphotic deformity can be associated with a degenerative disease, trauma, tumor, developmental anomaly and also a surgical procedure, both the anterior and posterior surgical approaches. The deformity can also result from systemic diseases, such as ankylosing spondylitis or rheumatoid arthritis.

**Methods:** Retrospective analysis of 102 patients underwent correction of cervical kyphosis at our department between May 2005 and April 2010, 90 patients were included in this study with an average age of 56.7 years. In 6 patients kyphosis was caused by an inveterate injury, in 71 by degenerative disease, in 6 by rheumatoid arthritis, and 7 due to previous surgery. Surgery was carried out from the anterior, posterior or combined approach. The surgical outcome was assessed using the Nurick score and Neck Disability Index (NDI), the Visual Analogue Scale (VAS) was used to evaluate pain intensity or paraesthesia.

**Results:** The average NDI value was 25.5 before surgery and 14.3 and 14.9 at one and two years after surgery. The average pre-operative Nurick score was 0.7, an average post-operative value of 0.6 and 0.6. The average VAS value for neck and radicular pain was 5.7 pre-operatively, and 2.5 and 2.7, respectively. Complete bone union was achieved at 6 months after surgery in 97.8% patients. The average pre-operative value for the cervical curvature index (Ishihara) was -13.7, postoperatively was +15.3. The average pre-operative cervical kyphosis was -14.4 degrees, postoperatively was +13.5.

**Conclusion:** The results showed a marked improvement in the patient’s quality of life after kyphosis correction, improved neurological status and an improved posture seen on radiograms of the cervical spine. The study also revealed a higher number of potential complications associated, in particular, with corrective osteotomy. The best results were achieved with the combined surgical approach, however, the choice of a surgical method was independent on the patient’s clinical status.

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**Predictors of Outcome Following Traumatic Spinal Cord Injury**

Daniel Yavin, Steven Casha, Anmo Al-Habib, R. John Hurlbert

**Introduction:** Various determinants of prognosis following spinal cord injury (SCI) have been proposed. Herein we report clinical and radiologic features predictive of outcomes following traumatic SCI.

**Methods:** A post hoc secondary analysis was performed of outcomes collected during a randomized-controlled trial evaluating minocycline in consenting adult patients with traumatic SCI. Outcome measures included the American Spinal Cord Injury Association (ASIA) Impairment Scale (AIS) score, Functional Independence Measure (FIM), London Handicap Score (LHS) scale, Short Form 36 (SF36), and Spinal Cord Independence Measure (SCIM). Five clinical and radiologic features were evaluated as predictors of outcome via a multivariate regression.

**Results:** Fifty-two patients were enrolled from June, 2004 to August, 2008 and followed for a mean duration of 13.5 months. Mean patient age was 36.7 years, 73% were male, and 67% of injuries occurred in the cervical spine. At baseline mean AIS was 129.0. Twelve-month mean AIS, LHS, SF36, and SCIM were 178.5, 75.5, 87.3, and 59.8, respectively. Features independently associated with outcomes at 12 months were age (LHS P = 0.05, and SCIM P = 0.03), baseline AIS (AIS P < 0.01, SCIM P < 0.01, LHS P < 0.01), length of parenchymal damage of T2-weighted MR imaging (AIS P = 0.05), maximum canal compromise (LHS P < 0.01), and maximal spinal cord compression (LHS P = 0.02).

**Conclusion:** Predictors varied with domains of outcome. Age, baseline AIS, length of parenchymal damage of T2-weighted MR imaging, maximum canal compromise and maximal spinal cord compression were predictive of outcomes following traumatic SCI.
greater functional improvement compared to ACDF at all follow-up time points and significantly less pain at earlier time points for 2-level treatment.

253 Does Recombinant Human Bone Morphogenetic Protein-2 (rhBMP-2) Dose and/or Cage Countersinking Depth Affect the Incidence of Heterotopic Bone Formation in Posterior Interbody Fusion?

Eric W. Nottmeier, Cammi Bowman, Zane Thompson, Matthew Hale

Introduction: Heterotopic bone formation has been reported with the off-label use of rhBMP-2 in posterior interbody fusion with and without clinical sequelae.[1-4] The authors report their findings in a large cohort of patients undergoing posterior interbody fusion using rhBMP-2 and polyetheretherketone (PEEK) cages.

Methods: The charts and postoperative computed tomographic (CT) scans of 165 patients undergoing posterior interbody fusion using PEEK cages and rhBMP-2 at 221 interbody levels were reviewed. The rhBMP-2 dose that was used in the interspace was adjusted twice in this cohort (Table 1). Heterotopic bone formation in the spinal canal was graded as less than 5mm or greater than 5mm. Cage countersinking was graded in a similar fashion. The incidence of heterotopic bone formation was compared within the rhBMP-2 dosing and cage countersinking groups, and to the overall incidence of radiculitis/chronic leg pain, by chi-squared tests.

Results: Mean follow-up in this study was 19 months. Overall results showed that lower doses of rhBMP-2 were significantly related to a lower incidence heterotopic bone formation ($P < .001$). Paired group comparisons showed Group 1 was significantly different than both Group 2 and 3 in the incidence of heterotopic bone formation (71%, 47%, 38%, respectively) ($P < .001$). Group 2 and Group 3 were not significantly different in the incidence of heterotopic bone formation ($P > .05$). Results also showed a cage depth of less than 5mm, as compared to greater than 5mm, was associated with a significantly higher incidence of heterotopic bone formation (56%, 12%, respectively) ($P < .001$). No significant increase in the incidence of radiculitis or chronic leg pain was observed in patients with heterotopic bone formation as compared to patients without heterotopic bone formation.

Conclusion: The dose of rhBMP-2 and cage countersinking depth can influence the incidence of heterotopic bone formation in posterior interbody fusion. However, no significant increase in the incidence of radiculitis or chronic leg pain existed in patients exhibiting heterotopic bone formation.

254 Diffusion Tensor Imaging: Evaluating the Spinal Cord in Animal Models and Humans

Shekar N. Kurpad, Brian Schmit, Aditya Vedantam, Marjorie C. Wang, Benjamin M. Ellingson

Introduction: T2-weighted magnetic resonance imaging (MRI) lacks sufficient sensitivity to detect neural injury. Diffusion Tensor Imaging (DTI) is a newer technique that is able to define axonal integrity by measuring the diffusion of water molecules. We present our experience with DTI in studying spinal cord injury (SCI) in rat models as well as patients.

Methods: We performed DTI measurements using a 9.4T MR scanner on Sprague-Dawley rats after a moderate contusion injury at T8 and documented the DTI changes as well as histological features up to 25 weeks after SCI. Also, we attempted to correlate spinal somatosensory evoked potentials (SpSEP’s) with DTI measurements. Subsequently, we described DTI parameters in human controls and chronic SCI patients.

Results: In rat models, the longitudinal apparent diffusion coefficient (lADC) was reduced throughout the cord up to 25 weeks after SCI, while the white matter (WM) fractional anisotropy (FA) decreased and the transverse apparent diffusion coefficient (tADC) increased around the lesion. Histological sections showed progressive cavitation with rostral-caudal spreading that correlated with the MD. Early SpSEP’s correlated with the diffusivity in medial WM tracts while the late SpSEP’s correlated with the MD of the lateral spinothalamic tract. In human controls, while the FA of the whole cord decreased in the rostral-caudal direction, MD was relatively constant throughout the cord. In chronic human SCI, just as MD, lADC and tADC increased around the lesion, the FA was greatly reduced and was able to accurately define the extent of the lesion.

Conclusion: Using rat models, we have showed that DTI parameters correlate well with histological and functional measures and this has helped us refine this modality for human research. DTI is able to provide a unique insight into the varied changes associated with SCI and we expect to see greater applications of DTI in studying human spinal cord disorders.

255 Early Stabilization of Thoracolumbar Injuries in Polytraumatized Patients

Timothy A. Moore, Michael P. Steinmetz, Heather Vallier

Introduction: Polytrauma patients often present with unstable thoraco-lumbar injuries. While most surgeons feel these injuries need to be stabilized, the timing of such an operation remains a topic of debate. We present a consecutive series of 98 thoraco-lumbar injuries stabilized in an early or late manner.

Methods: Ninety-eight skeletally mature patients with an Injury Severity Score greater than 18 presenting to our Level I trauma center were retrospectively reviewed. There were 79 men and 19 women. The average age was 37.3 (18-71) years. The average Injury Severity Score (ISS) was 37.3 (18-50). The “early” group was defined as definitive stabilization within 24 hours, 21 patients (21.4%) and “late” group after 24 hours, 77 patients (78.6%). Associated injuries of the chest, abdomen and head were documented along with ISS, Abbreviated Injury Scores and Glasgow Coma Scale. Transfusion requirements, length of ventilator assistance, length of ICU stay, and length of hospitalization were determined. Complications were reviewed, including wound infection, pulmonary complications (adult respiratory distress syndrome (ARDS), pneumonia, pulmonary embolism (PE)), renal failure, multiple organ failure (MOF) and deep venous thrombosis (DVT).

Results: The average ISS was 29.1 ± 9.3 for the early group and 32.5 ± 11.3 for the late group ($P = 0.001$). The late group had longer hospital stay and ICU stay. The early group had a lower rate of ARDS, pneumonia and sepsis compared to the late group. Rates of DVT, PE, wound infection, renal failure, MOF and death were not statistically significant between the two groups.

Conclusion: In polytraumatized patients with thoraco-lumbar injuries, prolonged recumbency has been shown to negatively impact pulmonary function. Pain reduction achieved by stabilization limits sympathetic discharge and reduce narcotic...
consumption causing less pulmonary suppression. Ninety-eight unstable thoracolumbar injuries in polytraumatized patients were reviewed. Patients who underwent definitive stabilization within 24 hours achieved shorter ICU and hospital stays and lower rates of pulmonary complications than those treated greater than 24 hours. We feel surgical timing should be a multi-disciplinary decision based on the patient’s physiologic and resuscitation status and the extent of the stabilization procedure.

256 Diffusion Tensor MRI and Motoneuron Morphometric Changes in Cervical Gray Matter After a Thoracic Spinal Cord Injury in the Rat
Shekar N. Kurpad, Brian Schmit, Benjamin M. Ellingson, Robin Mottackel
Introduction: We investigated the diffusion tensor imaging (DTI) changes in the cervical spinal cord gray matter (GM) as a result of a thoracic (T8) contusive spinal cord injury (SCI) in the rat.
Methods: DTI data from ex vivo rat spinal cords were registered to corresponding histological slices in unjured control, and 2, 15 and 25 weeks post injury (n = 5 all groups). Animals were perfused with 10% formalin, spinal cords excised, post-fixed for 7 days, and imaged using a Bruker 9.4T scanner using a standard pulsed gradient spin echo sequence. After imaging, samples were dehydrated, blocked in paraffin, sliced axially and stained with eriochrome cyanine R stain, H&E counter-stain, and osmium tetroxide with toluidine blue. The WM and the GM regions of interest were used to map DTI indices, including fractional anisotropy (FA), longitudinal apparent diffusion coefficient (LADC) and transverse apparent diffusion coefficient (TADC). Motoneuron size in the ventral GM was calculated and correlated to the DTI indices in GM.
Results: FA values in the dorsal GM ROI were significantly higher than the ventral GM in controls, 15 and 25 weeks post injury groups (P < 0.05). IADC in dorsal ROI was significantly higher than in ventral GM in controls, 15 and 25 weeks post injury (P < 0.05). The FA value within the entire GM at 25 weeks was significantly higher than the FA value at 2 weeks post injury (P < 0.05) and the FA value in controls (P < 0.05). Group analysis of the size of the motor neurons showed a 9% increase in the motoneuron size at 2 weeks (P < 0.01) and 42% increase at 25 weeks (P < 0.01) post injury as compared to controls.
Conclusion: These results suggest changes in gray matter structure rostral from a contusion injury can be detected and monitored using DTI.

257 Comprehensive Assessment of One-year Outcomes After Suboccipital Craniectomy for Chiari I Malformation in Adults
Scott L. Parker, Scott Zuckerman, David Shau, Stephen Mendenhall, Matthew McGirt
Introduction: Suboccipital craniectomy is a commonly performed procedure for Chiari I malformation, however, to date there has never been a study to comprehensively assess the effectiveness of suboccipital craniectomy using patient-reported outcome (PRO) measures. In light of this, we set out to assess the effectiveness of suboccipital craniectomy for treatment of adult patients with Chiari I malformation utilizing validated patient-reported outcome (PRO) metrics.
Methods: Forty-nine adult patients undergoing suboccipital craniectomy for Chiari I malformation were included in this study. Baseline and one-year VAS-Head, Headache Disability Inventory (HDI), Neck Disability Index (NDI), physical and mental quality of life (SF-12 PCS & MCS), health-state utility [EuroQol (EQ-5D)], time to return to work, and satisfaction with surgery were assessed.
Results: Baseline characteristics provided in Table 1. Each of the PROs assessed were significantly improved (P < 0.01) at one-year post-operatively, Figure 1. Thirty-nine (80%) patients were satisfied with their outcome as assessed by the net satisfaction index. Thirty-five (72%) patients returned to work by one-year post-operatively. Median [IQR] time to return to work was 12 [6-45] weeks.
Conclusion: Surgical management of Chiari I malformation in adults via suboccipital craniectomy provides significant and sustained improvement in pain, disability, and quality of life, as assessed by patient-reported outcomes at two-years post-operatively. This patient-centered assessment suggest that suboccipital craniectomy for Chiari I malformation in adults is a highly effective treatment strategy.
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Relationship Between Effective Lordosis and Patient Reported Neck Pain and Disability
Alex Riccio, David L. Semenoff, John W. German

Introduction: Kyphotic spinal curvature is thought to be associated with poor outcomes following cervical spine surgery leading some surgeons to suggest that the restoration of kyphosis should be an important goal of surgery even if more extensive surgery were to be required. To date few studies have specifically evaluated spinal curvature in non-operative patients with respect to present day clinical outcome measures. It is possible that patients who present with a straight or kyphotic spine may have a different baseline status with respect to neck disability and pain than those with a lordotic curvature.

Methods: Fifty patients who underwent an out-patient evaluation for chronic neck pain were included in this study. All patients underwent standing lateral x-rays to determine the presence (ELpr) or absence (ELab) of effective lordosis as described by Gwinn et al (2009) by two neurosurgery attendings. All patients also completed self-reported outcome measures (NDI, Neck VAS, SF-12 PCS, and SF-12 MCS) at the same clinic visit. Correlation between the presence or absence of EL and outcome measures was sought. Outcome measures were compared by t-test and reported as mean,SD.

Results: After classifying each x-ray with respect to EL no statistical difference could be found in any outcome measure: NDI (EF pr: 5.17, 18.348, EF ab : 4.833, 17.538, P = 0.57), Neck VAS (EF pr: 5.61, 1.87, ELab : 6.07, 2.56, P = 0.51), SF-12 PCS (ELpr: 28.94, 9.97, ELab: 33.52, 10.12, P = 0.15), or SF-12 MCS (ELpr: 44.27, 11.18, ELab: 40.41, 9.51, P = 0.23).

Conclusion: The absence of EL was not associated with a statistically significant difference in baseline patient reported outcome measures of neck pain or disability. Spinal curvature may contribute little to a chronic neck pain patient’s overall perception of neck pain and disability.

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Management of Incidental Durotomy in Minimally-Invasive Spine Surgery
Dmitry Ruban, John E. O'Toole

Introduction: Unintended durotomy is one of the most common complications in spine surgery that may lead to serious complications if not recognized or treated properly. There are few reports on management of durotomies incurred during minimally invasive spine surgery (MISS). The authors describe their experience in a series of consecutive MISS patients with unintended durotomies.

Methods: All patients who underwent minimally invasive spine surgery by the senior author from August 2006 to February 2011 were retrospectively reviewed and cases with unintended durotomies were identified. A case-control study was carried out comparing patient demographics and perioperative data between patients with and without durotomy. Surgical technique, including a proposed algorithm for management of durotomies, is described.

Results: Unintended durotomy occurred in 53 out of 563 patients (9.4%). Mean age at surgery was 60.7 years (range 30-85). Previous surgery at the same level was performed in 5 patients (9.4%). Two patients underwent posterior cervical surgery, and 51 patients underwent posterior lumbar surgery. Decompression alone was performed in 32 cases (60.4%), and fusion was performed in 21 cases (39.6%). Mean follow-up was 310 days, and there were no CSF-cutaneous fistulas, pseudomeningoceles, or other complications referable to durotomy in either group. Risk factors identified for durotomy included previous operation at the same level (P = 0.019) and operation in the lumbar spine region (P = 0.001).

Conclusion: In our consecutive series of patients undergoing MISS, an unintended durotomy was associated with fewer complications than previously reported for open spinal surgery. We propose a simple management algorithm that includes early mobilization and results in excellent clinical outcomes with no incidence of postoperative CSF-cutaneous fistula or other complications.

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Wilson Zachary Ray, Andrew Yee, Susan E. Mackinnon

Introduction: Nerve transfers using an expendable nearby motor nerve to reinervate a denervated nerve have resulted in more rapid and improved functional recovery than traditional nerve graft reconstruction following brachial plexus and distal peripheral nerve injuries. Through our experience with nerve transfers over the last two decades we have learned that the nerve to the brachialis muscle is expendable and the anatomical location of the anterior interosseous nerve (AIN) transfer.

Methods: Review the presentation, work-up, treatment and outcome of a patient with a complete cervical SCI injury treated with nerve transfers for the restoration of hand function.

Results: We report the successful reinnervation of the AIN to restore some finger and thumb flexion in a patient with a complete cervical spinal cord injury using a brachialis to anterior interosseous nerve (AIN) transfer.

Conclusion: The use of nerve transfers may represent a significant breakthrough toward improved independent function in select patients with cervical SCIs. Although limited to only a few case reports it appears that the time frame for performing nerve transfers following a spinal cord injury is longer than with other peripheral based lesions. Further studies will be required to assess reliable clinical outcomes and optimal timing for surgical intervention.
patients with isolated lower trunk injuries remain relatively uncommon, nerve transfers for the restoration of some hand function should be considered. Further studies will be required to accurately assess the long-term benefit of this transfer.

304 Incidence of Vertebral Artery Injury with Traumatic Cervical Spine Subluxations
Kamran Parsa, Omrid R. Hariri, Farid Janshidian, Dan Mulii, Javed Siddiqi

Introduction: The incidence of vertebral artery injuries in traumatic cervical spine subluxations has been reported to be variable, 3%-88% [1-5]. The purpose of this study is to investigate the incidence of vertebral artery injuries at our institution, the second busiest trauma center in southern California.

Methods: Retrospective data collected from our institution’s trauma registry from January 2000 – June 2011. Search criteria: (1) All traumatic cervical spine fractures presenting to the emergency room (2) All traumatic subluxed cervical spine, (3) Subluxed cervical spine injuries and vertebral artery injuries. Exclusion criteria: (1) Injury occurring because of damage to subclavian artery, (2) Injury occurring because of damage to neck soft tissue.

Results: 852 patients (582 male, 270 female) presented with traumatic cervical spine fractures. 102-(12%) had cervical spine subluxation injuries. 13 had subluxed cervical spine injuries with vertebral artery injuries. This is 1.5% [P < 0.01, 95% confidence interval (CI) of 0.00-0.02] of all cervical spine fractures, and 12.7% of all traumatically cervical subluxation injuries. The anatomical characteristics of injury were: 5-(38.4%) involved severe fracture with subluxation resulting in translocated vertebral bodies, 5-(38.4%) involved vertebral artery occlusion secondary to a perched facet and minor subluxation, 2-(15.4%) gunshot wounds associated with fractures and vertebral artery occlusion, 1-(6.6%) vertebral artery dissection associated with similar severe fracture and subluxation. According to the Blunt Cerebrovascular Injury (BCVI) Grading: 1-(6.6%) Grade V (transsection), 9-(69.2%) Grade IV (occluded), 3-(23.1%) Grade II (dissection).

Conclusion: At our institution over the past 11.5 years, our data suggests a 1.5% incidence of vertebral artery injuries associated with traumatic subluxation and fractures. There was no incidence of vertebral artery injury without a fracture. Compared to the most recent report by Mueller et al [5] and other major studies, our results fall below the lowest range of 3%. Occlusion (Grade IV) was the most common form of vertebral artery injury. Thus, in patients with cervical spine subluxation, vertebral artery injuries are not relatively frequent.

305 Sacral Dural Arteriovenous Fistula: Usefulness of Multidetector-row CT (MDCT) and Report of 4 Cases
Tomohiro Murakami, Izumi Koyanagi, Takahisa Kaneko, Satoshi Ookawa, Kei Miyata, Satoshi Iihoshi, Nobuhiro Mikuni

Introduction: Sacral dural arteriovenous fistula (dAVF) is a rare entity in spinal arteriovenous malformation. It is well known that feeding arteries of this region are branches of the internal iliac arteries, so it is difficult to detect and identify these feeding arteries. The purpose of this study is to analyze and to evaluate usefulness of magnetic resonance (MR) imaging and multidetector-row CT (MDCT) findings in the sacral dAVF.

Methods: This retrospective study included four cases (three men, one woman and mean aged 69 years) of sacral dAVF. We assessed the following: clinical symptoms, MRI and MDCT findings followed by comparing with spinal digital subtraction angiography (DSA) findings.

Results: The clinical symptoms were motor weakness of both lower extremities and sensory disturbance in all cases. On T2-weighted images of all cases, spinal cord had hyperintensity area below Th6 level and many flow voids. From these results we could diagnose spinal dAVF but it was difficult to detect and identify the feeding arteries. MDCT revealed dilated draining vein around the spinal cord in all cases. Especially, dilated venous drainers along S1 or S2 root or filum terminale from sacral bone were indeed characteristic findings in the sacral dAVF, which were fed by lateral sacral artery in three, L5 segmental artery in one. These feeders were identified precisely using spinal DSA.

Conclusion: Clinical symptoms of sacral dAVF had no specific differentiation compared with other regions dAVF. MRI was less invasive and useful for analysis of intra-spinal abnormalities but the field of view was limited. MDCT was useful for the diagnosis of sacral dural AVF, and could be helpful for the indentification of feeding arteries before spinal DSA.
307 Carpal Tunnel Surgery: A Novel Method with Preliminary Results in 52 Patients
Bruce M. McCormack, Edward F. Eyster, Michael J. Kaplan, William W. Bowen, Stephen Gaither, Jonathan J. Linthicum

Introduction: This is a retrospective review of 52 patients with carpal tunnel syndrome (CTS) treated with the MANOSTM Carpal Tunnel Release device. Methods: The ManosTM Carpal Tunnel Release device is a carpal tunnel blade that releases the transverse carpal ligament with wrist and palm skin punctures as small as 2.1 mm. A standard disposable nerve stimulator and awake patient provide feedback as the surgeon navigates a 14 gauge blunt probe across the undersurface of the ligament from a wrist stab wound. The leading tip is insulated and conducts 2 milliamps. The surgeon converts the blunt insulated probe into an uninsulated blade by advancing a 17 gauge sharp through the palm with a thumb activated trigger. The surgeon saws the ligament through the two skin punctures. A validated outcome questionnaire was used to retroactively assess preoperative symptoms and postoperative symptoms at three months. Results: Symptom severity and functional status scores were improved postoperatively and compare favorably to literature controls for open and endoscopic surgery at three months. One patient required reoperation for incomplete release. There were no tendon or nerve injuries. Conclusion: Preliminary results suggest the Manos™ Carpal Tunnel Release device to be safe and effective.

308 Facet Joint Contact Pressure Is Not Significantly Affected by ProDisc-C Disc Arthroplasty in Sagittal Bending: A Single Level Cadaveric Study
Joel A. Baum an, Nicolas V. Jaum ard, Benjamin B. Guarno, Christine L. Weisskaar, Daniel E. Lipschutz, William Charles Welch, Beth A. Winkelstein

Introduction: Total disc arthroplasty is a motion-preserving spinal procedure that has been investigated for its impact on spinal motions and adjacent level degeneration. However, the effects of disc arthroplasty on facet joint biomechanics remain undefined despite the critical role of these posterior elements in guiding and limiting spinal motion. Therefore, the purpose of this study was to measure the pressure in the facet joint in cadaveric human cervical spines subjected to sagittal bending prior to and after implantation of the ProDisc-C. Methods: Seven C2-T1 osteoligamentous cadaveric cervical spines were instrumented with a transducer to measure the C5-C6 facet pressure profiles during physiologic sagittal bending, before and after implantation of a ProDisc-C at that level. Rotations of the index segment and global cervical spine were also quantified. Results: The mean C5-C6 range of motion significantly increased (P = 0.009) from 9.6 ± 5.1° in the intact condition to 16.2 ± 3.7° after implantation. However, despite such changes in rotation, there was no significant difference in the facet contact pressure during extension between the intact (64 ± 30 kPa) and implanted (44 ± 55 kPa) conditions. Similarly, there was no difference in facet pressures developed during flexion. Conclusion: Although implantation of a ProDisc-C arthroplasty device at the C5-C6 level increases angular rotations it does not significantly alter the local facet pressure at the index level in flexion or extension. Using a technique that preserves the capsular ligament, this study provides the first direct measurement of cervical facet pressure in a disc arthroplasty condition.

309 Clinical Outcomes of Unstable Thoracolumbar Burst Fractures: Combined Posterior Short Segment Correction Followed by Thoracoscopic Corpectomy and Fusion
Wilson Zachary Ray, Khaled M. Krisht, Erica Fay Bisson, Andrew T. Dailey, Metc H. Schmidt

Introduction: The surgical management of thoracolumbar burst fractures varies widely among treated clinicians. The authors review their experience with anterior thoracoscopic corpectomy and short segment posterior fusion for the treatment of unstable thoracolumbar burst fractures. Methods: A retrospective chart review identified all patients treated by a single surgeon at our institution from 2002 to 2009 with anterior thoracoscopic corpectomy and fusion followed by short-segment posterior fusion for unstable thoracolumbar burst fractures. Demographic data, mechanism of injury, classification of fracture, Cobb angle, American Spinal Injury Association score, associated injuries, tobacco use, follow-up duration, and radiographic studies were all collected. Outcomes were assessed for fracture alignment (preoperative, postoperative, and long-term follow-up kyphosis), rate of fusion, neurological outcome, and treatment complications. Results: Thirty-four patients were identified, including 25 with lumbar fractures and 9 with thoracic fractures. At a mean follow-up of 19 months, 91% of patients had demonstrated radiographic evidence of fusion and 87% retained the correction of their kyphotic deformity. There were three complications in the series. Conclusion: Thoracoscopic anterior corpectomy with short segment posterior fusion represents an alternative to traditional open treatment of thoracolumbar burst fractures. A thoracoscopic approach allows for a short-segment posterior fusion, reducing the loss of adjacent motion segments, minimizes morbidity associated with traditional open anterior approaches, allows for anterior and posterior column stabilization, and is associated with a high rate of bony fusion and maintenance of kyphotic correction.

312 Do Porous Tantalum Implants Induce a Radiologically Detectable Osteosintesis? Results from the Analyses of X-rays and 3D CT Scans Obtained in a Series of 83 PLIF Procedures
Mario Ganau, Franco Ennas, Laura Ganau, Alberto Maleci

Introduction: The high volumetric porosity (70%–80%), low elasticity modulus (3MPa), and high friction characteristics of porous tantalum metal (PTM) make it a better conductive material than titanium to biologic fixation. Several in-vitro studies, although showing differences in expression levels of bone matrix markers dependent on the age and gender of cell’s donors, confirmed that PTM is a good substrate for the attachment, growth and differentiated function of human osteoblasts. Indeed, its introduction in the market of spinal surgery devices has yielded theroretically better fixation qualities and a so called “gap filling” effect, particularly valuable for patients with compromised bone foaming abilities (i.e. osteoporosis). Methods: To test, clinically and radiologically, the properties of PTM cages a prospective non-randomised study was conducted on 83 consecutive patients
implanted with PTM cages during PLIF surgery for degenerative spondylolisthesis, discopathies or segmental stenosis. Every patient from this cohort was assessed by VAS/ODI test and underwent X-rays/CT scans of the lumbar spine 6 months after intervention and later on after at least 2 years.

**Results:** No migration of implants in a ventral/dorsal direction or sideways was detected, no implant subsidence in a rotation/flexion fashion, nor osteolytic lesions between the cage and adjacent bone were noticed. Evaluation of bone ingrowth into the cage was difficult due to the high X-ray contrast effect of the material, nevertheless high quality bridging fusion lateral to the cages was seen on 3D CT scan in almost every patient despite the gender or the age. The clinical improvement is in agreement with the stability and fusion achieved.

**Conclusion:** While we can’t confirm clinically any difference in bone ingrowth dependent on the age and gender of the patients, the good radiological results in terms of spinal fusion and absence of implant subsidence or complications lead us to conclude that PTM seems an effective material for spinal surgical devices.

**313 Postoperative Urinary Retention in Elective Spinal Surgery Patients**

David J. Aitschul, John K. Houten

**Introduction:** Postoperative urinary retention (POUR) is a common problem in patients undergoing surgery. This study investigates its incidence in patients undergoing elective spine surgery and attempts to identify significant risk factors.

**Methods:** All elective spine surgery patients were monitored for POUR over a consecutive four-month period. Data collected included operative data including operative positioning, surgery duration, fluid administration, and blood loss as well as patient characteristics including age, sex, and medical comorbidities.

**Results:** 131 patients were included in the study. 28 of these patients (18.3%) developed POUR. There was no significant difference between groups with regard to age, gender, use of instrumentation, Foley placement, or surgery duration. Using chi-squared analysis, the urinary retention group had a higher percentage of thoracic/lumbar ($P = 0.002$) and posterior ($P = 0.045$) position procedures. A multivariate analysis revealed that diabetes ($P = 0.01$) and volume of intraoperative fluids ($P = 0.05$) were significantly different between groups, with the odds ratios for developing POUR with intravenous fluids $>2.0$ liters was 3.9, having a history of diabetes mellitus was 4.2, and having a post-op UTI was 3.4.

**Conclusion:** POUR in elective spine surgery is common. Patients with diabetes and those receiving more than $2.0$ liters intravenous fluids had significantly higher incidence of POUR. Knowledge of the incidence of POUR may be useful in evaluating postoperative spine surgery patients for cauda equina syndrome from hematoma insofar as that retention may, without other neurologic signs and symptoms, be insufficient grounds for emergent imaging.

**314 The Use of Three-dimensional Image-guidance for Redirecting Pedicle Screws in Revision Spinal Fusion**

Eric W. Nottmeier, Douglas S. Fenton, Todd Leibowitz, Stephen M. Pirris

**Introduction:** For patients undergoing revision spinal surgery, adequate redirection of previously misplaced pedicle screws can be challenging secondary to the tendency of the redirected screw to follow the cortically-lined tract of the previously misplaced screw. Additionally, placing a new screw down a previously misplaced pedicle screw tract can have an unfavorable clinical result in a patient that may have been symptomatic from the previously misplaced screw. The authors report their experience with the use of cone beam computed tomography (cbCT)-based, three-dimensional (3D) image guidance for redirection of pedicle screws in patients undergoing revision spinal fusion procedures.

**Methods:** The charts and radiological studies of 20 patients undergoing revision spinal fusion with redirection of pedicle screws were retrospectively reviewed. Thirty-five pedicle screws were redirected in these patients using cbCT-based, 3D image guidance (Table 1). Five patients in this cohort had neurologic symptoms related to a previously misplaced pedicle screw, none of which were aware that they were harboring a misplaced pedicle screw. There were 7 redirected pedicle screws in this study that were not previously misplaced, but were close to the medial or inferior border of the pedicle and could not be safely upsized. Redirection of new screws down a different trajectory was accomplished with image-guided probes, taps, and screwdrivers (Fig. 1). An independent radiologist graded pedicle breach in the screws that were previously misplaced, as well as the redirected screws using the system described by Mirza et al.1

**Results:** No complications occurred in this study as a result of image guidance or redirection of pedicle screws. Four pedicle screws were redirected using an in-out-in technique and these screws were left out of the breach analysis. No pedicle breach was noted in the 31 redirected pedicle screws that underwent breach analysis.

**Conclusion:** Redirection of pedicle screws can be accomplished safely and effectively with the use of cbCT-based, 3D image guidance.

**315 Stereotactic Navigation with the O-arm for Placement of S2 Alar-Iliac Screws in Pelvic-Lumbar Fixation**

Wilson Zachary Ray, Erica Fay Bissom, Meie H. Schmidt, Andrew T. Dailey

**Introduction:** Fixation to the pelvis is a crucial adjunct to many lumbar fusions in order to avoid L5-S1 pseudoarthrosis. Pelvic fixation is useful for treatment of kyphoscoliosis, high-grade spondylolisthesis, L5-S1 pseudoarthrosis, sacral tumors, lumbosacral dislocations and osteomyelitis. The most popular method, iliac fixation, has drawbacks including hardware prominence, the need for extensive muscle dissection and the need for connection devices. As a result, S2 alar-iliac fixation provides a useful primary or salvage alternative. We describe our techniques using stereotactic navigation for screw placement.

**Methods:** Twelve patients had computer assisted S2 alar-iliac fixation over a 12 month period. The O-arm Imaging System allowed for CT quality multiplanar reconstructions of the pelvis and registration to a Stealth Treon Station provided intraoperative guidance. Six patients had a diagnosis of kyphoscoliosis, 2 had L5-S1 pseudoarthrosis revision, 2 had tumor, 1 had salvage of failed iliac screws and 1 had distal adjacent segment degeneration.

**Results:** All patients had bilateral placement of the screws with length ranging from 80-100 mm. All placements were confirmed with a second multiplanar reconstruction. One screw was moved due to apparent anterior breach of the ilium. There were no immediate or delayed (4-
12 months) neurological or vascular complications from screw placement. The length of the screws required additional instruments including a longer pedicle finder and tap.

**Conclusion:** S2 alar-iliac fixation provides lower profile fixation and often can be performed without the need for connection devices. In addition, placing a screw across two cortical surfaces of the sacral alae as well as the cortex of the ilium and the thick cortical bone above the sciatic notch should provide superior biomechanical fixation. Placement can be achieved without more extensive muscle dissection or separate fascial incisions.

**316 Chiari I Malformation Assessment with Intraoperative Doppler Ultrasound**

Bennett Blumenkopf, Alexander Kwong-Tak Yu, Zachary G. Wright, Larry Guraly, Brandon Chew

**Introduction:** Chiari I malformation is a debilitating disorder resulting from cerebrospinal fluid (CSF) obstruction at the level of the foramen magnum. Patients typically present with headache and lower cranial nerve symptoms. Objective findings suggesting obstruction are often speculative, especially when using static magnetic resonance imaging (MRI)[ref.1]. Cine MRI is useful pre-operatively, but is not typically available intra-operatively. Ultrasound provides real-time assessment, and Doppler ultrasound assessment of flow [ref.2]. These were evaluated together as a modality to objectively determine the presence of CSF obstruction and flow across the foramen magnum before and after Chiari I decompression.

**Methods:** In a series of patients ultrasonography (HDI 5000 ATL with C8-5 8mHz probe) was utilized after suboccipital craniectomy with C1 laminectomy was performed. Prior to the dural opening, routine ultrasound was used to assess parenchymal pulsation, whereas, Doppler ultrasound was used to determine CSF flow at the level of the foramen magnum. Dural expansion using bovine pericardium was then performed in each patient. Studies were repeated prior to wound closure.

**Results:** Prior to the dural opening, ultrasound revealed nil to minimal pulsation of the cerebellum and tonsils, Doppler studies showed no CSF flow across the foramen magnum. After the duraplasty, routine ultrasound revealed pulsatile neural elements and the Doppler ultrasound clearly depicted flow through the decompression and across the foramen magnum.

**Conclusion:** Doppler ultrasound proved an effective, easy to use real-time imaging technique intraoperatively for the confirmation of CSF obstruction, and to assure the adequacy of suboccipital decompression with the re-establishment of CSF flow across the foramen magnum, in patients undergoing Chiari I decompression.

**317 Part II: The Safety and Efficacy of 1.05 mg of rh-BMP-2 in Minimally Invasive Transforaminal Lumbar Interbody Fusions**

Luís M. Tumialan, Frederick F. Marciano, Nicholas Theodore

**Introduction:** The recent literature has reported a significant complication rate in lumbar interbody fusions with rh-BMP-2. The doses in these reports are varied and doses as high as 12.1 mg in the interbody space have been reported. The purpose of this report is to review the experience of 42 consecutive minimally invasive single level transforaminal lumbar interbody fusions with 1.05 mg of rh-BMP-2.

**Methods:** The authors prospectively followed 42 consecutive patients who underwent a minimally invasive single level transforaminal lumbar interbody fusion. Preoperative and postoperative visual analogue scores (VAS), Owestry Disability Index (ODI) and Standard Form-36 (SF-36) were collected. The dose of rh-BMP-2 that was utilized within the interbody spacer was 1.05 mg. Patients were monitored for the known complications that have been reported, in particular, heterotopic bone formation, osteolysis and seroma formation.

**Results:** A total of 42 patients underwent a single level minimally invasive TLIF. Mean follow-up was 10.8 months. The mean preoperative ODI, VAS and SF-36 were: 45.7, 7.2 and 16.7 respectively. The mean postoperative values were 16.4, 3.7 and 32.8 respectively. There were no complications related to heterotopic bone formation, seroma formation or osteolysis during the immediate or long term postoperative period. One patient required a reoperation for persistent symptoms contralateral to the side of the TLIF. CT and MR imaging of this patient did not reveal any evidence of seroma in the vicinity of the TLIF or heterotopic bone formation. At six months 36 patients (86%) demonstrated fusion within the interbody device.

**Conclusion:** A dose of 1.05 mg of rh-BMP-2 is not associated with the various complications reported in the literature and appears to be sufficient to result in adequate bone formation within the interbody device. This study reinforces the dose related consequences of this technology and also demonstrates that when rh-BMP-2 is used at a low dose contained within an interbody spacer, it may be safely used in transforaminal approaches.

**318 Should Asymptomatic Degenerative Discs Be Included in a Two-level Anterior Cervical Discectomy and Fusion? A Decision Analysis**

Maxwell Boakye

**Introduction:** The annual incidence of adjacent segment disease (ASD) ranges from 1.5-4% with 10 year estimates as high as 25% after anterior cervical discectomy with fusion (ACDF). The incidence and rate of development of ASD is higher in patients with preexisting asymptomatic adjacent degenerative discs (AADD). A diagnosis of ASD often leads to additional surgery. Given the risks of ASD and need for additional procedures, the question arises whether AADD’s in patients with two-level cervical disc disease should be preemptively treated with fusion. Decision analysis is a tool that can aid in surgical decisions in the absence of randomized controlled studies. The goal of this paper is to perform a decision analysis regarding whether a two-level ACDF should be performed for a patient with two-level cervical disc disease, of which one level is asymptomatic.

**Methods:** Decision analysis was performed using Treeage Pro Suite 2008. Probabilities and utilities of alternative outcomes in the decision tree were assigned based on peer-review literature. Roll-back analysis determined the optimal treatment. Sensitivity analyses and Monte Carlo simulations were performed to identify effects of varying model parameters.

**Results:** Roll-back analysis provided expected values of 0.92 vs. 0.84 in favor of observation as the optimal decision. Sensitivity analysis identified the probability of developing ASD and the likelihood of surgery given a diagnosis of ASD as the most critical parameters.
influencing the decision. Observation was the preferred strategy at all values of probability of ASD less than 100%. At a probability of ASD of 100%, fusion was the preferred strategy only when the probability of surgery for ASD was 66% or greater or the utility assigned to successful nonoperative management was 0.84 or less.

Conclusion: Observation was the preferred strategy for management of AADD given the probabilities and utilities utilized in the decision analysis model. The study is limited by unavailability of precise estimates of the probability of development of adjacent segment disease and the probability of surgery after diagnosis of adjacent segment disease, the most critical factors influencing the decision. However the conclusions were robust given wide ranges used for these parameters in the sensitivity analysis.

319 Racial Disparities in Complication Rates and Resource Utilization After Spinal Surgery for Lumbar Stenosis Maxwell Bookye, Beatrice Ugilweneza

Introduction: Recent reviews suggest widespread racial disparities in surgical care. There have been limited studies of racial disparities in outcomes after spinal surgery. The goal of this study is to compare outcomes after surgery for lumbar stenosis between African American (AA) and White patients.

Methods: We used the Medicaid database of the Thomson Reuter’s MarketScan. African American and Non-Hispanic White patients who underwent a laminectomy or a fusion as a primary procedure for a concurrent primary diagnosis of lumbar stenosis were considered for the study. We retained patients who had at least two years post-operative continuous enrollment. Risk of post-operative complications and re-operation were compared using multivariate logistic regression, in-hospital days and healthcare resources charges were compared using generalized linear models, and the number of post-operative all-type outpatient services, Emergency Department outpatient services, prescribed medications were compared using negative binomial models. Data preprocessing and statistical analysis were performed in SAS 9.2.

Results: A cohort of 1263 patients (12.97% AA) was obtained. Four hundred and fifty of them had two years post-operative continuous enrollment. The average age in this group was 59 years (standard deviation- SD: 12 years) and 72.67% were females. One-year, two-year re-operation rates as well as post-operative healthcare resources utilization and charges were statistically similar in both racial groups. During the index hospitalization, AA patients had significantly longer hospital stays (mean: 5 days, SD: 5 days, vs. mean: 3 days, SD: 2 days, p-value < 0.0001) and higher charges (mean: $34,686, SD: $30,551 vs. mean: $25,886, SD: $32,668, p-value = 0.0002). Also, AA patients had significantly higher wound complication rates in comparison to White patients during the index hospitalization (9.92% vs. 3.13%, OR: 3.13, 95% CI: 1.27-7.72, p-value = 0.013), 30 days (11.45% vs. 4.39%, OR: 2.6, 95% CI: 1.16-5.83, p-value = 0.013), after surgery and 90 days after surgery (11.45% vs. 5.02%, OR: 2.3, 95% CI: 1.05-5.02, p-value = 0.037).

Conclusion: During the surgery hospitalization, the AA race was associated with longer stays and higher charges. After surgery for lumbar stenosis, AA patients had higher wound related complication rates. All other post-operative outcomes were not found to be statistically different.

320 Presacratal L5-S1 Interbody Fusion (AxiaLIF) for Obese Patients with LumbarSacral Degenerative Disease Frederik Pennings, George Malcolmson, John P. Weaver

Introduction: Obesity (BMI>30) is a medical condition that significantly increases the morbidity and mortality of spinal procedures and limits the surgeons’ ability to perform traditional open fusion procedures. Therefore, minimally invasive spinal procedures that reduce the amount of tissue destruction, blood loss and operative time may be beneficial for the (morbid) obese patients. An AxiaLIF is a novel minimally invasive presacral approach to treat symptomatic degenerative spinal pathologies of the lumbar sacral segment. We conducted this study to investigate the clinical outcome and fusion rates in obese patients undergoing the AxiaLIF procedure.

Methods: In a prospectively followed study population of twenty-six patients undergoing an AxiaLIF for single level L5-S1 pathology, eleven patients fulfilled the criteria of obesity. The Visual Analogue Score (VAS) and Oswestry Disability Index (ODI) were assessed pre-operatively, at 3, 6, 12 and 24 months after surgery. Computer tomography was obtained at 6 months and 12 months to determine fusion status. In addition, data on hospital stay time, operative time, blood loss, complications and reoperation rate were collected.

Results: The mean BMI was 37 ± 6 (range 30-47). Significant improvement occurred in back pain severity and functional impairment. Mean ODI scores improved from 59 ± 16% to 25 ± 15% at 24 months. The mean pain score improved from 74 ± 21 pre-operatively to 36 ± 36. The overall radiographic fusion was 82%. However, the two non-fused patients had osteoporosis. No surgical complications occurred. The total operative time was 108 ± 13 min, the average blood loss was 20 ± 19 cc. The average hospital stay was 37 ± 22 hrs.

Conclusion: The AxiaLIF provides a safe, fast and reliable minimally invasive surgical access to the lumbar sacral segment in morbid obese patients with good clinical and radiographical outcome. The absence of serious side effects and short hospital stay will reduce cost of treatment for this patient population.

321 Epidural Tuberculosis Involving the Entire Spine Jacob Mathew

Introduction: This study is a case report describing the clinical features and radiological presentation of epidural spinal tuberculosis involving the entire spine and its optimal management. This rare clinico-radiological presentation has never been reported in the literature.

Methods: We discuss an elderly male who developed back pain, rapidly progressing paraparesis and urinary retention consequent to L5-S1 spinal tuberculosis with dissemination of epidural tubercular abscess and granulation tissue to the cervical, thoracic, lumbar and sacral regions. The thoraco-lumbo-sacral pathology was tackled by L5 laminectomy and decompression along with a minimally invasive technique for the epidural extension superiorly and inferiorly. Subsequently he was found to have clinical and radiological evidence of extensive cervical extradural compression which required cervical laminectomy.

Results: At 9 months follow up with anti-tubercular treatment he had excellent neurological improvement. MRI screening of the entire spine showed complete resolution of the disease.

Conclusion: This report illustrates a rare
presentation of spinal TB involving the entire spine which has never been reported previously. We suggest that screening of the entire spine should be done in select cases of spinal TB based on symptomatology. In spite of the advanced age and complexity of the illness, this patient could be managed optimally and a good outcome was achieved.

324 Kinematic Assay of Multi-Level Anterior Cervical Discectomy and Fusion with Supplementary Facet Screw Instrumentation
Introduction: One-level anterior cervical discectomy and fusion (ACDF) operations demonstrate high clinical fusion rates (~95%). In contrast, attaining sufficient rigidity to achieve intervertebral fusion in multi-level ACDF operations is formidable. We hypothesized that transarticular facet screws would decrease acute range of motion (ROM) of the multi-level ACDF. A kinematic analysis of cadaveric cervical spines following a three-level ACDF supplemented with unilateral and bilateral trans-facet screws was performed to test this hypothesis.
Methods: 1.5 N-m moments were applied to C2-T1 human spines (n=8) in the axial rotation, flexion and extension, and lateral bending directions. Loadings were imposed on C2 with a robotic actuator while T1 was bound to a force sensing transducer. A typical stereophotogrammetric technique assessed intervertebral rotations. Each spine was tested in four surgical forms: 1) Untreated, 2) standard multi-level ACDF between C4-C7, 3) ACDF including Unilateral facet screws between C4-C7, and 4) ACDF including Bilateral facet screws between C4-C7 (Figure 1). ACDF hardware was comprised of the 3-level ATLANTIS VISION® anterior cervical plate with variable-angle screws at the more superior levels, fixed-angle screws at the caudal level, and VERTE-STACK®PERIMETR™ X5 polyester ether ketone (PEEK) spacers. The TOWNLEYTM TRANSFACETPEDICULAR Screw Fixation System was utilized for facet fixation.
Results: ROM declined at the treated levels following each operation. The decrease in ROM relative to the Untreated case was 74.9%, 87.7%, and 93.5% for the ACDF, Unilateral facet fixation, and Bilateral facet fixation cohorts, respectively. Bilateral facet fixation was the only treatment to consistently furnish a statistically-significant (P < 0.05) decrease in ROM over the standard ACDF (Figure 2).
Conclusion: Bilateral facet screws demonstrated a significant reduction in acute ROM vs. the standard ACDF operation. Thus, bilateral facet screw supplementation may be applicable for improving ACDF acute stability.

326 Axonal Misdirection in a Femoral Nerve Neuroma in Continuity Injury Model
Jacob D. Alant, Joanne Forden, Rajiv Midha
Introduction: Management of traumatic neuroma-in-continuity (NIC) poses ongoing challenges to peripheral nerve surgeons. Axonal misdirection with non-specific reinnervation, frustrated regeneration and axonal attrition following NIC injuries, are believed to be among the anatomical substrates that result in poor functional recovery and neuropathic pain. We hypothesize that unlike crush injuries, NIC injuries would result in axonal misdirection similar to transaction injuries.
Methods: A malleus nipper (MN) was modified and calibrated to exert a range of intense uniform compression forces (Fig.1). Histological NIC features were reproduced in vivo when sub-transection compression forces were applied to nerves with 3-second malleus nipper compression and optimized in combination with simultaneous 50g traction with a spring scale hooked around the nerves. 42 male Lewis rats were randomized into one of 7 groups of 6 rats each for left femoral nerve surgeries (Fig.2). At 28 days, Fast Blue and DiI were respectively applied distally, to the main motor and sensory divisions of the nerves for retrograde labeling of spinal cord motor neurons. Distal nerve segments were also harvested at this time for histomorphometry. 13 days later spinal cords and femoral nerves were harvested for longitudinal cryostat sectioning, counting of fluorescently labeled neurons and histological evaluation of injury zones.
Results: Axonal misdirection and motor-neuron counts of the (MN+50g)x2 group showed statistically significant differences compared to the sham and crush groups, similar to the transection and transection+repair groups (Fig.3). Other results are still pending.
Conclusion: So far our results further characterize this injury model by demonstrating a high degree of axonal misdirection and attrition in severe NIC injuries, consistent with long held theories. This NIC model may serve as a tool to help us to better understand the pathology of these devastating injuries in order to catalyze a breakthrough in early diagnostic and intervention strategies and ultimately lead to improved patient outcomes.

327 Lumbar Spine Annulus Yield May Contribute to Instability
Jamie Baisden
Introduction: Elevated single cycle or repeated loading leads to failure of lumbar intervertebral disc fibers. This contributes to increased segmental flexibility, accelerated disc and facet degeneration, and eventual instability. Mechanical yielding of annular fibers occurs prior to ultimate failure and results in decreased stiffness. This study outlined lumbar annular fiber yield characteristics to hypothesize whether yielding may contribute to segmental instability.
Methods: Intervertebral discs obtained from 5 cadaveric specimens were graded as mildly degenerated according to an accepted scale. Specimens obtained from a single annular layer, with all fibers running in parallel, were quasi-statically distracted to failure in an environmental chamber simulating in vivo conditions. Axial force and displacement were recorded and normalized to stress/strain based on initial specimen dimensions.
Results: Mechanical yield occurred prior to ultimate failure in all specimens and was characterized by a decrease in slope of the stress-strain curve. Yield and ultimate properties were not dependent upon spinal level. Yield occurred at 80% of the stress and 75% of the strain to ultimate failure. Post-yield modulus (e.g., slope of the stress-strain curve between yield and ultimate failure) was 54% of the elastic modulus (e.g., slope of the stress-strain curve in the physiologic region).
Conclusion: Mechanical yield of annular fibers occurs early in the tissue strain response, leaving 20-25% reserve strength/extensibility in the fibers. However, once yielded, fiber stiffness
increased by 46%. This early occurrence of yield and considerably decreased post-yield stiffness may play a role in segmental instability as it occurs at only 75% of the total fiber extensibility and may add considerable flexibility to the disc. Normal activities coupled with age-related changes may “push” limits especially in specific populations wherein routine loading of the back occurs and accelerate degenerative effects to the spine through the annulus yield mechanism.

328 Part I: Observations on Bone Morphogenetic Protein in Transformaminal Lumbar Interbody Fusions
Luis M. Tumialan, Mark A. Mahan, Frederick F. Marciano, Nicholas Theodore
Introduction: Ectopic bone formation, radiculopathy, seroma development and osteolysis have been identified in TLIF’s with rhBMP-2. ALIFs with rhBMP-2 in lumbar tapered cages, however, have not exhibited the same pattern of complications.

Methods: A retrospective review of clinical and radiographic data was performed on all patients over a three year period who had undergone lumbar interbody fusion through either a transformaminal or anterior approach with rhBMP-2. The milligram doses of rh-BMP-2 were correlated with complications and outcomes.

Results: Thirty-six patients were retrospectively reviewed over a 3 year period. Delayed radiculopathy, ectopic bone formation and osteolysis were all identified within the group (4 of 36 patients or 11% of the series). A delayed radiculopathy after a transforaminal lumbar interbody fusion appears to be the result of an inflammatory response of rhBMP-2 interacting with the exposed cancellous bone from the facetectomy. The area of hyperintensity on T2 weighted MR imaging obtained 9-12 weeks postoperatively is highly predictive of where bone deposition will occur. Bone formation has a tendency to form outside the collagen sponge and in the presence of the rh-BMP-2 solution that is in contact with the cancellous bone. This finding appears to be dose related. Violation of the cortical endplate and exposure of the cancellous bone appears to be the cause of osteolysis. None of these complications were identified in those patients who underwent an ALIF with the same or greater amount of rh-BMP-2.

Conclusion: A lower dose of rh-BMP-2 (1.05 mg), eliminating the exposure of rhBMP-2 solution to the neural elements and limiting the rh-BMP-2 enhanced sponge to an interbody device to avoid its compression, collectively minimizes the risk of delayed complications from use of this protein. A prospective study applying these principles will be subsequently reported.

329 Pressure Ulcer Prevention During Prone Position Spinal Surgery
Masahiko Akiyama, Shigekuni Tachibana, Hiroki Ohashi, Satoshi Tani, Toshiaki Abe
Introduction: Prevention of pressure ulcer formation is one of the issues during prone position spinal surgery. One of the major causes for pressure ulcer formation is direct compression of patient body to the operating table. We have tried the best effort to decompress local pressure sites using silicone gel pad, however, epidermolysis or blister formation have been occurred in some patients, which led to be one of major complaints after surgery. We have hypothesized that not only direct compression but friction between patient body and operating table could contribute for pressure sore formation. We started to apply baby powder to patient body and silicone gel pad to reduce the friction.

Methods: 110 patients, who underwent prone spine surgery, have been applied this method since April 2009.

Results: No epidermolysis or blister formation have occurred except one patient, who suffered from disseminated papule due to pre-existing dermatitis, had minor epidermolysis.

Conclusion: Application of baby powder to patient body and silicone gel pad is simple and effective method to reduce the friction at local compression sites and to prevent pressure ulcer formation during prone position spinal surgery.

330 Simultaneous Direct Lateral Interbody Fusion and Posterior Percutaneous Screw Fixation
Doniel Drazin, Ali Shirzadi, Michael S. Turner, Beren Tomooka, Srinath smugglingala, Wesley A. King, Terrence T. Kim, J. Patrick Johnson
Introduction: Simultaneous lateral lumbar fusion procedures are becoming more common for degenerative lumbar disease requiring fusion and they are typically performed by repositioning the patient to complete the second stage of the circumferential procedure. We have developed a method for performing both procedures in a single lateral position. This technique will shorten the length of surgery and increase operative efficiency while maintaining surgical precision.

Methods: We performed a retrospective chart review of ten patients who underwent both procedures simultaneously and compared the outcomes with a control group of ten patients who underwent the lateral interbody fusion and were then repositioned for posterior percutaneous screw fixation. Among the treated patients, one patient had a traumatic liganmental injury, one had bilateral pars fractures with instability, one had mobile grade two spondylolisthesis, and the remaining patients had severe degenerative disk disease at a single level. Indications for surgery included worsening back pain in patients who failed exhaustive conservative management.

Results: Ten patients underwent both procedures simultaneously. Avoiding repositioning, operative time from incision to closure averaged 130 minutes (vs. control 190 minutes, P = 0.009) and intraoperative blood loss was 108 ml (vs. 93 ml, NS). Non-repositioned patients were hospitalized an average of 4 days (vs. 7 days, NS). There was one complication in the control group requiring screw repositioning.

Conclusion: The lateral interbody fusion and percutaneous pedicle screw procedures are both readily accomplished in the lateral decubitus position. In select patients with adequate size pedicles, performing simultaneous procedures offers an advantage over sequential surgery requiring repositioning. Performing the surgeries together accomplished a three column fusion with increased stability over each procedure performed alone. Patient outcomes were excellent and comparable to procedures done in series.

331 Iliac Osteotomy to Enhance Exposure of the L4-5 Interspace in Minimally-Invasive Direct Lateral Interbody Fusion: A Cadaveric Feasibility Study
Ricardo B.V. Fontes, Vincent C. Traynelis
Introduction: Minimally-invasive direct lateral interbody fusion (DLIF) has emerged as a popular surgical technique in a remarkably short period of time. We have found that the iliac crest may occasionally prevent access to the L4-5...
interspace for a DLIF procedure. We propose that removal of a minimal amount of ilium may allow for successful exposure of the L4-5 interspace in those cases with a “high-riding” iliac crest.

**Methods:** Twenty L4-5 DLIF procedures were performed on 10 cadavers. L4-5 DLIF was successfully completed in 13/20 attempts. In the remaining 7 cases, the iliac crest prevented perfect orthogonal access to the L4-5 interspace. An iliac osteotomy was performed until the tubular retractors could be perfectly aligned with the L4-5 interspace and DLIF accomplished. Pre- and post-osteotomy AP fluoroscopy images were obtained. Working instrument-L5 superior endplate angle and cranio-caudal displacement were measured, as well as the resected iliac area.

**Results:** Iliac osteotomy enabled completion of L4-5 DLIF in the 7 remaining cases. Iliac resection was minimal, an average of 4.92 cm² of iliac surface was resected (range, 2.08-8.27 cm²) to enable L4-5 access. Adequate working angles were maintained (average 3.3 degrees change post-resection) while significant caudal translation of the tubular system was achieved (average 15.7 mm, range 5.2-27.6 mm).

**Conclusion:** A significant fraction of patients may have a “high-riding” iliac crest and that may have had an impact on DLIF series: L4-5 cases are scarce in relation to the mid-lumbar spine in most DLIF series. Significant caudal displacement of the tubular system was achieved with minimal iliac osteotomy, ensuring access to the L4-5 interspace in all specimens while maintaining the minimally-invasive philosophy behind DLIF.

**332**

**The Minimally Invasive TLIF: Are Two Surgeons Better than One?**

**Luís M. Tumialan, Frederick F. Marciano, Nicholas Theodore**

**Introduction:** The very nature of the minimally invasive TLIF requires two separate incisions and thereby two essentially distinct operative sites. The authors wished to determine the impact of a second surgeon in this operation, with a particular focus on operative time and radiation dose.

**Methods:** The authors retrospectively reviewed data from a prospectively collected database on minimally invasive TLIFs. Total fluoroscopy time, radiation dose, operative time, estimated blood loss, hospital stay and clinical outcomes were compared between cases performed by one and two surgeons. Statistical significance between the two groups was evaluated by a paired Student’s t-test.

**Results:** A total of 24 minimally invasive TLIFs were identified that met criteria for pairing. Indications for surgery included degenerative spondylolysisis and degenerative disc disease. Levels of surgery included L3-4, L4-5 and L5-S1. The mean fluoroscopy time, radiation dose and operative times for one surgeon were 113.54 seconds, 1.26 mGy.m², 228 minutes respectively, whereas for two surgeons the mean values were 67 seconds, 0.73 mGy.m², and 179 minutes. For one surgeon, the mean estimated blood loss, total hospital stay and clinical outcome at 90 days measured by change in preoperative and postoperative Oswestry Disability Index (ODI) were as follows: 115 cc, 1.8 days, 28.6, whereas for two surgeons the EBL was 118 cc, 1.74 days and 26.4. A paired Student’s-t-test demonstrated statistical significance in operative times (P = 0.000636), radiation dose (P = 0.025) and fluoroscopy times (P = 0.000252). There was no statistical significance between the two groups with regards to hospital stay, estimated blood loss and clinical outcomes.

**Conclusion:** Two surgeons working simultaneously in a minimally invasive TLIF decrease fluoroscopy times, total radiation dose and total operative time when compared to one surgeon. However, this does not appear to impact EBL, hospital stay or clinical outcome. A cost effective analysis to further study this is warranted.

**333**

**Can We Predict Adjacent Ligamentous Injury on MRI After Cervical Spine Fracture?**

**Margaret Carmody, Jeffrey Claridge, Michael Novak, John J. Como, Michael P. Steinmetz**

**Introduction:** Cervical spine injury is a common presenting diagnosis to trauma centers. The addition of MR to CT imaging to evaluate for adjacent ligamentous injury is often performed, however there is currently no standard as to when this should be done. This study was undertaken to determine the characteristics of soft tissue injuries that are associated with cervical spine injury, as well as develop guidelines for when MR imaging should be performed.

**Methods:** Retrospective analysis of all patients treated for traumatic cervical spine injury in a Level I trauma center from 2005 - 2010 was performed. All patients had evidence of a cervical fracture based on CT scan, while a subgroup underwent MRI. Analysis was then performed to show relationships between specific cervical spine fracture types, location and neurological status and any associated adjacent ligamentous injury based on MRI scan.

**Results:** During the study period, 787 patients had one or more cervical fractures identified on CT scan, 240 of these underwent MRI scanning. One hundred thirty-one (56%) had evidence of adjacent ligamentous injury. Patients with multiple fractures, multiple fracture types, and presence of neurologic injury were more likely to undergo MRI compared to those that did not (P < 0.001). Adjacent soft tissue issue was significantly associated with the presence of multiple contiguous fractures (P < 0.01), presence of more than one type of fracture (P < 0.002), and presence of any type of neurologic injury (P < 0.001).

**Conclusion:** Only 50% of the patients who underwent MRI following a cervical fracture actually had evidence of adjacent ligamentous injury. Factors that strongly predicted adjacent injury were multiple contiguous fractures, multiple fracture types and presence of neurological deficit. There is significant cost and time associated with these scans. Their use in these patients should be scrutinized for necessity and overall influence on decision making.

**334**

**Adult Degenerative Scoliosis Treated by XLIF: Clinical Results of a 24-month Multi-center Prospective Study**

**W.B. Rodgers, Frank M. Phillips, Antoine Tohmeh**

**Introduction:** Surgical intervention for adult deformity is associated with prolonged recovery periods and a high risk of complications, particularly in the elderly patient population. This report summarizes the longitudinal clinical results from a prospective multicenter study on the treatment of adult degenerative scoliosis with the lateral interbody fusion (XLIF) approach.

**Methods:** 107 patients who underwent the XLIF procedure with or without supplemental fixation for the treatment of degenerative scoliosis were enrolled in a
prospective multicenter, nonrandomized IRB-approved observational study of clinical and radiographic outcomes of the XLIF procedure from 2007-2009. Neurologic evaluation and patient-reported clinical outcomes ODI, VAS, SF-36, and satisfaction were collected at baseline, 1.5, 3, 6, 12, and 24 months.

Results: 79 patients have completed 24-month follow-up. Average patient age was 68 years. Mean Charlson co-morbidity score 0.48. A mean of 4.4 levels were treated per patient with anterior and/or posterior fixation. Supplemental pedicle screw fixation was used in 75.7% of patients. Mean operative time was 178 min and median EBL 100-200 mL. Mean hospital stay 3.8 days (2.9 unstaged, 8.1 staged). Of 34 motor and 20 and sensory deficits identified pre-operatively, 26 motor and 18 sensory were improved after surgery. New and persistent post-surgical neurologic deficits were identified in 7 patients. Clinical outcomes were improved (P < 0.05) from baseline to 24 months. At 24 months 85% were satisfied with their procedure and 85% stated that they would repeat their procedure. Major perioperative complications occurred in 13 patients (12.1%). Additional complications to date include 1 posterior revision for painful hardware and 1 cage failure without revision.

Conclusion: This prospective study represents the largest report of patients treated with XLIF for adult scoliosis. This study supports XLIF as a valuable adjunct in the treatment of adult scoliosis. Despite advanced age and co-morbidities, data from this study reflect promising clinical outcomes, low revision rates, and high patient satisfaction.

335 Predictors of Early Postoperative Discharge Following Minimally Invasive Lateral Interbody Fusion (MI-LIF)

W.B. Rodgers, Edward J. Gerber, Jeffrey A. Lehmen, Jody A. Rodgers

Introduction: Extended hospitalization following spine surgery has been shown to increase the potential for postoperative complications, namely infection, and substantially increase costs. In interbody fusion procedures, namely MI-LIF, where minimal approach morbidity has been shown to allow for early postoperative functionality and early discharge, though patient characteristics which may predict early discharge following MI-LIF are heretofore unreported.

Methods: Prospective data on 1033 consecutive MI-LIF patients from October 2006 through June 2011 were reviewed. Of these, 873 were discharged in <23 hours (outpatient), and 160 were discharged in >23 hours (inpatient). Within the outpatient group, 45 patients were discharged within 8 hours of surgery (ambulatory). Demographic data were compared between outpatient and inpatient groups, as well as between ambulatory and outpatients.

Results: Factors impacting early discharge (out- vs. in-patient) were age, gender, smoking, deformity, preop hemoglobin (Hgb) level, preop disc height, number of levels treated, and fixation type. Mean age for out- and in-patients was 61.9 and 66.7 years, P < 0.001. More males were outpatients (88.2%) compared to females (81%), P = 0.012. Smoking was, surprisingly, more frequent in outpatient compared to in-patients (34.3% and 22%), P = 0.003. Preoperative Hgb and disc height were higher in outpatients (13.8g and 6.3mm) than inpatients (13.1g and 5.4mm). More levels treated predicted being in patient (P < 0.001), and non-pedicle screw fixation favored outpatient discharge, P < 0.001. No differences were seen between out and inpatients in terms of number of comorbidities or having had prior surgery. Ambulatory patients were younger than both out- and in-patients (53.2 years, 62.4 years, and 66.7 years), P < 0.001, had even higher preoperative Hgb (14.4g, 13.7g, and 13.1g), P = 0.001, and preoperative disc height (7.6mm, 6.3mm, and 5.4mm, all respectively), P = 0.002.

Conclusion: These data suggest that factors including but not limited to lower age, elevated preoperative hemoglobin, elevated preoperative disc height at the index level, having fewer indicated levels with single-incision fixation may predict early discharge following MI-LIF.

336 Predicting Adjacent Segment Degeneration After Cervical Fusion Surgery: A Novel Grading System

Alexander E. Ropper, Yang D. Teng, Charles H. Cho

Introduction: Adjacent segment degeneration is a common, delayed complication of cervical fusion surgery. We evaluated the appearance of discs adjacent to cervical fusions, both before and after surgery, to determine if preoperative disc appearance was a prognostic factor for subsequent development of adjacent segment degeneration.

Methods: We retrospectively reviewed adult patients at a single institution who underwent any cervical spine fusion procedure for traumatic fractures, dislocations or ligamentous injury or for degenerative disc disease, spinal stenosis, ligamentous hypertrophy or foraminal stenosis over ten years. Any patient whose fusion construct contained at least one cervical vertebral body was included. A simple grading system (grades 0-4) was designed to evaluate intervertebral disc appearance on sagittal T2 MRI imaging. Preoperative and postoperative MRIs were reviewed and the adjacent disc(s) were graded and compared to evaluate progression of adjacent segment degeneration.

Results: 190 adjacent cervical discs were included in the analysis. The mean period from surgery to the last reviewable MRI was 16.3 months (median 10.3 months). Contrary to our hypothesis, the incidence of progression (to a higher grade) occurred in the same proportion of discs regardless of the preoperative grade. The percentage of discs that did not progress was closely clustered, between 66-69% based on preoperative grade.

Conclusion: The grading system described in this study provides a novel and simple characterization of adjacent cervical intervertebral discs. The data suggest that preoperative disc disease visible on MRI was not a prognostic factor in the development of adjacent segment degeneration. This pilot study can be used to guide larger scale, prospective research to define additional predictive imaging factors for adjacent disc degeneration in patients about to undergo cervical spinal fusion surgeries. This information can be valuable to surgeons for planning the extent of cervical fusion constructs.

337 Minimally Invasive Lateral Interbody Fusion (MI-LIF) at L4-5 and the Protective Effect of Prophylactic Dexamethasone

W.B. Rodgers, Edward J. Gerber, Jeffrey A. Lehmen, Jody A. Rodgers

Introduction: It has been reported that MI-LIF procedures performed at the L4-5 level have a higher incidence of postoperative motor deficits compared to other lumbar segments, and must occasionally be aborted to due anatomic constraints.

Methods: In our single-site consecutive
series of 1093 MI-LIF patients, 646 (59%) included the L4-5 level. Clinical and radiographic data were prospectively collected and reviewed to assess MI-LIF procedure at the L4-5 level.

**Results:** Age averaged 62.3 years (24-88 years). 92.9% had one or more comorbidities. 33.1% had prior lumbar surgery. All procedures were successfully completed. Hospital stay averaged 1.3 days. Average VAS pain scores improved from 8.6 at pre-op to 2.8 at 12 months and 2.7 at 24 months follow-up. Lenke fusion scores of 1-2 were present in 96.2% at 6 months, and 99.4% at 24 months. Neural complications included 4 (0.6% of all cases, 0.9% of L4-5 cases) transient lower leg weaknesses (3 quads, 1 anterior tibialis, all resolved within 3 months).

After the fourth postoperative motor deficit, we began to administer dexamethasone (10mgIV prior to skin incision) prophylactically in all MI-LIF patients in whom the L4-5 level was to be approached. Since the use of dexamethasone, no additional neural deficit developed, a statistically significant reduction in motor deficits.

**Conclusion:** The incidence of postoperative motor deficits following MI-LIF at L4-5 is low. The prophylactic administration of dexamethasone results in a statistically significant reduction in motor deficits.

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**338 XLIF for Grade II Spondylolisthesis at L4-5: The “Worst Case” Scenario**

W.B. Rodgers, Edward J. Gerber, Jeffrey A. Lehmen, Jody A. Rodgers

**Introduction:** The XLIF technique is an MIS alternative to traditional spinal fusion. However, concerns are raised about neural complications with the lateral approach, particularly at the L4-5 level where access is most difficult due to the lumbar plexus. Significant anterolisthesis at this level exacerbates this risk. Outcomes from a series of these “worst case scenario” patients treated with XLIF are reported.

**Methods:** 89 patients with Grade-II spondylolisthesis at L4-5, with and without concomitant stenosis, DDD, post-laminectomy instability, HNP, and/or scoliosis, were treated with XLIF. Clinical and radiographic data were reviewed to assess comorbidities, surgery details, hospital stay, complications, pain scores, changes in disk height and alignment, and fusion, and satisfaction scores at 24 months postop.

**Results:** Ages ranged from 25-91 years (ave 67.4 yrs.). Comorbidities were common (present in 93%). The L4-5 level was accessible in all cases. All cases included supplemental posterior fixation. LOS averaged 1.3 days. Complications included 1 pulmonary embolism requiring anticoagulation, 1 late-term hardware failure (screw fracture at 1 year), and 1 postop transfusion, ileus and postoperative arial fibrillation. No neural deficits were noted. In 28 patients at 24 months, VAS pain scores improved from 8.7 to 2.7. Average disk height improved from 4.6mm at pre-op to 10.3mm post-op, with 1.8mm settling at 24 months. Slip improved from 10.7mm at pre-op to 2.7mm and was maintained at 24 months. Lenke fusion scores averaged 1.9 at 3 months, 1.4 at 6 months, and 1.1 at 24 months. Eight patients underwent a CT scan at 12 months, all were judged as fused by an independent reviewer. 91% of patients were satisfied with the procedure and would do it again.

**Conclusion:** Grade-II spondylolisthesis at L4-5 can be treated successfully with a minimally invasive lateral approach. Results indicate good outcomes, few complications, and high satisfaction in the most difficult situation.

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**340 Recapping Laminoplasty for Spinal Surgery Using with Ultrasound Bone Curette**

Hidegori Matsuoka

**Introduction:** The laminoplasty technique is the most widely used procedure in spinal surgery. We developed a novel method of the recapping hemilaminoplasty in a retrospective study of the patients with spinal surgical disorders. This report describes the surgical technique and the results of the hemilaminoplasty using with ultrasonic bone curette. The aim of this study was to examine the safety and effectiveness of hemilaminoplasty technique in spinal surgery.

**Methods:** Twenty-nine patients who had undergone recapping hemilaminoplasty with ultrasonic bone curette for spinal disease between 2009 and 2010 did not need spinal canal enlargement after the intradural procedure was completed. In this study group, there were 17 men and 12 women with a mean age of 47.4 (range, 47-74 years). The mean follow-up period was 38.4 months (range, 5-91 months). The mean number of resected and restored lamina was 1.6. All patients were observed both neurologically and radiographically by dynamic plain radiographs and computed tomography (CT). Bony fusion was evaluated by dynamic plane radiographs based on Ray’s criteria and computed tomography for 3, 6, 12 months, and then every 12 months.

**Results:** Recapping laminoplasty was done safety to obtain an enough wider laminotomy space for an intradural procedure preserving posterior elements including spinous process, interspinous ligaments, supraspinous ligament and facet joint. CT confirmed primary bone fusion in the all patients by 6 months after surgery. Postoperatively, no major complications such as postoperative spinal canal stenosis, facet arthrosis, or kyphosis were reported.

**Conclusion:** Recapping hemilaminoplasty is a useful posterior approach for intraspinal canal procedure preserving the posterior elements. This method allows anatomical reconstruction of the excised bone preserving the posterior surrounding tissues.

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**341 Spinal Fusion with Porous Tantalum Interbody Cages: Experience in 149 Cases**

Ira M. Goldstein

**Introduction:** Porous tantalum (trabecular metal) is a highly porous, osteoconductive scaffold that has been used for numerous bony reconstruction applications since 1997. Its compressive strength and elastic modulus are similar to that of dense cancellous bone, serving as a mechanically stable graft material without the morbidity of autograft harvest or the potential for disease transmission of allograft utilization.

**Methods:** A retrospective chart review of 149 patients who underwent interbody fusion with trabecular metal cages and instrumentation. Fusion was assessed via the presence of visible bridging bone or by the absence of motion on flexion-extension Xrays and by the absence of hardware loosening.

**Results:** 149 patients underwent ACF (n = 130), TLIF (n = 13), ventral thoracolumbar corpectomy (n = 3), PLIF (n = 2), and ALIF (n = 1) between April 2005 and July 2011. Surgical indications were degenerative spinal disease (n = 97), trauma (n = 29), osteomyelitis (n = 13), deformity (n = 6), pseudoarthrosis (n = 3), or vertebral neoplasm (n = 1). Follow-up ranged from 1 to 36 months. 86 patients had follow-up of greater than 6 months. Graft expulsion or displacement was seen
in no patients. Persistence of infection (in patients with abscess/osteomyelitis preop) was seen in one patient who developed a superficial wound dehiscence. Pseudoarthrosis or loss of deformity correction was seen in no patients. Visible bridging bone adjacent to the tantalum cage was seen in most patients with ACDF (not corpectomy) or TLIF between 6 and 12 months postop. 1-2 mm of cage subsidence was common. Subsidence was more significant with posterior approaches.

Conclusion: Porous tantalum cages have been used in a variety of orthopedic applications with good success. Tantalum is extremely radiopaque, making CT evaluation difficult. Indirect measures of fusion via flexion-extension imaging as well as the direct visualization of bridging bone across more limited (less than 10 mm) intervertebral spaces allows for assessment of spinal stability.

342 O-arm Navigation For Placement of Atlantoaxial and Cervicothoracic Junction Screws: Technique and Initial Clinical Experience
John K. Houten, Gaurav Jain
Introduction: Compared with mid-cervical area lateral mass screw fixation technique, screw placement at the atlantoaxial level and cervicothoracic junction is particularly challenging, as minor imprecision of the trajectory may place the vertebral artery or spinal cord at risk. Fluoroscopy-guidance does not provide an axial view to determine the relationship of the pedicle wall and spinal canal and the shoulders obscure cervicothoracic junction visualization. Navigation preoperative CT scans is limited by inaccuracies from human error in paired-point matching during registration and by changes in spinal position between the supine preoperative scan and the prone operative position. The O-arm Multidimensional Surgical Imaging System promises to provide superior accuracy in screw placement by overcoming the limitations of earlier navigation technologies.
Methods: Fifteen consecutive patients (Table 1) mean age 56 (8-81) underwent posterior fusion with screw fixation at either the atlanto-axial or cervicothoracic junction area using computer-assisted navigation of intraoperative O-arm imaging. A tracker was fixed to the 3-pin head-holder (Figure 1) with an infrared camera positioned at the head of table. The bony tract was created with a Jamshidi needle with an integrated reflector array. (Figure 1) followed by screw hole creation using a navigated drill guide. Screws placed in the C1, C2, C7, T1 and T2 were reviewed for accuracy on postoperative CT scanning or O-arm scans.

Results: Sixty-eight screws were placed (Table 1), and 66/68 (97%) were entirely within the confines of bone. One T2 screw violated the lateral pedicle cortex 2 mm and one T1 screw breached the lateral cortex 5 mm. There were no clinical symptoms from the pedicle breaches. Conclusion: Initial experience with O-arm guided navigation showed good accuracy in cervical and upper thoracic screw fixation. Additional evaluation of the technology is warranted, particularly for patients with difficult surface anatomy or an anomalous course of the vertebral artery.

343 The Use of Three-Dimensional Image Guidance in Subaxial Anterior Cervical Surgery: Technical Note
Eric W. Nottmeier, Stephen M. Pirris
Introduction: Three-dimensional (3D) image guidance has been used to navigate posterior cervical spinal anatomy to aid in accurate instrumentation placement.[1-4] The use of 3D image guidance for navigating anterior cervical anatomy can be challenging because of the dynamism in this area of the spine and the difficulty of fixing the image-guided reference arc to the patient. The authors have found 3D image guidance helpful in navigating the spinal anatomy in revision anterior cervical procedures, as well as anterior cervical procedures involving corpectomy or tumor removal. The technique of 3D navigation of the anterior cervical spine utilizing cone based computed tomography (cbCT) is described.

Methods: This technique was used in 20 patients who underwent anterior cervical procedures utilizing cbCT-based, 3D image guidance (Table 1). In each case, the patient was placed supine on a short board of a radiolucent spine table allowing for the head to be suspended and fixated by a skull clamp headholder. The reference arc of the image-guided system was attached to the headholder. An intraoperative cbCT scan was accomplished prior to prepping the patient (Fig. 1). Image guidance was used to mark pertinent anatomical structures depending on the case. In corpectomy cases, the exact midline of the cervical spine and the borders of the corpectomy were marked. Image guidance was used to guide bone removal and/or locate specific anatomy relevant to the specific case being performed.

Results: Image guidance was able to reliably locate pertinent anatomical structures. No complications resulted from the use of image guidance and no vascular injuries occurred. No patients required a revision anterior surgery.

Conclusion: This technical note describes the setup and technique for the use of 3D image guidance in anterior cervical surgery. The authors have found 3D image guidance to be a useful adjunct in revision anterior cervical procedures, as well as anterior cervical procedures involving corpectomy or tumor removal.

344 Outcomes in Minimally Disruptive Lateral Interbody Fusion: 24 Month Minimum Follow-up in 268 Patients
W.B. Rodgers, Edward J. Gerber, Jeffrey A. Lehnen, Jody A. Rodgers
Introduction: This study presents the largest series of patients treated with minimally invasive lateral interbody fusion (MI-LIF) with long-term outcomes to date.

Methods: Prospective treatment, complication, functional outcome, and radiographic data on 1093 consecutive MI-LIF patients were reviewed. Of these, 268 were eligible for and completed 24 month follow-up. Patients were 63% female with a mean age of 62.2 years and BMI of 31.3. Baseline comorbidities included CAD (48%), smoking (31.5%), DM (24.2%), and prior spine surgery (38.3%). The most common primary indications included stenosis (46.4%), spondylolisthesis (17.7%), and DDD (11.3%). A total of 318 levels were treated with MI-LIF and supplemental internal fixation was used in all but 5 (2%) cases.

Results: In these 268 patients, 19 (7.1%) complications occurred. Complications related to the procedure included 3 hardware failures (posterior), 1 nerve injury (quadriiceps weakness), 4 vertebral body (VB) complications, and 1 incisional hernia. Pain (VAS) improved 65.7% from pre-op to 24 months (8.69 to 2.98, respectively). Disk height improved from 6mm pre-op to 10.3mm immediately post-op, settling at 8.9mm at 24 months. Slip was reduced from 4.5mm pre-op and was corrected and maintained by 83% through 24 months (0.85mm). Mean Lenke fusion...
345 Comparison of Resident Physician Thoracolumbar Pedicle Screw Placement Accuracy with Either O-arm Multidimensional Image Guidance or an Open, Lateral Fluoroscopy Technique

John K. Houten, Adam Lance Sandler, Adesh Tandon

Introduction: Minimally invasive technique in thoracolumbar fusion surgery is increasingly popular, and accurate placement of pedicle screws in these procedures necessitates skills beyond those needed for open, free-hand cases. The introduction of the O-arm system permits screw placement without examination of surface anatomy or fluoroscopy. The effect of adopting image-guided surgery using the O-arm upon resident training has not been studied. We compare the accuracy of open vs. O-arm guided pedicle screw placement by novice junior neurosurgical residents.

Methods: Two teams of first and third year neurosurgical residents placed pedicle screws in TruTrain spinel models using either using a percutaneous, O-arm-image-guided technique or a mini-open, lateral-fluoroscopy-guided technique. All models were imaged post-procedure by cone-beam CT scan. Screw placement accuracy was assessed using a published, four grade scale.

Results: In the O-arm group, two of forty (5%) screws breached the pedicle cortex compared with eleven of forty (27.5%) using lateral fluoroscopic guidance. \( P = 0.013 \) There were no grade two or three perforations using the O-arm compared with two grade two and one grade three perforations with the open, C-arm technique. There was no difference in accuracy between first and third year residents. Thoracic pedicle perforation occurred in 8/32 screws, a higher rate than the 7/48 seen in the lumbosacral area.

Conclusion: No statistically significant association of surgical approach is a complex series of history, physical examination, and diagnostic injection. The diagnosis of surgical level SIJ disease and its qualification for surgical approach is a complex series of history, physical examination, and diagnostic injection. The diagnosis of surgical level SIJ disease and its qualification for surgical approach is a complex series of history, physical examination, and diagnostic injection.

346 Minimally Invasive Lateral Interbody Fusion in the Morbidly Obese

W.B. Rogers, Edward I. Gerber, Jeffrey A. Lehm, Jody A. Rodgers

Introduction: Minimally invasive procedures are challenging in obese patients whose body habitus may decrease the accessibility of the spine to the instruments necessary to perform these procedures. The MI-LIF procedure, however, is performed in the lateral decubitus position, minimizing the difficulty of the pannus as it falls away from the exposure.

Methods: In our single-site prospective series of 1093 MI-LIF patients, 576 were identified as obese (BMI>30) and 192 of those were morbidly obese (BMI > 38). Comorbidities, surgical details, hospital stay, complications, pain scores, changes in disk height and alignment, and fusion were assessed.

Results: In all morbidly obese patients, no surgery could not be successfully completed due to body habitus. The heaviest patient to date weighed 427 lbs (193.7 kgs), the largest BMI was 61.8. Age ranged from 22-83 years. Comorbidities included smoking (34%), prior spine surgery (47%), diabetes (41%), CAD (37%), COPD (3%). 244 levels were treated in these 192 patients: 150 1-levels, 33 2-levels, 8 3-levels and 1 4-level, the majority at L4-5. All but 2 surgeries included supplemental fixation. There were 3 transfusions and no infections. Complications included 2 MI’s at 4 and 6 weeks, 3 atrial fibrillation, pneumonia requiring intubation for 5 days, one other respiratory distress requiring re-intubation, one pulmonary embolism, two posterior hardware failure/rod fracture at 6 and 18 months, and one fracture of vertebral osteophytes and a vertebral body fracture at 2 months requiring reoperation. Hospital stay averaged 1.54 days. From pre-op to 24 month follow-up: disk height increased an average 3.0mm, slip decreased an average 3.6mm in spondylolisthesis patients, and VAS pain scores decreased from 8.7 preop to 3.1 at 24 mos. Lenke scores were 2.1 at 3 months, 1.2 at 12 months, and 1.1 at 24 months.

Conclusion: Our results demonstrate the usefulness and safety of the MI-LIF technique in treating morbidly obese patients minimally invasively. Complications are minimal, procedures timely, and outcomes similar to non-obese patients.

348 Clinical Decision Making, Differentiating Disabling Sacroiliac Pain from Axial Disc Based Explanations

John G. Stark, Chris Idenmili

Introduction: The sacroiliac joint has been defined by many authors as a cause of back and buttock pain. Though thought to be common, the means of diagnosis and accurate differential diagnostic has not been established.

Methods: The sample consists of 67 SIJ fusions. Sixty-two cases had pre- and post-op functional data available for comparison. Forty-seven out of 62 cases demonstrated a net functional improvement at last follow-up after surgery, as reflected on the Million Visual Analog Scale. Prior to the decision for surgery, all patients were studied for confirming clinical findings, injection response, and correlation to clinical history. Elements of the decision making process were ranked in order of importance to the final decision for surgery. ANOVA was performed on functional improvement after separating the sample into groups by primary elements of diagnosis.

Results: There was a significant improvement in average Million VAS score (95% confidence interval of 16 to 31 points of improvement), yet no statistically significant association of outcome with any individual subset of clinical findings was found, including history, physical examination, imaging and diagnostic injection.

Conclusion: The diagnosis of surgical level SIJ disease and its qualification for surgical approach is a complex series of history, physical examination, and evaluation of other etiologies which could explain the patient’s symptoms. The failure of clinical response of lumbar spine surgery to relief...
of symptoms or improvement, as demonstrated in the SPORT study, should prompt a closer evaluation of the totality of patient symptoms, and sufficient weight (without overemphasis) to all inclusive and exclusionary criteria.

349 Effect of Machined Interfacet Allografts on in Foraminal Height and Area
Vincent C. Traynelis, Carter S. Gerard, Lee A. Tan, Brian A. O’Shaughnessy, Paul A. Anderson

Introduction: Machined allograft has a large surface area, provides solid support, and could distract the facets thereby increasing foraminal space. We tested the hypothesis that machined interfacet allografts increase cervical foraminal area.

Methods: The C45, 56, and 67 facets of four fresh adult cadavers were exposed and the identified. The cartilage was removed from each facet using curets and rasps. Machined allograft spacers were tamped into the joints. These spacers were in all cases except the C56 and 67 joints in one large cadaver. The spines were scanned with the O-arm before and after placement of the spacers. Two individuals measured foraminal height and area on obliquely angled sagittal images independently. Averaged measurements from these reviewers were compared using the paired t-Test.

Results: The Pearson correlation between the two radiographic reviewers was very strong (r = .971, P = 0.0001) as well as the Intraclass coefficient (ICC = .907, P = 0.0001). The data are displayed in the table below. Foraminal height and area was significantly greater following placement of the machined interfacet spacers at all levels.

Conclusion: The data confirm the hypothesis that machined interfacet allografts increase cervical foraminal height and area. Modest distraction of the facets produced by the machined interfacet spacers increases foraminal area and therefore can indirectly decompress the exiting nerve root. These grafts should prevent foraminal stenosis which may occur when placing the initially nonlordotic spine into lordosis with either repositioning after decompression or with correction using instrumentation. This is particularly important at C45 due to the exquisite sensitivity of the C5 root.

Machined interfacet allografts provide solid support and should be expected to heal rapidly since the facets bear axial load which places the grafts under compression. These grafts may be a useful adjunct to the surgical treatment of cervical spine disease.

350 Clinical Outcomes After Hardware Removal in Patients with a Previously Instrumented Spine
Victor Chang, Mokbel K. Chedid

Introduction: The purpose of this study is to evaluate clinical outcomes in patients who undergo surgery for hardware removal after previous spine instrumentation. The goal will be to assess the clinical benefit of such surgery, and to potentially understand what predictors exist for improved patient outcome after hardware removal.

Methods: A database of all patients who underwent hardware removal procedures between 2008 and 2010 was created. Age, gender, body mass index (BMI), spinal segment, primary indication, secondary indication, number of levels, need for additional instrumentation, need for additional decompression, average follow-up, and narcotic freedom at last follow-up were all considered. Chi-square tests, two sample t-tests and Wilcoxon two sample tests were done to compare patient and procedure characteristics between patients who were and were not narcotic free.

Results: There were 69 patients included in the following analyses. Of these 69, 63% were female and the mean age was 61.1 (s.d.=12.2) with a range from 37 to 88. The outcome of interest was narcotic free at last clinic visit, for which 33 (47%) of the patients were (Table 1). The difference in rate of narcotic freedom was significant, with females having a higher rate than males (58% vs. 29%, P = 0.023). Also, the difference in mean BMI between the two groups of patients was significant, with patients with narcotic freedom having a higher mean BMI than patients without narcotic freedom (31.5 vs. 28.2, P = 0.024, see table 2). In addition, there was a trend for age when comparing the two groups, with patients with narcotic freedom having a slightly higher mean age than patients without narcotic freedom (63.7 vs. 58.7, P = 0.086).

Conclusion: Hardware removal of spinal instrumentation can be an effective treatment in patients with continued pain and narcotic dependence after an initial spinal fusion supplemented with instrumentation.

351 A New Approach to Lateral Lumbar Interbody Fusion with One-year Follow-up
Mitchell Hardenbrook

Introduction: The lateral approach to the lumbar spine for interbody fusion is a versatile and less invasive approach to the spine compared to the anterior approach. However, the current retractor systems have many limitations. The percutaneous nature of the current systems requires an over-reliance on neuromonitoring to navigate through the neuroplexus within the psoas muscle. Additionally, the blades and retraction mechanism are radio-dense obscuring fluoroscopic imaging. These deficiencies have lead to well-documented complications that may be avoided with better visualization.

Methods: A new two-retractor system is utilized to improve the safety profile of the lateral approach. In this approach, a radiolucent, fixed tube is placed through the retroperitoneal space and positioned on the surface of the psoas muscle. Under direct visualization with loupe magnification, the fibers of the psoas muscle are split in line with the muscle fibers. Neural structures can be visualized and avoided. A second, expendable retractor is then placed through the fixed tube and the psoas muscle is retracted under direct visualization. A complete and thorough discectomy and placement of an implant can then be safely performed.

Results: 22 patients underwent lateral interbody fusion on 28 levels for degenerative spondylolisthesis of the spine with one year follow-up. The average age was 53 years old (33-73). 20 patients underwent surgery at the L4-5 level. A PEEK interbody device was used for anterior column support. Posterior fixation was used in all patients (7 pedicle screws, 3 facet screws, 12 interspinous process fixation). Estimated blood loss was 220ml with average hospital stay of 2.5 days. There were no intra-operative complications. VAS before surgery was 7.2 and 2.8 at last follow-up. 20 of the 22 patients had post-operative CT scans showing solid fusion. 2 patients refused the CT scan. 2 patients required revision surgery: one for adjacent segment degeneration requiring extent of the fusion, and one with herniated disc at the adjacent segment requiring decompression.

Conclusion: This new retractor system allowed for safe and reproducible access to the lumbar spine.
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Minimally Invasive Lateral Interbody Fusion (MI-LIF) in Smokers
W.B. Rodgers, Edward J. Gerber; Jeffrey A. Lehnen, Jody A. Rodgers
Introduction: In a large single-site series of MI-LIFs, 356 patients smoked at the time of surgery. Overall clinical and radiographic outcomes and are reported.
Methods: In our single-site prospective series of 1093 MI-LIF patients, 356 smoked at the time of surgery. Patient demographics and clinical/radiographic outcomes were assessed.
Results: Patients ranged in age from 22-84 years (average 56 years) and were treated for a variety of indications. 46% had previous spine surgery. 17% had diabetes, 34% had CAD, 8% had COPD, and 11% were chronic steroid users. 49% were obese or morbidly obese. 427 levels were treated: 296 1-levels, 49 2-levels, and 11 3-levels. Grafting materials included a composite of DBM, local bone graft, and bone marrow aspirate (81.5%), a beta-tricalcium phosphate/hydroxyapatite with bone marrow aspirate (6.5%), and allograft cellular bone matrix containing native mesenchymal stem cells (1.7%). All but two surgeries included supplemental fixation, most performed in the same surgical position. There were no infections. Complications included 1 transfusion, 2 pneumonia, 1 reintubation, 1 ileus, 2 urinary retention, 1 atrial fibrillation, 1 endplate fracture (healed without intervention), 1 sacral fracture, 3 intraoperative hardware failures (replaced without incident), 1 osteophyte fracture (required reoperation), 2 compression fractures (required vertebroplasty), and 1 quad weakness (resolved without intervention). Hospital stay averaged 1.1 days. From pre-op to 24 months post-op, average disk height improved by 2.9mm, average slip improved by 3.6mm, average VAS pain scores decreased by 5.2 points. Signs of fusion by Lenke scores of 1 or 2 were 80% at 3 months, 94% at 6 months, and 98% at 12 months and 98% at 24 months – not significantly different from the greater non-smoking (624 pts.) cohort (84%, 95%, 97% and 98%, respectively).
Conclusion: Our results show no significant difference in the clinical and radiographic outcomes between smokers and nonsmokers. MIS fusion approaches may offset some of the deleterious effects of smoking on bone healing.

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Optimum Timing of Routine Ultrasound Sonography for Deep Vein Thrombosis in Asymptomatic Spine Patients During Hospital Admission: An Analysis of 591 Consecutive Patients
Akit Patel, D. Kojo Hamilton
Introduction: Protocols for the screening and prevention of Deep Vein Thrombosis (DVT) in neurosurgery are not applied universally, particularly when considering patients undergoing spinal surgery. While there is data on this topic in the field of spinal surgery, the overall principles and practices in regards to spine patients remains vague. The idea of screening ultrasonography for earlier detection of DVT has gained more overall consensus, but the timing of screening continues to remain unclear.
Methods: A retrospective review of 591 consecutive adult patients, who underwent admission, as well as weekly ultrasound screening at a university hospital center, over 1 year was conducted. Inclusion criteria included use of chemical and mechanical prophylaxis.
Results: There was a 2.5% incidence in this spinal surgical population. Of this group, 80% were diagnosed with DVT within 7 days of hospital stay, 0% diagnosed within 8-14 days, and the rest (20%) were diagnosed after 14 days of stay (p-value <0.05). There was a higher incidence of DVT in plegic and paretic patients, both on admission and during hospitalization.
Conclusion: Routine ultrasonography screening for DVT should continue to be utilized, as it has shown merit, but the effectiveness may be most maximized if screening includes an initial admission study and also within the first week of hospital stay. Continued weekly screening of asymptomatic patients after 14 days in the hospital is of minor benefit.

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Incidence of Lumbar Spine Pedicle Breach Following Percutaneous Screw Fixation: A Radiographic Evaluation of 601 Screws in 151 Patients
Zachary Adam Smith, Cort D. Lawton, Richard G. Fessler
Introduction: Percutaneous pedicle screw fixation in the lumbar spine continues to be a technique embraced by modern spinal surgeons. The use of intra-operative fluoroscopic guidance is both a clinically safe and accurate method for instrumentation and is of comparable accuracy to other techniques. While trajectory errors may occur, they are rarely of clinical significance.

Conclusion: Percutaneous pedicle screw fixation in the lumbar spine continues to be a technique embraced by modern spinal surgeons. The use of intra-operative fluoroscopic guidance is both a clinically safe and accurate method for instrumentation and is of comparable accuracy to other techniques. While trajectory errors may occur, they are rarely of clinical significance.

355
Comparison of Surgically Treated Adult and Adolescent Main Thoracic Scoliosis Demonstrates Similar Acute Perioperative Outcomes: A Prospective, Matched Cohort Evaluation
Introduction: Popular belief indicates surgery for main thoracic (MT) scoliosis during adolescence provides greater
correction, shorter hospitalization and fewer complications compared to adults. Purpose: compare acute (<12 weeks) radiographic and operative data following posterior spinal fusion (PSF) of MT scoliosis <60° between mature adolescent idiopathic (AIS) and adult idiopathic scoliosis (ADULT) patients.

Methods: AIS patients (Risser grade 4-5 at surgery) consecutively enrolled into a prospective database were matched to ADULT patients consecutively enrolled into a prospective database. All received PSF pedicle screw constructs for MT curve <60°. Matching criteria: MT curve size, end vertebrae, lumbar curve size, and lumbar curve modifier (A-C).

Results: AIS (n = 26, mean age = 15.3) and ADULT (n = 14, mean age = 32.1) had similar preoperative MT (48.8° vs. 50.6°) and lumbar curves (31.5° vs. 29.9°), lumbar lordosis (60° vs. 54.8°), and spino-pelvic parameters, respectively (P > 0.05). Postoperative MT (14.3° vs. 17.1°) and lumbar curves (12.7° vs. 12.4°) were similar for AIS and ADULT, respectively (P > 0.05). MT correction (70.4% vs. 66.6%) and lumbar curve correction (60.7% vs. 60.4%) were similar for AIS and ADULT, respectively (P > 0.05). Most common lowest instrumented vertebra for AIS was T12 and L1 (31% each) and for ADULT was T12 and L1 (21% and 36%, respectively). Mean number PSF levels (9.7 vs. 10.8), posterior osteotomies (2.5 vs. 4), blood loss (841 vs. 929 ml), blood transfused (335 vs. 206 ml), operative time (269 vs. 276 minutes), and hospital stay (5.5 vs. 5.6 days) were similar for AIS vs. ADULT, respectively (P > 0.05). Mean total complications per patient was less for AIS than ADULT (0.2 vs. 0.6, respectively, P < 0.05).

Conclusion: Comparison of acute results following PSF for MT scoliosis<60° between AIS and ADULT demonstrated similar MT correction, number PSF levels, blood loss, and hospital stay. Complications were uncommon. AIS had fewer complications than ADULT. Further research will compare long-term outcomes.

356 Surgical Management of Flexion-Distraction Injuries
Andrew James Grossbach, David Kang, Patrick W. Hitchon

Introduction: Flexion-distraction injuries occur due to distractive forces causing disruption of the posterior and middle spinal columns. These fractures classically consist of a fracture line through the posterior bony elements, however, involvement of the posterior ligamentous complex is common. Surgical treatment is often required for these unstable injuries because the associated ligaments heal poorly and conservative management often leads to kyphotic deformity.

Methods: Patients with flexion-distraction injury who were treated between May 2003 – December 2010 were prospectively followed. Asia score and degree of kyphotic angulation were recorded at admission, discharge, and follow-up. Minimum follow-up was 60 days.

Results: We identified 27 patients, one who declined surgery. All had injury to posterior ligamentous complex. The average canal compromise was 10% ± 21%. All underwent open reduction and posterior instrumentation except 2 who underwent percutaneous pedicle screw fixation. Seven underwent short segment instrumentation. Two lacked sufficient follow up. Mean follow-up was 14.2 months. Average kyphotic angulation was 11.3° on admission, 5.9° at discharge, and 7.6° at follow-up. Average Asia score improved from 4.3 to 4.5. Average kyphosis in the short segment fixation group was 5.6° on admission, 1.3° at discharge, and 1.4° at follow-up. Average kyphosis in the long segment fixation group was 12.3° on admission, 8.0° at discharge, and 9.6° at follow-up. Average Asia score was 4.43 at both admission and follow-up in the short segment group, and improved from 4.37 to 4.58 in the long segment group. The patient who declined surgery has persistent back pain and progression of kyphosis from 8° to 32° at 5 months.

Conclusion: For thoracolumbar flexion-distraction injuries, posterior instrumentation is favored to correct deformity and restore stability. Short segment instrumentation, one level above and below injury, is sufficient to achieve these results. Conservative management often leads to kyphotic deformity.

357 Recapping Hemilaminoplasty for Spinal Surgical Disorders Using with Ultrasonic Bone Curette
Hidenori Matsuoka, Yasunobu Itoh, Kazuo Watanabe

Introduction: We developed a novel method of the recapping hemilaminoplasty in a retrospective study of the patients with spinal surgical disorders. This report describes the surgical technique and the results of the hemilaminoplasty using with ultrasonic bone curette. The aim of this study was to examine the safety and effectiveness of hemilaminoplasty technique in spinal surgery.

Methods: Twenty-nine patients who had undergone recapping hemilaminoplasty with ultrasonic bone curette for spinal surgical disorders between 2003 and 2010 did not need spinal canal enlargement after the indradural procedure was completed. Ultrasonic bone curette was used for division of the posterior elements. After resection of the lesion, the excised lamina was replaced exactly in situ to their original anatomic position with titanium plate. In this study group, there were 17 men and 12 women with a mean age of 47.4 (range, 4-74 years). The mean follow-up period was 38.4 months (ranged, 5-91 months). The mean follow-up period was 38.4 months (range, 5-91 months). All patients were observed both neurologically and radiographically by dynamic plain radiographs and computed tomography (CT).

Results: The mean number of resected and restored lamina was 1.7. CT confirmed primary bone fusion in the all patients by 6 months after surgery. Recapping hemilaminoplasty was done safety to obtain an enough wider laminotomy space for an intradural procedure preserving posterior elements including spinous process, interspinal ligaments, supraspinous ligament and facet joint. The ultrasonic bone curette did not cause any dural lacerations. Intradural procedure, dural reconstruction, and bone recapping were achieved without major complications such as postoperative cerebrospinal fluid in all patients. Postoperatively, no major complications such as postoperative spinal canal stenosis, facet arthrosis, or kyphosis were reported.

Conclusion: Recapping hemilaminoplasty is a useful posterior approach for intraspinal canal procedure preserving the posterior elements. This method allows anatomical reconstruction of the excised bone preserving the posterior surrounding tissues.
358 Does Cervical Spinal Canal Stenosis Affect the Neurological Outcomes After Spinal Cord Injury Without Radiological Evidence of Trauma?  
Tsuneaki Takao, Takeshi Maeda, Seiji Okada, Keiichiro Shibat, Takayoshi Ueda, Itaru Yugue, Eiji Mori, Osamu Kawanou, Hiroaki Sakai, Muneaki Masuda, Tetsuo Hayashi, Yuichiro Morishita, Fumihiko Katoh  
Introduction: The aim of this study is to evaluate the effect of cervical cord compression on neurological outcomes for SCIWORA, and discuss the indication of their treatments.  
Methods: 47 patients and 606 control subjects of health volunteers were retrospectively selected. The diameters of cervical cord were measured at the level of C2-3 to C7 by MR image. We calculated the general incidence rate of SCIWORA (0.00003). The relative and absolute risks of spinal canal stenosis on incidence of SCIWORA at the level of C3-4 were evaluated. We also evaluated the relationship between spinal canal stenosis and ASIA impairment scale at the time of admission and discharge.  
Results: The diameters for the subjects with SCIWORA were significantly narrower than that for the subjects with healthy volunteers at all levels. Only 6 out of 606 healthy volunteers (1%) demonstrated the evidence of spinal canal stenosis (less than 7mm), however, 24 out of 30 subjects with SCIWORA (80%) demonstrated the evidence of spinal canal stenosis. The relative risk of spinal canal stenosis on incidence of SCIWORA was 400 times higher than that of without spinal canal stenosis. However, the absolute risk of spinal canal stenosis was 0.0008. There were no significant relationships between C3-4 cord diameters and ASIA motor scores both at the time of admission and discharge.  
Conclusion: There were no significant relationships between the evidence of spinal canal stenosis and neurological outcomes for SCIWORA. As SCIWORA is rare trauma, the values between relative and absolute risks demonstrated remarkable differences. It is important to make a decision for the indication of prophylactic operation under consideration of both risks, and prophylactic operation should be considered in case of high absolute risk. Our results suggested that decompression surgery of canal stenosis in SCIWORA should not be recommended as a prophylactic therapy.

359 Posterior Approaches for Thoracic Disc Herniations: Is Anterior Surgery Necessary? Experience with 24 Consecutive Cases  
Ramanan Sivakumaran, Nitin R. Patel  
Introduction: The optimal surgical approach for thoracic disc herniations is open to much debate and controversy. We present our experience of the posterior trans-pedicular and trans-facet pedicle-sparing approaches for all types of thoracic disc protrusions.  
Methods: Between 2001 and 2010, the senior author performed posterior thoracic discectomy via a trans-pedicular or trans-facet pedicle sparing approach in 24 consecutive patients with 25 symptomatic disc herniations. Clinical, radiological and operative data was analysed retrospectively, with follow-up duration ranging from 4-36 months. No patients were lost to follow-up. Twenty-four patients (17 women & 7 men) with a mean age of 56 years (range 36 - 79) were included. All disc herniations were located between T6/7 and T11/12. Pre-operative clinical features included myelopathy (n = 17), radicular pain (n = 15), axial pain (n = 8), sensory disturbance (n = 13) and bladder dysfunction (n = 13). On pre-operative imaging, and 11 disc herniations were calcified (including 3 with an intradural component) and fourteen were found to be soft.  
Results: A total of 26 operations were performed on 24 patients with twenty-five symptomatic disc herniations. This comprised 16 unilateral and 4 bilateral approaches performed as a single procedure. In addition to these, one patient had two operations at one level and another had two procedures for two separate levels. Complete spinal cord decompression was achieved in all patients. Following surgery, 16 patients reported improvement in myelopathy (84%). Radicular pain improved in 8 patients (62%) and axial pain improved in 4 patients (50%) post-operatively. Twelve patients (92%) reported an improvement in bladder dysfunction and sensory disturbance improved in 9 (69%) patients. No major complications occurred in our series and overall, 20 (83%) patients reported improvement following surgery.  
Conclusion: In our experience, posterior approaches are suitable for all thoracic discs including large centrally calcified herniations. These approaches have a low complication rate with good clinical outcomes.

360 BMP-2 Inhibits Tumor Growth of Human Renal Cell Carcinoma by Induction of Bone Formation  
Lin Wang, Paul Park, Khoi Duc Than, Shayan Rahman, Frank La Marca, Chia-Ying Lin  
Introduction: Renal cell carcinoma (RCC) is the fourth most common metastatic tumor of the spine. Bone morphogenetic protein-2 (BMP-2) has been shown to have inhibitory effect on many tumor types. However, the effect of BMP-2 on human RCC is still unknown.  
Methods: Human renal carcinoma cell lines ACHN and Caki-2 were cultured and injected with BMP-2 (30 µg/animal) or vehicle control into NOD/SCID mice. After 12 weeks, animals were sacrificed for evaluation of bone formation. Radiographs were obtained using the Faxitron x-ray. For microcomputed tomography (micro-CT) analysis, specimens were scanned on a micro-CT scanner. For histomorphometry, specimens were stained for hematoxylin and eosin (H&E) and Masson’s trichrome to evaluate for collagen type I protein in the newly formed bone. Sections were stained with von-Kossa staining to identify the calcification during osteogenesis in the tumor.  
Results: All animals receiving low number of ACHN (1x10^4) and Caki-2 (5x10^4) cells treated with 30 µg BMP-2 per animal showed limited tumor growth with significant bone formation, while untreated cells developed large tumor masses without bone formation in NOD/SCID mice.  
Conclusion: BMP-2 inhibited tumor growth of human renal cell carcinoma cells by inducing bone formation. BMP-2 may be useful as a novel therapeutic agent for treatment of renal cell carcinoma.

Phillip G. St. Louis, Daniel Castillo, Tara Batz, Jennifer Clements, Kairry Colon-Sanchez  
Introduction: Minimally Invasive Surgical (MIS) techniques in the lumbar spine results in long term improvement in functional status and pain level.  
Methods: Ninety-seven patients were treated with MIS Lumbar Spine Surgery and followed for an average of 18 months. The average age was 56.06 years and Body Mass Index was 29.41 (overweight
by U.S. Dept. of Health and Human Services). Results were obtained by review of 1) perioperative data (estimated blood loss, operative time, length of hospital stay, postoperative medication use, postoperative complications) and 2) validated outcome measurement tools (ODI, SF-36, and patient satisfaction surveys) completed preoperatively and at follow-up postoperatively.

**Results:** Patients experienced longer operative time, shorter hospital stay, and lower narcotic use immediately postoperatively, as compared to published results in open procedure studies. There were no perioperative transfusions or postoperative infections observed. Long-term postoperative patient satisfaction surveys revealed that 61% of patients were very satisfied with their surgical experience and 44% of patients disclosed that they were taking none or less pain medication postoperatively. Seventy-nine percent of patients indicated no change or an increase in functional daily activities (95% confidence interval [CI], 0.9, 42.5). Ninety-three percent of patients reported no change or an improvement in work and physical activities (95% CI, 11.6, 41.6).

Eighty percent of patients reported a reduction in pain postoperatively (95% CI, 10.3, 45.5). Results of Oswestry Disability Index survey showed that sixty-seven percent of patients had improvement postoperatively as compared to preoperatively (95% CI, 22.1, 14.7).

**Conclusion:** Patients treated with MIS spine surgery demonstrated high satisfaction regarding the surgical experience, an improved functional status, and an ability to manage in everyday life. This operative technique results in a reduced surgical complication rate in those patients that are overweight and obese, as also a reduced hospital length of stay and decreased postoperative narcotic use.

**362**
**Prospective Study of Clinical Outcome After Minimally Invasive Transforaminal Lumbar Inter-body Fusion (MI-TLIF) for Degenerative Spondylolisthesis Grades I-III**

**Manish Singh, Olawale Sulaiyman**

**Introduction:** Minimally invasive transforaminal lumbar interbody fusion (MI-TLIF) is a new surgical technique that allows for circumferential arthrodesis with adequate decompression of neural structure without excessive iatrogenic soft tissue/muscle injuries. There are only a few studies that have carefully and prospectively collected and reported clinical outcomes in patients with degenerative spondylolisthesis treated using the MI-TLIF technique. Here, we present a comprehensive analysis of our experience in treating this group of patients.

**Methods:** Analysis of preoperative, intraoperative and post-operative clinical data was collected on patients undergoing MI-TLIF (40 pts.) and open procedure (10 pts.) for degenerative spondylolisthesis grades I-III. All patients completed Oswestry low back pain disability index (ODI) and visual analog pain scale (VAS) pre-operatively and at 6 weeks, 3, 6, 12 months and 24 months. Fisher test was used for association between procedure groups and complication and student t test was used for comparison of continuous variables.

**Results:** Minimum follow-up period was 12 months. Average LOS was = 48 hours for 1 level and 2-3 days for 2 levels. Average EBL was 100 ml for 1 level, 200ml for 2 level. All patients achieved at least a 10% improvement in their ODI with mean ODI improving to 36.70 at 6 weeks, 26.8 at 6 months and and 23.78 at 1 year. We also did a cost compassion analysis of open vs. MIS-TLIF and fusion rate.

**Conclusion:** MI-TLIF is an effective, cost-effective, less morbid treatment option for symptomatic spondylolisthesis grades I-III.

**363**
**The Appearance of Dural Sealants Under Magnetic Resonance Imaging**

Phiroz E. Tarapore, Pratik Mukherjee, Praveen V. Munmaneni, Christopher P. Ames

**Introduction:** Dural sealants are an adjunct to obtain watertight closure after intradural procedures. This study aims to characterize the appearance on magnetic resonance imaging of three commonly employed dural sealants: fibrin glue, polyethylene glycol based hydrogel (PEGH), and a bovine serum albumin gluteraldehyde polymer (BSAG).

**Methods:** Patients who underwent spinal intradural procedures that included the use of dural sealant during closure were identified retrospectively. Post-operative data was gathered on 15 patients, including complications such as pseudomeningocele formation and infection, were gathered. The appearance of dural sealants on follow-up MRI scans within 3 days of surgery was analyzed.

**Results:** Fifteen patients were identified (5 with fibrin glue, 5 with PEGH, and 5 with BSAG applied during closure) with appropriately timed post-operative MRI scans. All three substances were identifiable based on anatomic location and imaging characteristics on post-operative MRI in standard T1, T1 post-gadolinium, and T2 fast spin echo sequences. Definite differentiation between cerebrospinal fluid (CSF) and fibrin glue or PEGH was not possible with the T1-weighted pre- or post-gadolinium sequence, or with the T2-weighted fast spin echo sequence. Differences in intensity between CSF and BSAG were also not significant on either T1-weighted sequence, but they were statistically significant on the T2-weighted fast spin echo sequence. All patients had an uneventful post-operative course, and no patients developed post-operative pseudomeningocele at 30 days.

**Conclusion:** Water-based dural sealants such as fibrin glue and PEGH are difficult to differentiate from CSF on standard T1-weighted, T1-weighted post-gadolinium and T2-weighted fast spin echo sequences, while BSAG is easily recognized on the T2-weighted fast spin echo sequence. Recognition of water-based sealants therefore requires communication between the neurosurgeon and the neuroradiologist to avoid post-operative misidentification.

**364**
**Metanalysis of Heterotopic Ossification (HO) following Cervical Artificial Disc Replacement (CADR)**

Kenneth Pettine, Thomas C. Coburn

**Introduction:** Ascertain the incidence of HO following CADR and whether this incidence is influenced by implant type, class of data, or length of follow-up.

**Methods:** Forty-seven articles/abstracts were reviewed on HO following CADR. This information was stratified based on class of data, severity of HO (McAfee classification), length of follow-up and type of implant.

**Results:** Class I data indicates the incidence of grade-4 HO in ProDisc-C to be 4% at 24 month and 8% at 48-month follow-up, 4% in Kineflex-C at 24 months, Bryan not reported. PCM had 4.4% incidence of grade-3 or 4 HO at 24 month follow-up. Prestige had zero anterior HO at 2 and 5 year follow-up. Class II data indicates ProDisc-C at four-year follow-up grade-0 = 12%, 1 - 13%, 2 - 12%, 3 - 45%, 4 - 18%, Mobi-C disc at
Pullout strength was also performed on the revised screw and the contralateral screw. **Results:** DEXA demonstrated 2 osteopenic and 2 osteoporotic specimen. Using paired t-test, values for both axial rotation ($P = 0.38$) and flexion/extension ($P = 0.36$) were significantly decreased in the revised construct. Pullout strengths, with a mean difference of 435 newtons, were also significantly decreased ($P = 0.042$) in the revised screws (Fig 2).

**Conclusion:** We found significant differences in pullout strength, axial rotation, and flexion/extension in a revised lumbar pedicle screw construct. Our recommendation is to take great care to initially place screws in an optimal position. Also, we recommend leaving a suboptimally placed lumbar pedicle screw in. More specimen will likely increase the power of this pilot study.

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**Adjustment of Suboptimally Placed Lumbar Pedicle Screws Decreases Pull-Out Strength and Alters Biomechanics of the Construct: A Pilot Cadaveric Study**

**Rishi Kumar Wadhwa, Jai D. Thakur, Imad S. Khan, Osama Ahmed, Alan Ogden, Debi P. Mukherjee, Bharat Gathikonda, Anil Nanda**

**Introduction:** Lumbar pedicle screws are placed for internal fixation and help to enhance fusion. Optimal screws are medially directed, parallel to or pointing to the superior endplate, and penetrate 50-80% of the vertebral body. (1-4) “Suboptimal” pedicle screws can be inadvertently placed within the confines of the pedicle and vertebral body but are sometimes replaced to obtain a more acceptable post-operative image. We define a suboptimal screw to be in the pedicle and body and not violating bone, however not parallel to the superior endplate. We suspect “cored-out” grooves left in the bone from the initial screw placement compromise the integrity of the bone and thus the construct. We tested both screw pullout strength and biomechanics of the construct.

**Methods:** DEXA scans and L4-5 laminectomy were performed on 4 fresh-frozen cadaveric lumbar spines. We placed 2 optimal L4 pedicle screws, 1 optimal L5 screw and one suboptimal screw in L5 (Fig 1a). Axial rotation, flexion/extension and lateral bending were tested and the suboptimal screw was replaced optimally (Fig 1b) and retested.

Operative visit. Radiographically all patients maintained reduction. **Conclusion:** Intraoperative reduction using neuromuscular blockade and intraoperative traction is an effective method to further reduce basilar invagination in the pediatric age group. This is the first reported application of intraoperative CT imaging using the o-arm in cranio cervical surgery to demonstrate in detail successful reduction.

**367**

**Spine Surgery at an Ambulatory Surgery Center**

**Kenneth Pettine, Thomas C. Coburn**

**Introduction:** To determine if spine surgery be safely performed at an ambulatory surgery center (ASC)?

**Methods:** 710 spine surgeries performed at an ASC from spring 2005 through 2008 were prospectively evaluated. Instrumented Spine Surgery: 333 Patients, Anterior Cervical Fusion: 193 Patients, Cervical Artificial Disc: 57 Patients, Lumbar Artificial Disc: 83 Patients, Non-Instrumented Spine Surgery: 377 Patients, Lumbar microdiscectomy and/or nerve decompressions. All cases were evaluated with ODl, NDI and VAS. The patients were evaluated at pre-op, three-month, six-month, one-year and often two-year follow-up. Analysis also included minutes in OR, recovery and convalescent center as well as patient satisfaction and cost. This data will be presented.

**Results:** There were no perioperative complications and no unplanned transfers in the ACF group. There was statistically significant improvement in NDI and VAS values ($P < 0.01$). Patients who underwent cervical ADR showed statistically significant improvement in NDI and VAS at two-year follow-up to a p-value < 0.02. There were no perioperative complications and no unplanned transfers in these patients. One lumbar ADR patient had an unplanned hospital transfer. There was a statistically significant improvement in ODl and VAS to a p-value < 0.001 at two-year follow-up. One patient in the non-instrumented spine surgery group had a perioperative complication. There were no unplanned transfers to the hospital. All of the patients undergoing an anterior cervical fusion, cervical and lumbar artificial disc replacement and non-instrumented lumbar spine surgery were released home within 24 hours of their surgery. Outside insurance audits indicate a 60% cost savings when performing these procedures at an ASC vs. a standard
hospital setting. Patients reported a 97% satisfaction rate.

**Conclusion:** Prospective analysis of 710 spine cases at an ASC indicate anterior cervical fusion, lumbar nerve decompression, discectomy, lumbar and cervical artificial disc replacements can be safely performed with efficacy at an ASC.

### 368 Cervical Artificial Disc Replacement at an Ambulatory Surgery Center
Kenneth Pettine, Thomas C. Coburn

**Introduction:** The following data will show Cervical Artificial Disc Replacements (CADR) can be performed at an ASC with safety and efficacy.

**Methods:** A total of 224 patients have undergone cervical ADR at the Loveland Surgery Center. These included five different types of artificial discs. Eleven patients received the Kineflex-C, 39 patients received the NeoDisc, 21 patients received the ProDisc-C, 10 patients received the Discover and 143 patients received the Prestige.

**Results:** There were 162 patients who had a one-level artificial disc replacement. Fifty-six patients received a two-level artificial disc replacement. Five patients received a three-level artificial disc replacement and one patient received a four-level artificial disc replacement. The average age of the patients was 45.3 years with a BMI of 27. The ratio of smokers to non-smokers was 1:5. There were a total of three re-operations, one patient in 2007, one patient in 2008 and one patient in 2009 all underwent revision of the original implant. None of these re-operations occurred during their initial stay. The average operative time for a one-level disc replacement was 63 minutes, a two-level procedure averaged 86 minutes and the average operative time for a three-level procedure was 100 minutes for an overall average of 84 minutes. The average time in the convalescent center was 16 hours. Every patient left within 24 hours with no unplanned transfers to the hospital in any case. Pre-op NDI went from 54.6 to 23 at 2-year follow-up (P < 0.01). Pre-op VAS went from 74 to 28 at 2-year follow-up (P < 0.006).

**Conclusion:** Based on statistically significant improvement in NDI and VAS without surgical complications, this data indicates cervical artificial disc surgery can be safely performed with clinical efficacy at an ambulatory surgery center.

### 369 Comparison of Surgical Outcomes After Cervical Laminoplasty: Open Door Technique vs. French Door Technique
Sun-Ho Lee, Sungjin Kim, Dong-Geun Lee, Eun-Sang Kim, Whan Eoh

**Introduction:** Cervical laminoplasty is an effective method for decompressing multilevel cervical spinal cord compressions. The procedures used are mainly classified as Open-door and French-door laminoplasty, but it is still unclear whether laminoplasty technique affects cervical alignment and clinical outcomes, including axial symptoms and health-related quality of life. The aim of this study was to compare the surgical outcomes of these two methods of cervical laminoplasty (Open-door laminoplasty and French-door laminoplasty).

**Methods:** Fifty-one patients underwent cervical laminoplasty over a 2-year period for cervical spondylotic myelopathy, ossification of the posterior longitudinal ligament, or both. The following criteria were evaluated and compared retrospectively for Open-door laminoplasty (Group A) and French-door laminoplasty (Group B): Nurick grades, Japanese Orthopedic Association (JOA) scores, Neck disability indices (NDI), and Visual Analog Scale (VAS) scores for axial neck pain and radiating pain. For radiological evaluations, changes of cervical lordotic angles and ranges of motion (ROM) were measured at C2-C7.

**Results:** Postoperatively, neurological improvement was 12.5% according to the Nurick grade and 28% according to the JOA score in all study subjects. In particular, Nurick grade was significantly improved in group A (P < 0.05). Furthermore, recovery rates were higher in group A, which achieved rates of 23.5% according to Nurick grade (P < 0.05) and 44.4% according to JOA scores (P < 0.05). Radiologically, cervical lordotic angle and ROM were more significantly decreased in group B (P < 0.05). In group B, there were seven complications, namely, 2 of C5 palsy, 3 wound infections, 1 pulmonary thromboembolism, and 1 postoperative hematoma, and in group A, there were only two complications, that is, one CSF leakage and one C5 palsy.

**Conclusion:** Though both open-door and French-door laminoplasty were found to be effective for treating cervical compressive myelopathy, the open-door technique seems to be superior to the French-door technique with respect to clinical and radiological outcomes and complication rates.

### 370 Outpatient Minimally Invasive Lumbar Fusion
Kenneth Pettine, Thomas C. Coburn

**Introduction:** This abstract describes a surgical technique involving a 3-5cm midline incision with standard exposure to the facet joints followed by a bilateral hemi-laminotomy, medial facetectomy and foraminotomy with posterolateral fusion or a complete facetectomy with a TLIF interbody fusion both utilizing the CoFlex-F implant.

**Methods:** 90 posterolateral fusions were performed, 46 at one level and 44 at two levels. There were 7 cases performed with a TLIF procedure at one or two levels.

**Results:** Average pre-operative VAS for one level CoFlex-F was 7 and ODI of 50%. At 6 month follow up VAS was 21 (P < 0.001) and ODI was 21 (P < 0.003). The average pre-op VAS for a 2 level was 7 with an average ODI of 54. At 6-month follow-up the VAS was 21 (P < 0.001) and the ODI was 34 (P < 0.01). The average operative time for a one-level procedure was 42 minutes and a two-level procedure averaged 73 minutes. Adding a TLIF increased the operative times an average of 17 minutes per level. All TLIF fusions were performed utilizing locally harvested autogenous graft, BMP and an expandable PEEK implant. The average blood loss for a one-level procedure was 23cc and a two-level procedure was 38cc. The average fluoroscopy time was three seconds for location identification prior to skin incision and post operative implant x-rays. Two cases required more than a 23-hour stay. There were four re-operations. These cases will be discussed.

**Conclusion:** This series of cases indicates performing a one- or two-level lumbar fusion through a minimal midline incision using the CoFlex-F implant can be successfully performed as an outpatient procedure. All spine surgeons are familiar with a midline approach. This procedure incorporates the standard current techniques through a small MIS dissect.
371 The Incidence of Adjacent Segment Disease Following Thoracic Pedicle Screw Fixation

Introduction: Pedicle screw fixation is a widely utilized technique employed for conditions ranging from spine deformities to fractures. The use of pedicle screws, as opposed to hooks, in spine deformity surgeries has demonstrated lower complication rates, better three-dimensional correction, better pull-out strength, and shorter fusion lengths. Traditionally, pedicle screws were used in the lumbar spine, however, pedicle screws are being used with increasing frequency in the thoracic spine, as a more favorable alternative to hooks. While safety concerns, such as the incidence of adjacent segment disease (ASD) following cervical and lumbar fusions (30% incidence of ASD) have been reported, these issues have yet to be thoroughly addressed for the thoracic spine.

Methods: A retrospective review of a prospectively maintained database was performed to determine the incidence of complications for 123 consecutive patients (76 males and 47 females, mean age - 39 years), who underwent thoracic pedicle screw fixations over 13 years. Inclusion criteria were: adults with thoracic pedicle fixation. Patients were excluded if: pregnant or lactating, children, and prisoners. By comparing the preoperative and postoperative radiographic imaging, the occurrence of ASD and disease within the surgical construct was determined.

Results: Definitive radiographic fusion was detected in 108 (88%) patients. Seven incidences of hardware failure and eight luencies surrounding the screws were observed. In total, 1135 thoracic pedicle screws and 233 rods were placed. Thirty-two (26%) patients demonstrated disease within the surgical construct, fifteen (12%) developed ASD, and thirteen (11%) experienced perioperative complications. Mean duration of follow-up was 50 months.

Conclusion: Radiographic evaluation showed the use pedicles screws for thoracic fixation to be an effective stabilization modality. The analysis of long-term patient outcomes demonstrated a lower incidence of adjacent segment disease compared to previously published studies.

372 Long-Term Outcomes from IDE Study of OptiMesh Interbody Fusion Device
Mick J. Perez-Cruet

Introduction: OptiMesh interbody fusion device is inserted through a small portal then expands when filled with graft material to conform to the endplates, resulting in a large structural fusion construct.

Methods: An ongoing prospective, multicenter, IDE study to evaluate safety and effectiveness of OptiMesh filled with mixture of allograft and autograft to treat single level lumbar degenerative disc disease. Phase II randomized trial was conducted comparing Optimesh to a cortical allograft spacer with added autograft. Pedicle screw constructs added as fixation. Clinical outcomes measured using VAS and ODI. Fusion was determined by independent radiologists.

Results: At 11 sites between 7/03 and 10/10, 123 patients were implanted with OptiMesh and 33 patients with control. For the OptiMesh group, 107 reached 12 months, 85 at 24 months, 41 at 36 months, and 15 at 48 months. Average age 51, 66 (54%) female and 57 (46%) male. Mean VAS/ODI scores were 6.8/45.4 pre-op, 2.8/33.8 at 6 weeks, 2.5/22.3 at 12 months, 2.7/24.1 at 24 months, 2.5/21.4 at 36 months, and 2.4/20.2 at 48 months. Fusion rates are 84% at 12 months, 92% at 24 months, 91% at 36 months, and 95% at 48 months. No OptiMesh failures, no loss of graft containment, and no expulsions. For the control group, 28 reached 12 months, 12 at 24 months, 13 at 36 months, and 4 at 48 months. Average age 54 years, 18 (55%) female and 15 (45%) male. Mean VAS/ODI scores were 7.6/48.7 pre-op, 2.8/35.3 at 6 weeks, 3.4/27.0 at 12 months, 3.1/26.3 at 24 months, 2.5/18.8 at 36 months, and 3.4/17.0 at 48 months. Fusion rates are 81% at 12 months, 100% at 24 months, 100% and at 36 months.

Conclusion: These current study data show that OptiMesh is safe and effective with clinical and fusion results equivalent to allograft spacer used as interbody fusion device with pedicle screw fixation. This study is ongoing.

373 Movement of Retroperitoneal Structures with Change in Position from Supine to Lateral Decubitus Using Magnetic Resonance Imaging (MRI): Implications on the Lateral Approach to the Lumbar Spine
Armen Deukmedjian, Juan S. Uribe, Elias Dakwar, Tien V. Le

Introduction: In the MIS lateral approach to the lumbar spine, the surgical corridor lies close to peritoneal structures at risk for injury. Although preoperative imaging is performed supine, the procedure is performed in the lateral position. The effect of positioning on abdominal viscera is unexamined. In this study we measure changes in location of the aorta, vena cava, and kidneys with regards to the spine when moving from supine to lateral.

Methods: Lumbar 3T MRI’s were performed on 10 volunteers in supine, left and right decubitus positions. These were analyzed, comparing the location of the aorta, vena cava and kidneys at the L1/2, L2/3, and L3/4 disc spaces, going from supine to left and right decubitus position.

Results: In the right decubitus position, the aorta moves to the right 2.5mm at L1/2, 5mm at L2/3 and L3/4, and slightly anterior, with the greatest displacement of 2mm at L1/2. The vena cava moves to the right 5mm and anterior at all levels. The left kidney for all patients moved anterior ranging from 0.7-4.7cm and caudal from 0.2-2.2cm, while no conclusions were drawn about the right kidney. In the left decubitus position, the aorta shifts to the left ~1.5mm at all levels with very little anterior/posterior displacement. At L1/2, there is significant shift of the vena cava 1cm to the left, and 1.2cm anterior, and at L2/3 it shifts 5mm anterior and to the left. At L3/4 there is movement 1.5mm leftward and 1mm anterior. The left kidney moved up to 2cm anterior/posterior, and from 1.4cm caudal to 2.4cm cranial. The right kidney moved anterior up to 4.5cm and from 1.6cm caudal to 0.5cm cranial.

Conclusion: We believe the movements we describe of the abdominal viscera with the patient in lateral position are vital in preoperative planning for MIS lateral transpsoas surgery to prevent potential complications.
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**Metanalysis of Class I Results of Anterior Cervical Decompression and Fusion with Allograft and Plating**

*Kenneth Pettine, Lukas Eisermann, Thomas C. Coburn*

**Introduction:** What are the clinical results of anterior cervical discectomy and fusion (ACDF) with plating? Most spine surgeons would answer a one-level ACDF has a 95% fusion rate and 95% excellent clinical results. This perception is based on class III or class IV data, retrospective reviews typically performed by a spine fellow or resident on a senior author’s surgical series.

**Methods:** Class I data from six FDA IDE studies involving ACDF allograft with plating were reviewed. The studies include: The Prestige (265 patients), ProDisc (103 patients), Bryan (221 patients), PCM (185 patients), Kineflex-C (133 patients), and Secure-C (144 patients) artificial discs vs. intervertebral allograft with plating. Total number of patients included in this metanalysis was 1,051. FDA clinical Success was very similar in all studies and defined as a 15 point or 20% improvement in NDI, no reoperation, and no neurologic deterioration.

**Results:** The average re-operation rate for a pseudarthrosis, adjacent level degeneration, or index level revision at two-year follow-up was 9.8% (table one illustrates individual study results). Clinical success rates at two-year follow-up averaged 68% (table two illustrates individual study results).

**Conclusion:** Based on a metanalysis of class I data, the results of ACDF with allograft and plating are a 9.8% reoperation rate at two-year follow-up due to pseudarthrosis, adjacent level degeneration or revision of the index surgical site and a 68% clinical success. These results emphasize the importance in differentiating the validity of information gained from class I vs. class III and IV data.

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**Risk Factors Associated with Development of Post-traumatic Syringomyelia**

*Taylor J. Abel, Nader S. Dohdahle, Aaron From, Youssef Karram, Patrick W. Hitchen*

**Introduction:** Post-traumatic syringomyelia (PTS) is an uncommon and debilitating complication of spinal trauma that results in delayed onset of neurological deficit. Until the recent advent of magnetic resonance imaging, PTS was a largely under-recognized entity and clinical research of its risk factors and mechanisms is ongoing. Previous work has suggested that post-traumatic deformity leading to decreased residual canal, increased angulation, and concomitant blockage of subarchnoid CSF flow leads to PTS.

**Methods:** Reviewing records from 1986 - 2010, 22 patients treated for PTS were identified. Subsequently, 28 patients with either flexion-distraction (17 patients) or fracture-dislocation (11 patients) injuries who did not develop PTS were selected as controls. Data was reviewed retrospectively from the medical record. Angulation and residual canal were recorded when neuro-imaging data was available.

**Results:** PTS patients presented with an average Frankel score of 2.4, whereas non-PTS patients presented with an average Frankel score of 3.5. Majority of non-PTS patients (96%) underwent surgical fusion, compared to only 40% of PTS patients. At follow-up, PTS patients had an average angulation of 27 degrees and average residual canal of 63%. Non-PTS patients, conversely, had an average of 11 degrees of angulation and 71% residual canal.

**Conclusion:** In our hands, PTS is associated with a greater degree of post-traumatic kyphosis and canal stenosis. Our results suggest that early surgery, by reducing post-traumatic deformity, may reduce the incidence of PTS. These findings support early surgery for fractures associated with deformity and stenosis to prevent PTS.

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**Comparison of Thromboembolic Events in Open vs. Minimal Access Surgical Technique in Posterior Spinal Fusions**

*Michael J. Cirivello, Daniel J. Coughlin, Chris J. Neal, Michael K. Rosner*

**Introduction:** The purpose of the study was to identify the incidence of pulmonary embolism (PE) and deep venous thrombosis (DVT) in a patient population receiving early thromboembolism chemophrophylaxis (heparin or low molecular weight heparin) after spinal fusion and to evaluate the rate of hemorrhagic complications in this population related to treatment.

**Methods:** 126 Cases of posterior spinal fusion limited only to levels L3-S1 of the senior author from 2004-2010 were retrospectively evaluated. The population was divided based on technique, MAST (103) and open (23). The type of chemophrophylaxis administered, rate of symptomatic DVT and PE, treatment after diagnosis of thromboembolism and the incidence of hemorrhagic complications of these two subpopulations were documented. The incidence of PE between the two subpopulations was analyzed using a student t-test to evaluate for statistical significance.

**Results:** Within the open posterior spinal fusion population, the mean post-operative day (POD) that chemophrophylaxis was started was 1.13 (3 on DOS, 22 on POD1, 2 on POD2-4) with a PE rate of 4.1% (1). Of those patients who underwent fusion using MAST, the mean POD for chemophrophylaxis was 1.08 (72 on POD1, 10 on POD2-4, 18 were not started on DVT prophylaxis) with a PE rate of 2.9% (3). No reports of DVT were documented within either group. There was no significant difference in the incidence of PE using MAST vs. open technique (P = 0.36) for L3-S1 posterior spinal fusions.

**Conclusion:** There is no significant difference in rate of PE or DVT between subjects who underwent MAST and open posterior spinal fusions. In addition, the use of early heparin and low-molecular-weight heparin appear to have acceptable margins of safety in both the prophylaxis and treatment of thromboembolic disease after posterior spinal fusion.

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**Early Chemophrophylaxis in the Prevention and Treatment of Thromboembolism in Posterior Spinal Fusions**

*Michael J. Cirivello, Daniel J. Coughlin, Chris J. Neal, Michael K. Rosner*

**Introduction:** The purpose of the study was to identify the incidence of pulmonary embolism (PE) and deep venous thrombosis (DVT) in a patient population receiving early thromboembolism chemophrophylaxis (heparin or low molecular weight heparin) after spinal fusion and to evaluate the rate of hemorrhagic complications in this population related to treatment.

**Methods:** 177 cases of degenerative and deformity thoracolumbar spinal fusions in 2004-2010 of the senior author from 2004-2010 were retrospectively evaluated.
379 Less Invasive Surgery of Thoracolumbar Fractures
Abdolhamid Khoshab

Introduction: Minimally invasive spine surgery is growing rapidly. Compared with the traditional posterior approach with long and wide exposure, the minimally invasive approach offers significant advantages in treating patients with spine fractures.

Methods: 43 patients (age range, 21-73 years) underwent minimally invasive spine surgery ± BK P,and 14 patients underwent conventional open surgery. All patients underwent pre and postoperative CT, MRI to analyze the fracture. Blood loss, postoperative complications including wound complication, leakage, and hardware malposition, also operative time, postoperative pain score, postoperative analgesic usage, and recovery time after surgery were recorded.

Results: Blood loss was minimal in the 1st group (<40 mL), in the open group ranged from 250 to 500 mL. Operative time ranged from 75 to 90 minutes in the 1st group and 78 to 100 minutes in the other group. Radiation exposure was higher in the MIS group. No patients in the 1st group experienced any postoperative complication. In the conventional surgery group, 4 patient had a superficial wound infection. Postoperative VAS were recorded on postoperative day (1st group: day 1, 5/10, open group: day 1, 6/10). Patients in the MIS group were ambulating 2 to 3 days postoperatively, while in the open group were ambulating 3 to 4 days.

Conclusion: This system is applicable for most burst fractures. We recommend using the minimally invasive approach for treatment of thoracolumbar fractures in fresh fractures and in cases that do not require excessive force to reduce the fracture. The minimally invasive spine surgery system decreased intraoperative blood loss. The procedure is fast, and patients can ambulate shortly after surgery. Analgesics are used less compared with the open group. The same can be said regarding postoperative VAS scores. Radiation exposure was higher in the 1st group. This could potentially be avoided if and when navigation systems replace conventional fluoroscopy. Using the MIS system to treat thoracolumbar burst fractures offers many advantages and could replace conventional open surgery in most cases.

380 International Classification of Disease Clinical Modification 9 Modeling of the Patient Comorbidity Score Predicts Incidence of Perioperative Complications in a Nationwide Inpatient Sample Assessment
Rohan Chitale, Peter Campbell,
Sanjay Yadla, Robert G. Whitmore,
Mitchell Gil Maltenfort, John K. Ratliff

Introduction: Our group has developed a basic comorbidity score (CMS) from a prospective study of spine surgery patients. To validate the CMS, we developed an ICD-CM-9 model of the score and correlated the score with complication incidence in a group of patients from the Nationwide Inpatient Sample (NIS) database. We compared the predictive value of the score to the Charlson index.

Methods: We conducted a retrospective assessment of NIS patients undergoing cervical or thoracolumbar spine surgery for degenerative pathology. We generated an ICD-9 coding-based model of our prospectively derived CMS, categorizing diagnostic codes to represent relevant comorbidities. Multivariate models were performed to eliminate the least significant variables. ICD-9-CM coding was used to calculate a Charlson comorbidity score for each patient. Accuracy of the CMS was compared to the Charlson index through use of a receiver operating curve (ROC).

Results: A total of 352,535 patients undergoing 369,454 spine procedures for degenerative disease were gathered. Hypertension and hyperlipidemia were the most common comorbidities. Cervical procedures resulted in 8,286 complications (4.50%) while thoracolumbar procedures produced 25,118 complications (13.55%). Increasing CMS correlated linearly with increasing complication incidence (OR 1.11, 95% CI 1.10-1.13, P < 0.0001). Logistic regression revealed that neurological deficit, cardiac conditions, and drug or alcohol use had greatest association with complication occurrence. The Charlson index also correlated with complication occurrence in both cervical (OR 1.25, 95% CI 1.23-1.27) and thoracolumbar (1.11, 95% CI 1.10-1.12) patient groups. ROC analysis allowed a comparison of accuracy of the indices by comparing predictive values. The CMS performed as well as the Charlson index in predicting complication occurrence in both cervical and thoracic spine patients.

Conclusion: ICD-9 based modeling validated that CMS correlates with complication occurrence. The CMS performed as well as the Charlson index in predicting risk of complication in spine patients.

381 Stable Anteroposterior Diameter of the Spinal Canal on Follow-up CT Scans After Open Door Laminoplasty
Ben Z. Rothberg, Melissa Stamates

Introduction: Re-closure of open door laminoplasty is a common concern, prompting development of devices to keep the spinal canal expanded. Adding hardware may add to the cost, time and risk of the procedure. There is little quantitative information available regarding canal diameter stability in open door laminoplasty without adding hardware.

Methods: This is a retrospective analysis of prospective data from our spine outcome database. Our open door laminoplasty uses two autograft supports, at C4 and C6. Patients have postoperative CT scans within 48 hours, and then at ± 6 months. A researcher who is not part of the treatment team measured the A-P diameter at each vertebral level at the immediate post op baseline and at follow up.

Results: Required imaging was available in 14 consecutive patients who had a C3-7 open door laminoplasty for cervical myelopathy, 9 male, 5 female, ages 46-86. Immediate postoperative AP diameter was 17.4 ± 0.5 mm at C3, 19.4 ± 0.7 mm at C4, 19.4 ± 0.6 mm at C5, 20.1 ± 0.6 mm at C6, and 20.4 ± 0.5 mm at C7. The 6
months follow up demonstrated bony fusion in all cases. At that time the canal diameter was 17.4 ± 0.5 mm at C3, 19.6 ± 0.6 at C4, 19.7 ± 0.5 at C5, 20.3 ± 0.6 at C6, and 20.9 ± 0.5 at C7. (NS at all levels between the two time points). There were no cases of re-closure or any narrowing of the canal.

Conclusion: Canal diameter was maintained both at levels directly supported by a graft (C4 and C6) and those not supported (C3, C5, C7). At 6 months there was bony fusion and no re-closure of the canal in open door laminoplasty with two autografts only and without hardware. Fusion occurred in all cases at the time of last CT scan, at the graft and at the hinge.

382 Resistive Capacity of the Human Cervical Spinal Column in Coronal Bending
Christopher E. Wolfka,
Narayan Yoganandan, John R. Humm,
Dennis J. Mainman, Frank A. Pintar
Introduction: While studies exist on the clinical biomechanics of the spine under low magnitude static or quasi-static pure moments, physiologic activities and traumatic events often induce loads at higher magnitudes and rates. The objective of this study is to determine the injury threshold of the human cervical column to coronal bending moments at these higher loading magnitudes and rates.

Methods: Data was obtained from tests using ten human cadavers: eight were at velocities up to 65 km/h, two were subjected to pure coronal moments using an electrohydraulic testing device at rates up to 51.5 rad/s. The head was included in all specimens, allowing the cervical column to sustain eccentric flexion-compression loading from the preloaded head mass. Multi axial accelerometers were placed on the head to obtain cranial kinematics from which forces and moments were determined at the occipital condyles. The presence of injury was determined by palpation, radiographs, computed tomography, and/or detailed dissection.

Results: Sled tests resulted in injuries to the axis and lower cervical spine associated with tension and bending mechanisms. Peak moments up to 62 Nm were associated with axial tensile forces up to 2300 N, indicating a complex, combined loading pattern. In contrast, tests using electrohydraulic device induced pure coronal moments without tensile forces. At coronal moments of up to 75 Nm, injury to the cervical spine did not occur.

Conclusion: These results indicate that the cervical spine is more susceptible to injury under combined loading than under pure moment loading. These results suggest that the level of pure moment loading (less than 10 Nm) often selected in the evaluation of clinical stability of the cervical spine is too low to exercise the column at magnitudes representative of many real world activities including traumatic loading.

383 Outcome and Complications of Anterior Cervical Discetomy and Fusion(ACDF) in Elderly Population: A Single Surgeon Experience
Ashish Sonig, Imad S. Khan, Dai D. Thakur,
Papirotty Bollam, Anil Nanda
Introduction: Elderly patients have multiple co-morbidities and are at the terminal stage of natural history of degenerative spine disease. Higher incidence of multiple level disease and prior neck surgeries makes them even more vulnerable. Our aim was to analyze the outcome and complications in such patients.

Methods: We retrospectively reviewed the medical records of all elderly patients (>65yrs) operated by the senior author. A total of 67 consecutive patients underwent ACDF for 100 levels from January 1998-December 2010. Nuricks-grade was used for outcome analysis and Comorbidity was assessed by Kaplan-Feinstein index. Data was analyzed using chi square/fisher-exact test and binary logistic regression.

Results: The mean age was 70.6 years and F:M ratio was 1.6:1. Mean duration of symptoms was 12.2 months, most common presentation was Nuricks-Grade 0 (44.8%). KFI was >1 in 28.4% patients, these patients had a significantly longer duration of hospital stay (P = 0.01). C5-6 was the most common single level fusion performed (23.9%, n =16) and C5-7 was the most common multi-level fusion (16.4%, n =11). Un-instrumented spine fusion was done in 6% cases. Overall complications were seen in 13.4% patients, and the most common was dysphagia (5%). None had root/cord injury or epidural-hematoma/graft extrusion. Multi-level fusions and re-surgeries were not associated with higher complication rate. Mean follow-up was 10.6 months. Radiological fusion was achieved in 55 (82.1%) patients and no instability was detected. There was no statistical difference in fusion rates on the basis of gender and level of surgery. 72% patients improved or became asymptomatic after surgery. Patients with single level fusion had statistically better outcome compared to multiple fusion (P = 0.04).

Conclusion: A high percentage (82.1%) of fusion can be achieved in multi/single level surgeries, with overall good-outcome (72%) and minimal complications. Multi-level fusion and increased comorbidity adds to the poor-outcome (P = 0.04) and longer hospital-stay (P =0.01), these factors should always be considered while deciding ACDF in the elderly population.

385 Six Month Outcomes of iO-Flex System Assisted Decompression vs. Traditional Minimally Invasive Decompression in the Treatment of Lumbar Spinal Stenosis
Robert E. Isaacs, Scott Tyler Brigeman
Introduction: Although the results of decompression from spinal stenosis from the SPORT trial were exemplary, concern for suboptimal long-term results of standard decompression techniques has been raised in several studies. From a surgeon’s perspective, there is a potential tradeoff between inadequate decompression and iatrogenic instability. The iO-Flex device has been touted as a way to potentially decompress under the facet and through the neural foramen while limiting the risk for delayed instability. Our goal was to examine patients undergoing decompression assisted with the Baxano device vs. those undergoing traditional MIS decompression.

Methods: All patients undergoing lumbar decompression between January 2010 and March 2011 were included to ensure the availability of 6 month data. The Baxano device was used if available. Patients were grouped by surgical technique (Baxano vs. MIS decompression). VAS leg and back pain scores were studied 6 weeks and 6 months postoperatively when available.

Results: 10 patients were treated with the Baxano device and 11 patients received traditional MIS decompressions. The groups were similar in age (71.5 Baxano/74.1 control, P = 0.39), male to female ratio (7:3/8:3, P = 0.89), and number of levels treated (2.1/1.8, P = 0.58), with L4-L5 being the primary level
treated. All but 1 patient in each group reached SCB in leg or back pain 6 weeks postoperatively. At 6 months, though, 89% of those treated with the iO-Flex device reached SCB in leg pain, compared to 60% of those treated with traditional MIS decompressions ($P = 0.04$). Further, 100% of Baxano patients reached SCB in back pain, compared to 80% of the control group ($P = 0.08$).

**Conclusion:** This small matched cohort shows a greater tendency for improvement in leg and back pain in patients receiving lumbar decompression using the iO-Flex device compared to those receiving MIS decompression alone. Patients undergoing decompression alone showed positive outcomes at 6 weeks but deteriorated some by 6 months. Differences in the number of patients reaching leg SCB between the groups were statistically significant, those for back SCB showed strong trends. Larger controlled studies are needed to determine if this observation continues.

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**Instrumentation Following Decompression for Spinal Metastases**

Philippe A. Mercier, W. Bradley Jacobs

**Introduction:** Decompression and instrumentation has proven beneficial to the neurological outcome and quality of life for selected patients with spinal metastases. Due to the limited expected survival of this population and the lack of suitable local bone graft many physicians rely on the instrumentation alone to stabilize the vertebral column.

**Methods:** We conducted a retrospective chart review of patients that had undergone decompression and instrumentation for spinal metastases in a multisurgeon spine practice to measure the rate of instrumentation failure.

**Results:** Thirty-three patients were identified who had surgery within the last 4 years. No reports of instrument failure were identified in the patients in this series. Four patients had second procedures during which infiltrated bone was decompressed a second time or new sites of metastases were decompressed and/or instrumented. As expected bone graft was used in only 12% of patients while instrumentation was augmented with methylmethacrylate or bone graft substitute in 61% while the remainder did not use any bone graft substitute.

**Conclusion:** This small study suggests that failure of spinal instrumentation in patients with spinal metastases is an uncommon occurrence despite the lack of bone graft in the constructs use to stabilize the vertebral column.

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**Minimally Disruptive Lateral Interbody Fusion in the Treatment of Degenerative Spondylolisthesis: A Prospective Evaluation of Mid-term Clinical Outcomes**

Kaveh Khajavi, Alessandria Y. Shen, Anthony Hutchinson

**Introduction:** Over the past decade, non-endoscopic minimally disruptive approaches for lumbar interbody fusion (IBF) have gained popularity due to modern specialized access instrumentation and implants which fulfill the goals of conventional surgery without the associated morbidity. The aim of this report is to examine mid-term clinical outcomes following a minimally disruptive, 90° lateral, transposas approach for IBF in degenerative spondylolisthesis patients.

**Methods:** 61 consecutive patients treated with extreme lateral interbody fusion (XLIF) for Grade I or II degenerative spondylolisthesis were followed in an IRB-approved, prospective registry (ProSTOS, PhDx) at a single institution in Atlanta, GA. Mean patient age was 67 years, 75% were female and 31% had undergone a previous lumbar surgery. In total, 73 levels were treated with 49 (80%) single-level and 12 (20%) 2-level cases. Supplemental fixation was used in 57 (93%) cases and 26 (43%) patients underwent a direct posterior decompression. In all cases, rhBMP-2 was used. Low back (LB P) and leg pain (LP), disability, and quality of life (QOL) were measured using VAS, ODI and SF-36 (PCS & MCS).

**Results:** Average follow-up was 12.1 months. Average ORT, EBL, and LOS were 205 minutes, 82cc, and 1.31 days, respectively. Complications occurred in three (5%) patients: one MI, one superficial infection in posterior instrumentation, and one urinary retention. Transient approach-related thigh/groin was observed in six (10%) cases, all resolving by 3 months postoperative. At one year, LB P and LP improved 78% (8.0 to 1.8) and 70% (7.6 to 2.3), respectively ($P < 0.001$), ODI decreased 48% from 42% to 23% ($P < 0.001$), SF-36 PCS and MCS improved 38% (31.2 to 42.9, $P < 0.001$) and 21% (43.1 to 52.1, $P = 0.003$), respectively.

**Conclusion:** MIS lateral IBF resulted in a hastened postoperative recovery with a low complication rate and high clinical efficacy on pain, disability and QOL measures, compared to conventional approaches.

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**The Effect of the Minimally Invasive Lateral Retroperitoneal Transposas Lumbar Interbody Fusion on Segmental and Regional Lumbar Lordosis**

Tien Viet Le, Andrew C. Vivas, Elias Dakwar, Ali A. Baaj, Juan S. Uribe

**Introduction:** Minimally invasive spine surgery is increasingly used to treat multiple spine pathologies. The minimally invasive lateral interbody fusion (MIS LIF) via retroperitoneal transposas approach in the lumbar spine can correct coronal Cobb angles, but the effect on sagittal plane correction is unclear. Our objective is to study the effect of MIS LIF on the restoration of segmental and regional lumbar lordosis in patients with degenerative spine disease.

**Methods:** Thirty-five patients with lumbar degenerative disease who underwent MIS LIF without supplemental posterior instrumentation using 10° lordotic interbody cages were studied. The most recent postoperative radiograph was compared to the preoperative radiograph for comparison. Segmental and regional Cobb angles were measured to determine lordosis. Mean disc height changes were also measured.

**Results:** The mean follow-up period was 13.3 months. Fifty total levels were fused with a mean of 1.42 levels fused per patient. Mean segmental Cobb angle increased from 11.10° to 13.61° ($P < 0.001$), or 22.6%. L2-3 had the greatest proportional increase in segmental lordosis. Mean regional Cobb angle increased from 52.47° to 53.45° ($P = 0.392$). Mean disc height increased from 6.50 mm to 10.04 mm ($P < 0.001$), or 54.5%. There was also a significant increase at each individual segment.

**Conclusion:** Minimally invasive LIF significantly improves segmental lordosis and disc height in the lumbar spine, but not regional lumbar lordosis. Anterior longitudinal ligament sectioning and/or the addition of a more lordotic implant may be necessary in cases where significant increases in regional lumbar lordosis is desired.
Adult Neural Stem/Progenitor Cell Response to Differentiation Factors Is Affected by Cell Origin: Impact on Therapeutic Application
Eve C. Tsai, Matthew Coyle, Ushananthini Shanmugalingam, Harrison Westwick, May Griffith, Xiaodong Cao

Introduction: Many therapeutic models have utilized stem/progenitor cells (NSPCs) from various regions of the body for brain and spinal cord injury repair. To translate these models to clinical application, it is essential to determine if the controls for the differentiation of NSPCs are affected by the origin of the NSPCs.

Methods: We evaluated adult spinal cord (SC) and subventricular zone (SVZ) NSP differentiation into neurons, oligodendrocytes and astrocytes with retinoic acid (RA), platelet derived growth factor (PDGF) and bone morphogenetic protein 4 (BMP-4), respectively. After proliferation in culture for seven days, primary neurospheres were plated in concentrations of RA, PDGF and BMP-4 ranging from 0-500 ng/ml. Seven days post factor exposure NSPCs were fixed and stained for O4, glial fibrillary acidic protein (GFAP), β-III-tubulin (βIIIIT), brain lipid binding protein (BLBP), Nestin, BrdU (pulsed 24hr before fixation), TUNEL and Hoechst. Percentage of positive cell staining out of the total number of cells plated at all concentrations were obtained and compared (ANOVA, Tukey’s post hoc test) to control (differentiating factor absent) conditions.

Results: While βIIIIT positive SVZ NSPCs increased with RA concentrations greater than 125ng/ml (P < 0.001), there was no increase with SC NSPCs. However, with RA concentrations ≥250 ng/ml an increase in the proportion of BLBP positive cells was seen in both SVZ and SC cells compared to control (P < 0.01). Although PDGF increased the number of O4 positive SVZ NSPCs when it was ≥500 ng/ml (P < 0.01), PDGF did not increase the number of O4 positive SC NSPCs. With PDGF concentrations ≥250 ng/ml, there was an increase in the number of BrdU positive SVZ NSPCs (P < 0.001). While an increase in the proportion of GFAP positive SVZ NSPCs was seen with BMP-4 concentrations = 250 ng/ml (P < 0.001). BMP-4 at concentrations = 125 ng/ml reduced the number of GFAP positive SC NSPCs (P < 0.001).

Conclusion: As factors that induce differentiation for SVZ NSPCs may not produce the same result with SC derived NSPCs, further work in identifying the appropriate differentiation cues will be required prior to appropriate therapeutic application of NSPCs.

The Naso-Axial Line: A New Method of Accurately Predicting the Inferior Limit of the Endoscopic Endonasal Approach to the Craniovertebral Junction
Philipp R. Aldana, Emanuele La Corte

Introduction: Endoscopic approaches to anterior pathology of the craniovertebral junction (CVJ) have arisen as alternatives to open approaches. Understanding and predicting the limits to the endoscopic approach to CVJ is important in surgical planning. The endoscopic nasoaxial approach (EEA) is commonly used thus we sought to develop a method that accurately predicts the inferior limit of this to the CVJ. The method developed was compared to methods currently used to predict the same.

Methods: Nine fresh-frozen adult cadaver heads were used for anatomical dissection. Preoperative and postoperative volumetric computerized tomographic scans were performed to compare the naso-axial line (NAL) vs. naso-palatine (NPL, or Kassam, line) used to predict the inferior limit of the EEA to the actual extent of surgical dissection.

Results: The mean differences between the NAL and the actual inferior surgical exposure of EEA at C2 cortex (anterior and posterior) were both 0.3mm. Anatomically, the actual inferior surgical limit ranged from the dens to the upper half of the C2 body, which matched that predicted by the NAL. The NPL predicted an inferior EEA limit much lower range than the actual - from the lower half of the C2 body to the superior endplate of C3. Using the least-square means (LSM) method to estimate the deviation from post-surgical measurements, we found no difference between the NAL and the actual inferior surgical limit (LSM 0, P = 1.0). In contrast, the NPL predicted a significantly lower EEA limit than the actual surgical limit (LSM 13.5, P < 0.001).

Conclusion: The naso-axial line accurately predicts the inferior limit of the EEA, which ranges from the dens to the upper half of C2. This new method can be used in presurgical planning to assess the suitability of the EEA to craniovertebral junction pathology.

Sacroiliac Arthrodesis by Minimal Incision Method: One-Year Outcomes
John G. Stark, Chris Idemmi

Introduction: Though fusion has been advocated for SIJ pain, undergoing SIJ arthrodesis using a combined extra- and partial intraarticular technique featuring a posterior-midline incision, controlled distraction/measurement of the extraarticular recess, BMP-2/allografting of adjacent surfaces, and application of an interference-fit threaded implant. Patient sample consisted of 4 males and 11 females. Mean age was 43 (range 22-65). The Oswestry Disability Index (ODI) and Million Visual Analog Scale (MVAS) were the primary functional outcome measures. Patient self-report of improvement, satisfaction, and percent resolution of back and leg pain were collected.

Results: Blood loss averaged 55cc (range 10-300cc). Mean hospital stay was 2.2 days. Average patient function improved significantly. MVAS scores improved 45.6 points (95% confidence interval 30.8 to 60.8 points, 43% improvement, P < .0001). ODI scores improved 20 points (95% confidence interval 8.2 to 31.8 points, 36% improvement, P < .0001). Patients reported 78% resolution of back pain (95% Confidence interval: 66%-90%) and 86% resolution of leg pain (95% Confidence interval: 77%-96%).

Conclusion: Judged by back and leg pain relief, the surgery is promising in all patients. The SIJ region can be grafted and implanted by minimal incision methods. Patient satisfaction is high. There were no nerve injuries, displacements, infections, or malpositioned implants. Most patients showed significant improvement by three months.

Percutaneous Pedicle Screw Fixation for Thoracolumbar Fractures
Nader S. Dahdaleh, Brian J. Dlouhy, Patrick W. Hitchon

Introduction: Percutaneous surgery has
been gaining popularity in the past 2 decades due to its advantages of less muscle dissection, faster recovery and less complication rates. In parallel to its application to degenerative spine disease it is also a treatment option for thoracolumbar fractures. We present our experience with percutaneous pedicle screw fixation (PPSF) in the treatment of a variety of thoracolumbar fractures.

**Methods:** This is retrospective study on 13 patients who suffered a variety of thoracolumbar fractures and were treated with PPSF at our institution between January of 2009 and June 2011. Their electronic charts and spine imaging were reviewed. Our indications for percutaneous fixation for unstable spine fractures include absence of spinal cord compression, absence of an irreducible dislocation, and a Load sharing score of <6 obviating the need for anterior column reconstruction.

**Results:** The average age of the group was 48.9 years. All but 2 were males. All but 3 patients were neurologically normal. 4 (30.8%) fractures were thoracic, 7 (53.8%) thoracolumbar (T11-L2), and 2 (15.4%) were lumbar. Types of fracture were: 5 (38.5%) flexion distraction, 4 (30.8%) burst, 2 (15.4%) extension distraction, 1 (7.7%) fracture dislocation, and 1 (7.7%) compression fracture (Figure 1). The average follow up was 5.15 months. One patient without deficit required screw revision for pedicle violation. All were pain free or improved postoperatively.

**Conclusion:** Percutaneous pedicle screw fixation is a treatment option in select patients with thoracolumbar spine fractures. The varieties of fractures that can be treated encompass flexion and extension distraction injuries, burst fractures, and compression fractures.

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**Use of Expandable Interbody Device to Restore Disc Height in Minimally Invasive Spine Fusion Surgery**

*Mick J. Perez-Cruet, Namath Syed Hussain, Joseph John Joshua, Evan Begun*

**Introduction:** Degenerative disc disease is a common, progressive disease process that leads to disc height loss which contributes to foraminal height loss and various foraminal impingement pain syndromes. The efficacy of minimally invasive spine fusion methods in improving disc height and reducing subluxation and its effect on Health-related Quality of Life (HRQL) measures has not been well studied. The interbody device Staxx which is inserted at a height of 7mm and can expand to 15mm was evaluated.

**Methods:** 46 consecutive patients underwent minimally invasive transforminal lumbar interbody fusion (MlTLIF) between December 2009 and August 2011 using the Staxx expandable interbody device. Preoperative and postoperative morphometric data (intervertebral height, foraminal height, and degree of subluxation) was collected on plain radiographs. A validated full set of Health-related Quality of Life (HRQL) Measures, including Visual Analog Scale (VAS), Oswestry Disability Index (ODI), and SF-36 were also collected preoperatively and postoperatively.

**Results:** Preoperative disc height increased from 6.7mm (range 2.5 – 12.8mm, SD = 2.3mm) to 10.9mm postoperatively (range 8.3 – 15mm, SD = 1.6mm, P value <.05). Preoperative foraminal height increased from 20.0mm (range 14.5 – 26.8mm, SD = 4.4mm) to 24.1mm postoperatively (range 15.5 – 32.3mm, SD = 4.6mm, P value <.05). Preoperative subluxation decreased from 9.9mm (range 4.5 – 24.7mm, SD = 5.8mm) down to 4.6mm postoperatively (range 0 – 7.2mm, SD = 2.6mm, P value <.05). Successful fusion was achieved in >95% of patients based on postoperative dynamic radiographs at 3 month interval. No neurological complication occurred. No electromyographic (EMG) activity was noted with implant insertion and disc height restoration. Statistically significant improvements in VAS, ODI, and SF-36 scores were reported starting at 6 weeks post-operatively.

**Conclusion:** MITLIF provides adequate disc height and foraminal height restoration using the Staxx device with a concomitant reduction of spondylolisthesis. This study validates that this MITLIF approach improves morphometric parameters that can be correlated with improved clinical outcomes.
developed sciatic nerve palsy from heterotopic ossification after surgically repaired pelvic fracture and treatment course.

**Methods:** A 35-year-old veteran male who was hit by a garbage truck and sustained a pelvic fracture for which he underwent open reduction and internal fixation in the same year and a revision next year. Over the course of 6 years, he developed right foot drop. His preoperative workup which included MRI of lumbar region were negative. On the EMG/NCS study, it was demonstrated that the patient has the right sciatic neuropathy affecting the peroneal division above the knee. On the clinical exam, the motor strength of his right lower extremity was 5/5 except ankle dorsiflexion 3/5, plantar flexion 5/5, eversion 3/5 and inversion 4/5. He also had diminished sensation in superficial, deep peroneal nerve distribution and some reduced sensation in the tibial nerve distribution.

**Results:** He underwent exploration of the sciatic nerve from buttok level to upper thigh and heterotopic bone formation compressing the sciatic nerve was decompressed. After the surgery, patient’s neurologic status was unchanged, but had immediate improvement in his radicular right leg pain. He underwent local radiation therapy of 7.5 Gy and started on indomethacin treatment.

**Conclusion:** Sciatic nerve entrapment due to heterotopic osseous formation are rare. Patients with sciatic/peroneal neuropathy with a distant history of trauma/orthopedic surgery in the adjacent bones need to be investigated carefully with proper work-up especially when there is a negative spine MRI or even minor degree of spine pathology demonstrated on MRI that are unlikely to be an etiology of patients’ signs and symptoms. There has not been an established treatment course for this pathology. Post-operative radiation treatment for prevention of heterotopic ossification has been reported with favorable outcome and could be considered as an option when it is appropriate.

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**Outcome After Decompression Surgery for the Treatment of Chiari Type I Malformation**

Mark Mahan, Samuel Kalb, Luis Perez-Orribo, Ruth E. Bristol, Nicholas Theodore

**Introduction:** Decompression of Chiari I malformations is one of the more controversial procedures in neurosurgery. There is a wide spectrum of symptoms and radiographic findings at presentation, making the decision to proceed with intervention, at times controversial. Similarly, the surgical procedure itself can be performed in a variety of ways. Our goal was to evaluate the outcomes with respect to symptomatology from a large group of surgeons who use diverse surgical techniques.

**Methods:** 104 patients who underwent decompression surgery for the treatment of symptomatic Chiari I malformation were reviewed. Factors predicting symptomatic outcome including clinical presentation, surgical procedure performed, presence or absence of syringomyelia, previous medical conditions, and the use of postoperative steroid or muscle relaxants medications were assessed. Mean follow-up was 10 months.

**Results:** Symptomatic improvement was evident in the majority of the cases. Patients who initially presented with syringomyelia showed fewer symptomatic improvements, however, symptomatic worsening was not associated with the presence of syrinx. Duromy was performed in 97.1%, arachnoid opening in 60.6% with visualization of the fourth ventricle in 51.9% of the patients. Neither arachnoid opening nor fourth ventricle visualization affected symptomatic outcome. Duroplasty was performed in 94.2% of the cases, and Chiari plate was used in 13.4% cases resulting in favorable symptomatic outcome. The use of postoperative steroid or muscle relaxants medications did not change the course of symptom outcome. Follow-up MRI of patients who initially presented with syringomyelia showed a 62.5% improvement rate.

**Conclusion:** Bony decompression is probably the most important aspect of Chiari I surgery. Whether or not syringomyelia responds better to opening of the outlet of the fourth ventricle will require a larger study population. Even with the variety of surgical techniques in a large group of surgeons, symptomatic improvement can be achieved in the majority of patients.

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**Ocicopitocervical Fusion Surgery: A Single Institution Single Surgeon Experience**

Mark Mahan, Samuel Kalb, Juan Christian Ribas Nijkerk, Nikolay L. Martinovsky, Nicholas Theodore

**Introduction:** The craniovertebral junction (CVJ) constitutes the most mobile portion of the spinal axis. The complex anatomical properties and kinematic relationships at this site make it difficult to achieve proper surgical fusion. This study evaluates outcomes between different surgical techniques used for ocicopitocervical (OC) fusion.

**Methods:** 70 patients who underwent OC fusion by a single surgeon were reviewed. Surgical outcomes were evaluated using the modified Japanese Orthopaedic Association scale (mJOA) and postoperative recovery rate.

**Results:** Indications for surgery included congenital malformations, degenerative disease, rheumatoid arthritis, trauma, infection and tumor. Fusion was mostly performed at O-C2, O-C3, and O-C4. Autograft was installed using rib (50%) or iliac crest (27%). Additional cases were fused using fibular allograft. At follow up, the rate of successful fusion was 97% and the overall complication rates was 12.9%, 2.9% of which occurred intraoperatively and 10% during follow up. Patients with complications were younger (P = 0.008), predominantly males (P = 0.039) and with hypertension (P = 0.033). Follow-up complications were associated with the indication of surgery, where congenital malformations, degenerative disease, and infection were associated with the incidence of complications (P = <0.001). Also, the higher the number of fused levels the higher the complication rate (P = <0.001). Clinical outcomes improved from 14.19 (preoperative) to 16.5 (postoperative) with a recovery rate of 45%. Postoperative improvement was associated with the number of levels fused, where shorter constructs showed better outcomes compared to longer fusions (P = <0.001).

**Conclusion:** CVJ pathology requiring surgical treatment remains challenging, with an elevated rate of complications compared to fusion in other regions of the spine. Many of the problems that lead to the initial deformity are often the source of complications and have to be considered in advanced surgical planning. Shorter fusion constructs appear to be better tolerated long-term, but may be essential for multiple disease levels or polysegmental instability.
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Analysis of Cervical Sagittal Alignment Following Lateral Mass Screw-Rod Fixation
Robert F. Heary, Osamah J. Choudhry, Devesh Jakal, Nitin Agarwal

Introduction: The use of posterior instrumentation constructs is well established for performing subaxial cervical stabilizations/fusions. The importance of global and regional sagittal balance has become increasingly recognized. Using preoperative and postoperative imaging, long-term analysis was performed to determine the effect of posterior instrumentation on postoperative cervical sagittal alignment at long-term follow-up.

Methods: Over a period of 6 years, 64 consecutive patients (45 males and 19 females, mean age - 47 years) underwent cervical lateral mass screw-rod fixation. Plain radiographs, CT scans, and MR images were analyzed preoperatively to assess sagittal balance (C2-C7). Postoperatively, CT scans and serial radiographs were obtained in all patients. Using two independent observers, changes in sagittal balance were determined by comparing the preoperative and postoperative imaging studies. A minimum of 6 months follow-up was obtained in all patients.

Results: In total, 455 screws were placed in the cervical spines of 64 patients. Definitive radiographic fusion was detected in all 64 (100%) patients. There were no incidences of instrumentation failures or luencies surrounding any screws. The mean preoperative Cobb angle in all patients was -6.2° ± 1.9°. The mean postoperative sagittal angle on late follow-up imaging was -8.3° ± 1.9°. Patients with preoperative kyphosis (N = 23, mean +10.3°) significantly improved (P = .003) their sagittal alignment by 7.7° (to a mean value of +2.6°) while patients with preoperative lordosis (N = 41, mean -15.4°) maintained their lordosis (to a mean value of -14.9°). There were no neuroforaminal, 3 foram en transversarium, and 9 facet joint violations. Mean duration of follow-up was 36.2 months.

Conclusion: Radiographic analysis showed lateral mass fixation to be safe and effective. Certain operative techniques allowed for substantial deformity correction, fusion in all patients, and maintenance of long-term correction of deformity. Lateral mass screw-rod fixation is an effective method for maintaining lordotic cervical alignment and for significantly correcting kyphotic deformity.
responses to cervical nerve root injections in patients with cervical radiculopathy.

**Methods:** A retrospective chart review identified 100 consecutive patients treated at a single tertiary referral center. Data collected included patient demographics, neuroforaminal area of the symptomatic side and contralateral side, Visual Analog Score pre- and post-injection, history of previous cervical surgery, comorbidities, and history of tobacco use.

**Results:** One hundred consecutive patients with symptoms of cervical radiculopathy were treated with neuroforaminal nerve root injections were identified. Immediate symptomatic improvement of post-injection visual analog scores correlated with foraminal areas at least one standard deviation smaller as compared to the contralateral control side.

**Conclusion:** Measurement of neuroforaminal areas may represent a useful pre-procedural technique to predict which patients with symptoms of cervical radiculopathy secondary to foraminal stenosis are likely to respond to selective nerve root injections. Larger prospective studies are needed to verify these retrospective results and make more meaningful conclusions regarding other demographic predictors.

### 403

**Thoracic Chance Fractures: Treatment and Outcomes in the Largest Reported Series**

Sanjay S. Dhall, Daniel J. Hoh

**Introduction:** Chance fractures are typically reported in the lumbar spine, and thoracic Chance fractures are very rare. To the best of our knowledge, this is the largest reported series of thoracic chance fractures and their management.

**Methods:** A study at three level 1 trauma centers was performed of patients with traumatic thoracic Chance fractures. Charts were assessed for clinical presentation, treatment modalities, admission and post-treatment neurologic status, and complications.

**Results:** Twelve patients were identified with thoracic Chance fractures. Seven of the patients were ASIA A (complete spinal cord injury), one ASIA C, and four were ASIA E (intact). Two patients were managed with bracing, nine patients underwent posterior instrumented stabilization, and one patient underwent combined anterior-posterior stabilization. Half of the patients suffered multiple severe chest injuries, including aortic dissection and flail chest. One patient died from these injuries. Two patients had improved ASIA scores at discharge, and none of the patients worsened postoperatively.

**Conclusion:** Though thoracic chance fractures are a rare injury, they are a high energy injury resulting in multiple organ trauma as well as spinal injury. Though many of these patients suffer spinal cord injury, a significant number can remain neurologically intact or even improve after spinal cord injury.

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**Management and Outcome of Inadvertent Durotomies in Lumbar Spine Surgeries for Degenerative Conditions**

Imad S. Khan, Ashish Sonig, Jai D. Thakur, Prashant Chittiboina, Anil Nanda

**Introduction:** Inadvertent durotomies are relatively common complications in lumbar surgeries for degenerative conditions. Our aim was to analyze our institutional experience of management strategies to deal with these durotomies intraoperatively and their outcomes.

**Methods:** We retrospectively reviewed all the patients with documented durotomies during surgery. A total of 50 consecutive patients had inadvertent intra-operative durotomies in relevant surgeries from January 2001 to December 2010.

**Results:** The average age of the patients was 57.1 years with a 1:1 sex ratio. The most common procedure was instrumented lumbar surgery (35%). The durotomy was intraoperatively managed with suture (silk or nylon) and glue (fibrin or polyethylene-glycol-hydrogel) in 21 patients, and suture alone in 17 patients. In 8 patients when no definite durotomy was identified, or its location was not amenable to suturing, glue along with muscle or fat patch was used. All patients underwent an intra-operative valsalva maneuver, history of tobacco use.

**Conclusion:** Metabolic epidural spinal cord compression (MESCC) is a debilitating complication of cancer resulting in motor or sensory deficits and bowel and bladder incontinence. While chemotherapy and radiation are the primary treatment for MESCC, surgery is indicated for intractable pain, impending mechanical failure or instability, and neurological deficits. Open surgical techniques often cause extensive dissection, increased post operative pain, immobility and longer hospitalizations. Advances in technology and refinement of techniques in minimally invasive spine surgery (MIS) may provide effective decompression and stabilization in the MESCC patient.

**Methods:** We retrospectively reviewed the perioperative results from a series of 19 patients with malignant metastatic spine disease treated with minimally invasive techniques of posterior decompression and stabilization by the senior author. These results are compared to a consecutive series of similar patients performed at our institution by open surgery.

**Results:** Satisfactory decompression and stabilization was achieved in all patients thorough one of the three techniques: microtubular laminectomy, transpedicular corpectomy and constrotansverse corpectomy. None of the patients experienced procedure related neurological deterioration and the deficits improved in all cases except those with complete spinal cord injury. The mean blood loss was 755 mL. The blood loss in a similar the open cohort was 2500 mL. The length of stay in our MIS series was 3.5 days as compared with 9.4 days in...
patients who underwent open surgery. Conclusion: This case series demonstrates the feasibility of MIS approach for treatment of MESCC patients.

406 Incidence of and Factors Associated with Severe Dysphagia Following Circumferential Cervical Spine Surgery Dwight Sautelle, Kai-Ming G. Fu, Justin S. Smith, Christopher I. Shaffrey Introduction: The objective of this study was to evaluate the incidence and potential influencing factors of severe dysphagia after combined anterior-posterior cervical spine surgeries. Methods: Medical records of 30 consecutive patients undergoing same-day anterior-posterior (AP) cervical spine fusions were retrospectively reviewed, including general assessment of demographic, radiographic, and surgical factors, and specific assessment of dysphagia. Results: Mean age was 59.1 (range 36-80), with 17 men and 13 women. Diagnoses were cervical spondylotic myelopathy (43%), pseudarthrosis with kyphotic deformity (27%), rheumatoid arthritis (13%), adjacent level disease (10%), and metastasis (7%). The mean number of levels fused anteriorly was 3.4 (range 1-6) and posteriorly was 5.6 (range 2-8). Fifteen (50%) patients required formal postoperative swallowing evaluation, and 12 (40%) had objective evidence of dysphagia. An NG tube was placed in 9 (30%) patients, with 6 (20%) requiring PEG tube placement. Of these six, one was lost to follow-up and another expired postoperatively. The remaining four PEG recipients had complete resolution of dysphagia with PEG removal an average of 6 months after surgery. Patients requiring speech evaluation underwent more levels of anterior exposure (4.1 vs 2.7 P = 0.001) and had longer hospital stays (10.4 vs 5.4 P = 0.001) compared with patients not requiring speech evaluation. Factors including duration of anterior procedure, degree of correction and preoperative kyphosis did not differ significantly. Four patients had subjective complaints of dysphagia pre-operatively, with two of these patients ultimately receiving a PEG after surgery. Conclusion: There is a high rate of severe dysphagia and PEG tube placement following AP cervical spine reconstructions. A greater number of levels treated anteriorly was significantly associated with greater risk of postoperative dysphagia. These data may prove valuable for patient counseling and on-going efforts to improve the safety of patient care and suggest that further study is warranted.

407 Posterior Minimally Invasive Decompression and Stabilization for the Management of Benign, Intradural, Extramedullary Neoplasms of the Thoraco-lumbar Spine Vibhor Krishna, Brian Blaker, Avery Lee Buchholz, Steven Morgan, Bruce M. Frankel Introduction: Benign intradural extramedullary neoplasms of the thoraco-lumbar spine produce an array of neurological symptoms that have a significant impact on quality of life. The recognized limitations of the ‘open’ approach include acceleration of degenerative changes, epidural fibrosis, and paraspinal muscle damage. With recent advancements in the minimally invasive spine (MIS) techniques it can be employed for the benign neoplasms of thoraco-lumbar spine. Methods: A retrospective review of consecutive patients with benign spinal tumors treated by the senior author with MIS techniques was performed. Results: Gross total resection was achieved in all patients. None of the patients required a conversion to open procedure. Preoperative neurological deficits improved in all patients. Conclusion: MIS techniques are feasible for resection of small and moderate size benign intradural, extramedullary tumors of the thoraco-lumbar spine.

408 The Impact of Sagittal Balance on Clinical Outcome Following Decompressive Surgery for Cervical Spondylotic Myelopathy Richard Kaplan, Han Rimlawi Malone, Oscar Flores Medrano, Michael Maurice McDowell, Michael G. Kaiser Introduction: Cervical spondylotic myelopathy (CSM) is the most common cause of spinal cord dysfunction in patients over 55 years of age (1). In addition to spinal cord decompression, maintenance of sagittal balance is a potentially important outcome measure that may be influenced by surgical approach (2-4). To better characterize the importance of this parameter, we investigated its association with clinical outcome. Methods: The charts of 528 patients undergoing surgery for CSM at Columbia University between 1998 and 2010 were retrospectively reviewed. Demographic data, surgical approach, and pre and postoperative clinical and radiographic outcomes were analyzed. Cervical alignment was determined by measuring the C2-C7 lordotic angle from upright lateral x-rays (5,6). Correlation analysis with a Pearson two-tailed test was used to investigate the relationship between sagittal balance (pre/post op lordosis angles, as well as angle change) and assessments of clinical outcome utilizing standard neurological testing. Results: Pre and post-operative radiographic data was compiled for 55 patients. Preliminary analysis did not find a significant correlation between clinical outcome and postoperative sagittal balance (P = 0.45) or change in sagittal balance (P = 0.33) following surgery. Conclusion: In our initial surgical cohort, we found no significant correlation between sagittal balance and clinical outcome. We intend to expand this study as we accrue more patients. Prospective data collection is currently underway to increase sample size and address the potential relationship between sagittal balance and postoperative pain, as measured by the neck disability index.

409 Posterior Less Invasive Decompression and Stabilization for the Treatment of Thoraco-lumbar Traumatic Spine Fractures Vibhor Krishna, Libby M. Kosnik, Steven Morgan, William A. Vandergrift, III, Bruce M. Frankel Introduction: The treatment of patients with traumatic fractures affecting the axial spine, can be approached in a variety of ways, each with its own risks and benefits. In an effort to reduce surgical-related patient morbidity in multiple system injured trauma patients, we have employed several posterior less-invasive techniques to decompress and stabilize the thoraco-lumbar spine. Methods: We retrospectively reviewed the charts of 30 patients treated with one of three posterior less invasive methods (MIS) of decompression including: microtubular decompressive laminectomy and facetectomy, microtubular transpedicular partial or complete corpectomy, or micro-
tubular costo-transverse partial or complete corpectomy. In these patients anterior column reconstruction was performed, where necessary, by either tamping fractured bone fragments or performing VBR cage insertion. Three-column fixation was performed using percutaneous pedicle screw insertion and augmented with PMMA where indicated. The rate of complications, blood loss and hospital length of stay were compared with the historical open cohort.

**Results:** The mean age of the patient cohort was 47.5 years (18 males, 13 females). A variety of disparate pathologies were treated including AO classification sub-types: A-3, B, and C, both with and without neurological injury (SCI). There were no cases of new postoperative neurological deficits, deficit stabilization or improvement was seen in all patients except those presenting with a complete SCI. The mean number of segments fused were 3.8 (Range: 2-8 levels). The mean postoperative length of stay was 6.5 days (Range: 1-28 days). The mean blood loss was 518 cc (Range: 50-2800 cc). There were two cases (6%) of hardware failure requiring re-operation within 6 months postoperatively, and one superficial wound infection treated with antibiotics.

**Conclusion:** Posterior less invasive techniques of decompression and stabilization of the thoraco-lumbar spine should be considered as a treatment option for patients with traumatic fractures affecting the axial spine. Length of hospitalization, blood loss and complication profiles compare favorably to historical controls utilizing “open” procedures.

**410 The Role of Vertebroplasty in Acute Osteoporotic Vertebral Fractures: A Meta-analysis of Randomized Trials**

Vibhor Krishna, Yasmeen Rauf, Sarah Denham, Joyce Nicholas, Bruce M. Frankel

**Introduction:** The role of vertebroplasty in the treatment of acute osteoporotic fractures remains controversial. Recently, a subgroup analysis from combined patient data of two large trials was published. A meta-analysis of these data with two other trials permitted detection of even small treatment effects from vertebroplasty after acute osteoporotic fractures.

**Methods:** A meta-analysis was performed with three publications of four trials: INVEST, the Australian trial, VETOS II and the Netherlands trial. The primary outcome was improvement in pain scores on an 11-point visual analogue scale (VAS). An improvement of ≥3 was considered significant. The cumulative improvement in pain score was calculated using DerSimonian-Laird (D-L) method.

**Results:** The cumulative resolution in pain during a short-term (less than 3 months) follow-up is 1.15 (-2.48, 0.19) and for long-term (12 months) is -1.14 (-1.79, -0.49). Both these results are clinically insignificant (improvement in VAS score <3).

**Conclusion:** Both short- and long-term pain relief from vertebroplasty is clinically insignificant for acute osteoporotic fractures. The ongoing randomized trials should further investigate the subset of patients likely to benefit from vertebroplasty.

**411 Surgical Outcome of Extreme Lateral Interbody Fusion: A Comparative Retrospective Study of the Clinical and Measured Radiological Results**

Marjan Alimi, Christoph Hofstetter, Apostolos Tsirouris, Andrew R. James, Danika Paulo, Eric H. Elovitz, Roger Hartl

**Introduction:** Extreme lateral interbody fusion (ELIF) is an increasingly popular technique for anterior fixation of the lumbar spine. More comprehensive outcome studies are needed to better define appropriate indications for this technique.

**Methods:** Demographic and peri-operative data of 90 patients who underwent ELIF between 2007 and 2011 were collected retrospectively. For radiographic outcome, pre-op, immediate post-op and follow-up coronal Cobb angles, disc heights and foraminal heights were measured. Clinical outcome was evaluated by Oswestry Disability Index and Visual Analog Scale scores.

**Results:** Ninety patients (35 males, 55 females) with a mean age of 64 years underwent ELIF surgery. More than half of the procedures involved a single-level and the remaining constructs involved 2, 3 or 4 levels. Among 156 operated levels, L4/L5 was the most common level, followed by L3/L4, L2/L3, L1/L2. 76.6% of constructs were stabilized by posterior pedicle screws, 14.4% by lateral plates and 8.9% were stand-alone. Mean time of surgery, estimated blood loss, and length of hospital stay were 203 ± 94.4 (±SD) minutes, 195 ± 325.7 ml and 4.6 ± 4.9 days, respectively. Latest follow-up data was obtained 12.4 months following the procedure. Radiographic evaluation revealed a mean pre-operative coronal deformity of 7.2 ± 7.40 degrees which was reduced to 5.5 ± 5.03 degrees postoperatively. The ELIF procedure resulted in a significant postoperative reduction of deformity (defined as decrease of ≥ 5 degrees) in 21.6% of patients. Moreover, ELIF increased foraminal height by an average of 3.17 mms. Clinical evaluation revealed a mean ODI, VAS back, buttock and leg decrease of 10.73 ± 9.64, 3.78 ± 3.93, 3.57 ± 4.02 and 3.83 ± 4.06 points, respectively. 84.8% of the patients had a Macnab of excellent, good or fair.

**Conclusion:** ELIF is well-tolerated procedure for instrumentation of the lumbar anterior spinal column. It allows for restoration of foraminal height and some correction of coronal deformity in patients with symptomatic lumbar spondylolisthesis.

**412 Preoperative Diagnosis and Surgical Treatment of Spinal Meningiomas**

Tomohiro Murakami, Izumi Koyanagi, Takahisa Kaneko, Nobuhiro Mikuni

**Introduction:** In spinal meningiomas, the management of the dura attachment will be important to prevent recurrence. Therefore preoperative diagnosis may play a role of the surgical strategy. The purpose of this study is to analyze the preoperative diagnosis and determine the surgical management strategies for spinal meningiomas in our institute.

**Methods:** This retrospective study included 18 patients (4 men and 14 women) between 2002 and 2011 aged mean 57.1 years (range: 22-83 years). The levels of tumor were cervical in 8 cases, thoracic in 8 and thoraco-lumbar in 2. Three cases were associated with neurofibromatosis type 2 (NF2).

**Results:** All cases were diagnosed as meningioma preoperatively and underwent removal of tumor via hemilaminectomy or laminectomy. Four tumors were located at the intra- and extradural spaces of upper cervical spine. In two of them, we resected the tumor and also the dorso-lateral hypertrophic dura mater with duraplasty. In other meningiomas located intradurally, the attached dura was bipolar-coagulated adequately. Tumors were totally removed in 15 cases, subtotally in 3 cases. During the follow-up period, there was no recurrence of the tumors.
Conclusion: Bipolar-coagulation of the attached dura mater is sufficient to prevent recurrence of the intradural spinal meningoima. For meningiomas showing intra- and extradural extension, surgical removal of the hypertrophied dura and duraplasty may be important.

413 Spinal Somatosensory Evoked Potentials Correlate with BBB Scores After Spinal Cord Injury of Varying Severity
Shekar N. Kurpad
Introduction: We have correlated BBB scores with Spinal somatosensory evoked potentials (SpSEPs) in the rat after spinal cord injury (SCI). SpSEPs have previously been shown to detect and characterize different latency components associated with specific spinal pathways. SpSEPs could prove useful in understanding spinal cord function following an injury and provide insight into course of treatment.

Methods: SpSEPs were collected on 40 female Sprague-Dawley rats 10 weeks post-injury. 4 groups were included: sham, mild, moderate, and severe thoracic SCI derived from an NYU impactor. SpSEPs characteristics were correlated with BBB locomotor scores. Stimulation was applied to the sciatic nerve to yield SpSEPs. Recording electrodes were placed rostral to T5 and T11. The range of signal amplitude was found as the maximum amplitude-minimum amplitude (D1 = P1-N1) between 10 and 25ms for the mid-latency and 25-100 ms for the long latency (D2 = P2-N2). Finally SpSEPs were correlated to BBB scores.

Results: The varying injury severities resulted in different SpSEP responses. The individual peaks and valleys of the evoked potential epochs were collected and compared against the BBB scores. Correlations were noted between the overall SpSEP amplitude (D1 and D2 amplitudes) and the BBB scoring and severity. D1 time and amplitude were significant (P < 0.05), where the D2 correlations were not significant.

Conclusion: There are characteristic differences in SpSEPs between injuries with different severities and correlate with BBB scores. Overall there was a relation between the severity and the mid- or long-latency components.

414 Treatment of Herniated Lumbar Disc by Sequestrectomy or Conventional Discectomy
Mohammed F. Shamji, Ish Bains, Emma Yong, Garnette R. Sutherland, R. John Hurlbert
Introduction: Optimal surgical technique for treatment of herniated lumbar disc remains uncertain. Advocates of sequestrectomy cite less perioperative pain and preserved disk architecture, whereas advocates of conventional discectomy cite less frequent reherniation. We investigated perioperative and postoperative endpoints to evaluate the comparative success of each procedure.

Methods: Consecutive discectomy patients were treated at a single center by surgeons with technique to either consistently perform sequestrectomy or conventional discectomy. Retrospective collection of demographic, radiographic, and outcomes data provided analysis of each procedure’s efficacy, with particular attention to clinical outcome and reherniation with or without need for further operation. Continuous and categorical variables were analyzed by ANOVA and Pearson likelihood ratio with surgical technique as factor, at the 0.05 level of significance.

Results: Of 172 patients treated, 74 were underwent conventional discectomy and 98 underwent sequestrectomy, followed for median 6 years. There were no differences in age, gender, smoking status, and level of disc herniation (alpha=0.05). Intraoperatively, conventional discectomy did not associate with any greater blood loss (P = 0.90) or longer duration of surgery (P = 0.67), nor with any perioperative difference in length of stay. Postoperatively, we reoperated for disc herniation in 14% of patients, variable by surgical technique (P < 0.01). Among conventional discectomy, the reoperation rate was 10% (6% same-level, 4% adjacent-level), lower than sequestrectomy with reoperation rate of 19% (15% same-level, 4% adjacent-level). In the latter group, a trend of reherniation was observed among smokers.

Conclusion: This cohort of patients with good long-term follow-up exhibited a reoperation rate of 14%, more frequent with sequestrectomy than conventional discectomy. No significant differences occurred with blood loss, surgical time, or hospital length of stay. Clearly, while a larger prospective RCT may more definitively answer this question, this study provides substantial support for a more conventional surgical approach.

415 Rates of Infection with Dynamic Stabilization Compared to Posterior Instrumented Fusion
Ira M. Goldstein, Nitin Agarwal, Antonios Mamalis, James Barrese, Lana D. Cristiano
Introduction: Dynamic stabilization offers an adjunct to fusion with motion preservation. Dynamic stabilization constructs include a polycarbonate urethane spacer secured by titanium pedicle screws, which allows for limited flexion and extension. In comparison, standard instrumented fusion (IF) consists of titanium screws and rods/plates, which do not allow for motion at the level of the fusion. The reported infection rate following a standard IF ranges from 0.2%–7%.

Methods: A retrospective chart review of 142 patients who underwent posterior lumbar stabilization procedures was conducted. Ten patients received dynamic stabilization and 132 patients had a standard IF. Rates of infection, requiring hardware removal, were compared between the aforementioned groups. Comorbidity scores were assigned to each patient, using the Charlson Comorbidity Index.

Results: Of the 132 patients undergoing posterior IF, 3 developed a deep wound infection requiring removal of hardware (2.3%). Of the 10 patients undergoing dynamic stabilization, 3 developed a deep wound infection (30%) with 2 requiring removal of hardware (20%), secondary to persistent deep wound infection or osteomyelitis at the pedicle screw sites. There was a significantly increased risk of deep wound infection (P < 0.0001) with the use of dynamic stabilization compared to standard IF. Comorbidity scores demonstrated no difference between the dynamic stabilization and IF groups, but a significant difference (P < 0.05) was found, within the IF group, comparing patients that did and did not develop infection.

Conclusion: Our series demonstrates that the infection rate in patients undergoing dynamic stabilization is higher than that for instrumented fusion. We postulate that the polycarbonate urethane spacer acts as a medium for bacteria, whereas the titanium screws and rods are smooth, solid, and inert, resulting in a lower risk of infection. Future research should include a prospective trial comparing the infection rates of posterior instrumented fusion to that of posterior dynamic constructs.
Results: The median patient age was 48 (range, 22-93). Twenty-seven (44%) patients were male. The most prevalent comorbidities were: hypertension (19%), and hyperlipidemia (11%). Presenting symptoms included: sensory deficit (76%), back pain (74%), motor deficit (60%), and urinary/bowel incontinence (31%). Tumors were located most commonly in the cervical (46.8%) and thoracic (46.8%) spine. Tumors were located intradural-extramedullary (29%) and intramedullary (71%). The most common tumor pathologies were: ependymoma (5%), meningioma (26%), and astrocytoma (10%). Post-operatively, all patients wore compression stockings and intermittent pneumatic compression devices. 42 (68%) patients were administered heparin subcutaneously (1000U) every 12 hours starting 12-48 hours after surgery. The median length of stay was 5 days. Postoperatively, 81% showed improvement in motor function, 68% showed improvement in urinary/bowel incontinence, 65% showed improvement in back pain, and 62% showed improvement in sensory deficit. There were 12 complications: 4 CSF leaks, 3 surgical site infections, 2 epidural hematomas requiring surgical intervention, 2 DVTs, and 1 PE which resulted in death. There were no instances of intradural/intraparenchymal hemorrhage requiring surgical intervention. Of the 3 (4.8%) cases of DVT/PE complications, two patients did not receive subcutaneous heparin postoperatively. Of the 2 (3.2%) cases of epidural hematomas, one patient was on anticoagulation.

Conclusion: DVT/PE after surgical resection of spinal cord tumors may be more common than previously recognized. DVT prophylaxis cannot fully protect a patient from this complication. Administration of subcutaneous heparin does not appear to increase the risk of postoperative hemorrhagic complications in this patient population.

418 Evaluation of Radiographic Evidence of Interspinous Fusion in Various Constructs of Minimally Invasive Lumbar Surgery
Amir A. Vokshoor, Aryan Esmaili, Sanjay Khurana, Peter Filsinger, Dean Wilson

Introduction: InterSpinous Process (ISP) fixation for fusion has gained recent attraction as a less invasive option for patients undergoing lumbar fusion surgery for the treatment of degenerative disc disease, spondylosis and/or instability of the lumbar spine. ISP fixation can be used in a variety of constructs, their actual fusion success rate has yet to be determined in a large case series.

Methods: 46 patients who underwent ISP fixation over a 48-month period were evaluated. In patients who underwent lumbar fusion with an ISP fixation device, interspinous fusion (and interbody fusion if applicable), was assessed using post-operative CT imaging obtained between 2 and 23 months. These images were reviewed by an independent radiologist to evaluate success of fusion for the ISP space using the following scale: Grade 1 indicates small islands of bone, Grade 2 shows larger islands of coalescence with bridging to the surrounding anatomy, Grade 3 indicates some solid incorporation and bridging bone, Grade 4 shows solid fusion, with incorporation and obvious stability and maturity. Fusion of the intervertebral space was assessed using the Burkus criteria.

Results: 38 patients represented a total of 43 lumbar levels with ISP fixation for fusion. 91% of levels demonstrated Grades 4 ISP fusion based on the aforementioned scale. 25 levels (64%) fused posteriorly also had placement of an interbody cage. 21 of these levels (84%) showed solid interbody fusion (BSF-3). Of the 4 pseudoarthrodesed levels, 2 had adjacent pedicle screw fixation, and 2 were interbody and ISP fixation alone. 2 of these patients underwent re-exploration and explantation due to post-operative pain secondary to fracture of the spinous process and/or lamina.

Conclusion: ISP fixation is a safe and effective minimally invasive technique in lumbar fusion surgery and uses a less invasive approach than traditional fixation.
occipital headaches from a C1 screw impinging on the C2 nerve root with pain resolving after hardware removal.

**Conclusion:** Atlanto-axial (C1-2) fusion using C1 lateral mass and C2 pedicle screws with C2-nerve sparing C1-2 intra-articular arthrodesis is a safe and reliable technique with high fusion and low complication rates.

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**420 Two-Level Anterior Cervical Discectomy vs. One-Level Corpectomy in Cervical Spine: Biomechanical Study**

**Kamran Aghayev, Imam Saleh, Nam Duy Tran, Frank D. Vrionis**

**Introduction:** The aim of the study was to compare the biomechanical behavior of human cervical cadaveric segments in the following conditions: intact, one level corpectomy, and two level discectomy.

**Methods:** Seven fresh frozen human cadaveric spines (C3-T1) were used. The initial testing was performed on intact specimens. Pressure transducers were inserted at C3-C4, and C6-C7 disc spaces. Strain gauges were affixed on facets of C3-C4 and C6-C7 bilaterally. Pressure transducer and strain gauge signals were conditioned and amplified by a signal conditioner and recorded by the servohydraulic mechanical testing system. Discectomy was performed at C4-5 and C5-6 levels, with cage and anterior plate reconstruction, followed by C5 corpectomy with cage and plate reconstruction. The outputs of the pressure transducers and strain gauges were determined for each specimen in the following conditions and order: 1) intact, 2) after discectomy and implantation of two cages and anterior plate 3) after corpectomy and implantation of cage and anterior plate. Calculated responses of the intact and simulated fusions were compared at each loading condition.

**Results:** Statistical significance (P < .05) reached for both: range of motion and stiffness between the intact/two discectomy and corpectomy/two discectomy conditions in all moving conditions. In the intact condition both superior and inferior adjacent discs had the highest mean intradiscal pressure, followed by corpectomy (P > .05). The two discectomy condition had the lowest mean adjacent disc intradiscal pressures and statistical significance between the intact and two discectomy conditions was significant (P > .05) for superior and inferior intradiscal pressures in flexion-extension as well as superior intradiscal pressure in axial rotation. For all motions and conditions peak superior facet microstrains were higher than inferior. There were no statistically significant facet microstrain differences between the intact and simulated fusions.

**Conclusion:** Stiffness and range of motion data show that two discectomy more stable than corpectomy. Conversely to previous reports we found that simulated fusion decreases intradiscal pressure and there is an inverse relation between the stiffness and intradiscal pressure.

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**421 Intracranial Complications Associated With Spinal Surgery**

**Martin Pham, Alexander Tuchman, Andrew Platt, Sara Kingston, Thomas C. Chen, Patrick C. Hsieh**

**Introduction:** Though rare, intracranial complications have been reported as a result from spinal surgery. Most if not all of these are a result of intracranial hypotension from CSF leak and hypovolemia.

**Methods:** We conducted a retrospective review of all patients who underwent spinal surgery at our institution by two neurosurgeons from July 2008 to April 2011.

**Results:** Our review yielded 484 patients who underwent spinal surgery for a total of 616 procedures. There were 227 (47%) men and 257 (53%) women. Their mean age was 58.3 years (range 20-90).

Intracranial imaging using either CT or MRI were obtained on 22 (3.6%) patients after a procedure due to neurologic change. Two patients (0.3%) were found to have bilateral subdural hygromas suggestive of acute intracranial hypotension. There were no reports of any hemorrhages, strokes, or other complications of the intracranial compartment.

**Conclusion:** Intracranial complications from spinal surgery are a rare event. We demonstrate an incidence of 0.3% of total intracranial pathology, all of which were subdural hygromas. There were no cases of intracranial hemorrhage and infarction.

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**422 Biomechanical Comparison of Anterior Cervical Spine Instrumentation Techniques After Two Levels Corpectomy**

**Kamran Aghayev, Imam Saleh, Nam Duy Tran, Frank D. Vrionis**

**Introduction:** The aim of this study was to compare the stiffness and range of motion of four cervical spine constructs and the intact condition: three anterior cervical discectomies with three level anterior plate, one discectomy and one corpectomy with three level anterior plate, two levels corpectomy with three level anterior plate, two levels corpectomy with anterior plate and posterior fixation.

**Methods:** Eight human cadaveric fresh-frozen cervical spines from C2-T2 were utilized. Three-dimensional motion analysis with an optical tracking device was used to determine motion following various reconstruction methods. The specimens were tested in the following conditions: 1) intact, 2) segmental construct with discectomies at C4-C5, C5-C6, C6-C7, PEEK interbody graft, and anterior plate 3) segmental construct with discectomy at C6-C7, corpectomy of C5, with PEEK interbody graft at discectomy level and titanium cage at corpectomy level 4) corpectomy at C5 and C6 with titanium cage and an anterior cervical plate and 5) corpectomy at C5 and C6 with titanium cage and an anterior cervical plate and posterior lateral mass screws/rod system from C4 to C7. All specimens underwent a pure moment application of 2 Nm with regards to flexion, extension, lateral bending, and axial rotation.

**Results:** In all tested motions the statistical comparison between intact and the two levels corpectomy with anterior plate and posterior fixation construct was significant. All other comparisons were not statistically significant except between the three levels discectomy and the two level corpectomy in axial rotation.

**Conclusion:** Segmental plate fixation (three levels discectomy) affords the same stiffness and range of motion as circumferential fusion in two level cervical spine corpectomy. This obviates the need for staged circumferential procedures for multilevel cervical spondylotic myelopathy. The placement of posterior instrumentation should be strongly considered to significantly improve the overall stability of the stability after a two level cervical corpectomy.
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**High-Grade Traumatic Cervical Subluxation Injuries: Treatment Strategies and Outcomes**

Sanjay S. Dhall, Daniel J. Hoh

**Introduction:** Traumatic high-grade (>50%) cervical subluxations are uncommon spinal injuries, often associated with severe neurologic compromise. Particularly, traumatic cervical spondylolisthesis (>100% subluxation) is rare, with little reported in the literature regarding treatment and outcome. To the best of our knowledge, we present the first reported case series describing management of these complex spinal injuries.

**Methods:** A study at three level I trauma centers was performed of patients with traumatic cervical subluxation >50%. Charts were assessed for clinical presentation, treatment modalities, admission and post-treatment neurologic status, and complications.

**Results:** Eleven patients with high-grade subluxation were identified, 7 who had >100% subluxation. Ages ranged 19 to 76 years. High-energy closed spinal injury was the mechanism in all but one patient. Admission ASIA grade varied (A=4, B=1, C=4, D=1, E=1). Ten patients underwent halo traction with five (50%) failing closed reduction. High-dose methylprednisolone was administered in 4 patients. All patients underwent surgical stabilization ± open reduction: anterior only (n = 3), posterior only (n = 3), combined anterior-posterior (n = 5). Four patients (36.4%) had good post-treatment neurologic outcome (ASIA D, E), 2 of whom improved one ASIA grade. One additional patient remained ASIA B, however, improved in neurologic level of injury post-treatment. Complications included neurologic worsening (n = 1), traction pin-site scalp laceration (n = 2), hardware failure (n = 1), vertebral artery injury (n = 1), infection (n = 1), DVT (n = 1), death (n = 1).

**Conclusion:** High grade traumatic cervical subluxations are complex, unstable injuries. Remarkably, 45.5% demonstrated good neurologic outcomes as defined in ASIA grade, neurologic level of injury, or preservation of good ASIA grade. Pre-operative traction did not significantly improve neurologic outcome and was associated with high failure rate of reduction. Likely due to severity of these injuries, there was a high incidence of related complications. However, given the observed potential for neurologic improvement, we recommend aggressive surgical reduction and stabilization for these complex spinal injuries.

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**424**

**Validation of the SRS-Schwab Adult Deformity Classification**

Justin S. Smith, Christopher I. Shaffrey, Benjamin Ungar, Frank Schwab, Virginie Lafage, Benjamin Blondel, Jacob Buchowski, Jeffrey Coe, Hossein Mehdian, Clifford Tribus

**Introduction:** A classification system for adult spinal deformity (ASD) can serve several purposes, including: consistent characterization of a clinical entity, a basis for comparing different treatments, and a basis for recommending treatments. Based upon a Scoliosis Research Society (SRS) effort, this study seeks to determine if a proposed new ASD classification system is clear and reliable.

**Methods:** Initiated by the SRS Adult Deformity Committee, this study used a classification system previously published by Schwab and revised to include pelvic parameters. Modifiers cutoffs were determined using health-related quality of life data from a multi-center database of adult deformity patients. 9 readers graded 21 pre-marked cases twice each, approximately one week apart. Inter- and intra-rater reliability and inter-rater agreement were determined for the curve type and each modifier separately. Fleiss’ Kappa was used for reliability measures, with values of 0.00-0.20 considered slight, 0.21-0.40 fair, 0.41-0.60 moderate, 0.61-0.80 substantial, and 0.81-1.00 almost perfect agreement.

**Results:** Inter-rater Kappa for curve type was 0.80 and 0.87 for the two readings, respectively, with modifier Kappas of 0.75 and 0.86, 0.97 and 0.98, and 0.96 and 0.96 for pelvic incidence-lumbar lordosis (PI-LL), pelvic tilt (PT), and sagittal vertical axis (SVA), respectively. By the second reading, curve type was identified by all readers consistently in 66.7%, PI-LL in 71.4%, PT in 95.2%, and SVA in 90.5% of cases. Intra-rater Kappa averaged 0.94 for Curve Type, 0.88 for PI-LL, 0.97 for PT, and 0.97 for SVA across all readers.

**Conclusion:** Data from this study show that there is excellent inter- and intra-rater reliability and inter-rater agreement for curve type and each modifier. The high degree of reliability demonstrates that applying the SRS-Schwab system is easy and consistent. Greater Kappa values in the second set of readings also demonstrate a learning curve in application of the classification system.

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**PEEK Rods for Stabilization of the Lumbar Spine**

Robert M. Galler

**Introduction:** Instrumented fixation for spinal surgery has become an increasingly utilized method to achieve fusion. With the rising use of rigid fixation there has been recognition of the development of problems with adjacent segments in terms of premature degeneration. The exact mechanism is unclear but it is believed that the increased stresses on the adjacent segment to the fused segment in the presence of hardware provides increased tension on the elements of the spine leading to degeneration, spondylolisthesis and stenosis. Polyetheretherketone (PEEK) has been used as a biomaterial for orthopedic, and spinal implants. PEEK is a thermoplastic polymer whose chemical structure maintains stability at temperatures exceeding 300°C, resists chemical and radiation damage, exhibits greater strength per mass than many metals, and offers compatibility with many reinforcing agents. PEEK as a biomaterial is fully biocompatible, with numerous studies documenting minimal systemic, intracutaneous, and intramuscular toxicity.

**Methods:** This is a retrospective case series of the surgical experience of a single surgeon. 65 cases of patients implanted with PEEK rods are reviewed. The CD Horizon Legacy PEEK rod system was used in all cases with or without the addition of interbody grafting. The interbody grafts were PEEK implants or Bone.

**Results:** The patients were followed at 1 week, 1 month, 3 month and 6-month intervals. All patients are to be followed at one year with clinical and radiographic evaluation. Fusion mass developed with excellent clinical results. Complication rates were comparable to previous experience and published reports with no evidence of rod breakage in either group. One patient in the PEEK rod group retro pulsed a graft after a postoperative fall. This required re-operation.

**Conclusion:** PEEK rods represent a safe alternative to Titanium rods for instrumentation of the lumbar spine.
Outcomes in Surgical Management for Adult Degenerative Lumbar Scoliosis: A Comparison of Three Different Approaches
Anish A. Patel, Jared Fridley, Ibrahim Omeis

Introduction: Adult degenerative lumbar scoliosis is a complicated spinal disorder in which the optimal management algorithm is often not clear in patients who require surgical intervention. The purpose of this study was to review the literature in order to review the pre- and post-operative spinal measurements, clinical outcomes, and complications between three general surgical approaches for treating this disease: decompression alone, decompression with short segment fusion, and decompression with full-curve fusion.

Methods: The published literature was reviewed using manual and electronic search techniques. Data included demographics, presenting symptoms, Cobb angle, lumbar lordosis, lateral listhesis, sagittal plumb angle, number of levels decompressed and fused, recovery, post-operative complications, Oswestry disability index (ODI), and incidence of revision surgery.

Results: Six relevant publications were found, reporting on a total of 37 patients in the decompression alone group, 110 patients in the partial fusion group, and 190 patients in the long fusion group. Among the three groups, the average number of decompressions was 1.9, 2.5, and 3.1 levels, respectively. There was a mean of 3.1 levels fused for the short fusion group and 5.9 levels for the long fusion group. Pre-operative Cobb angles was similar for each group (21.1, 21.7, and 23.8 degrees). During their postoperative follow up, in the decompression group, 75% were reported to have recurrent stenosis and 14% needing revision. In the partial fusion group, 36% of patients had adjacent segment disease and 11% underwent revision. In the long fusion group, 26% developed adjacent segment disease, with 16% needing revision. The average improvements in ODI for the decompression group, partial fusion group, and long fusion group were 7.9, 11.2, and 11.4, respectively.

Conclusion: Although all three approaches showed good post-operative outcomes, each method also has its own set of complication and revision rates that were likely influenced by pre-operative conditions as well as co-morbidities. Likewise, these patients were not randomized thus leaving selection bias as a significant confounding factor. Thus, more studies are needed to specifically determine what pre-operative variables and range of deviation necessitate a specific approach.

Loading Rate Dependency of Thoraco-Lumbar Spine Fracture Location: An Investigation of Trauma in Military Scenarios
Brian D. Stemper, Jamie Baisden, Narayan Voganandan, Dennis J. Mainman, Frank A. Pintar

Introduction: Diverse injury mechanisms in military environments necessitate the study of associated spinal injuries and relevant clinical biomechanics. Aviator ejections and helicopter crashes have traditionally constituted the most common spinal injury modes. However, current conflicts have demonstrated a prevalence of underbody blast (UBB) events due to increased use of improvised explosive devices. Although all three environments involve primarily vertical acceleration/deceleration, the differences lie in the loading rate, with helicopter crashes and UBB occurring at higher accelerations and with greater rates of onset.

Methods: This abstract presents an analysis of clinical, descriptive, and biomechanical studies in these areas.

Results: Ejection-related injuries were distributed across the entire vertebral column, focused in the mid-thoracic region and thoraco-lumbar junction. However, helicopter crash and UBB-related injuries were biased toward dorsal regions. Specifically, 38%, 42%, and 2% of ejection injuries occurred in the middle thoracic, thoraco-lumbar, and lower lumbar regions. In contrast, 12%, 52%, and 16% of helicopter crashes affected those regions. Likewise, 10%, 52%, and 38% of UBB injuries affected the same regions. Injuries were focused in the mid-thoracic areas for ejection and in the middle and lower regions of the lumbar spine for higher-rate scenarios.

Conclusion: These patterns indicate that the primary mode of external load transmission, as well as rate at which the loading is applied, affect injury distributions within the anatomical structure. These distributions contrast civilian populations wherein the thoracolumbar junction is the most vulnerable region for acute trauma.

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Conclusion: These patterns indicate that the primary mode of external load transmission, as well as rate at which the loading is applied, affect injury distributions within the anatomical structure. These distributions contrast civilian populations wherein the thoracolumbar junction is the most vulnerable region for acute trauma.

Important biomechanical factors affecting trauma included loading rate, dynamic load level, occupant anthropometry, and posture/alignment with respect to the loading vector at the time of the transmission of the external load. The changing injury patterns resulting in caudal migration for underbody blast and rostral migration for ejection loadings may have implications in the treatment regimen.

Correlation Between Thoracic and Thoracolumbar Spinal and Neurological Injuries and Magnetic Resonance Imaging Findings
Daniel Robert Fassett, Swetha Naroji, Mitchell Gil Maltzofort, Yazhini Gnanasambanthan, Shiveindra Jeyamohan, James S. Harrop

Introduction: The objective of this study was to correlate MRI findings with neurological deficits associated with thoracic spinal cord injuries (SCIs).

Methods: The association between neurological deficits and MRI findings was assessed in a case control series of consecutive patients who underwent thoracic spine MRI as part of evaluation for traumatic injuries. Spinal canal compromise, spinal cord compression, extent of cord edema, and parenchymal hemorrhage were analyzed for correlation with the presence and degree of neurological deficits.

Results: Seventy-seven patients (51 male, 26 female) with a mean age of 34.6 years were identified (36 patients with neurologic deficits attributable to spinal cord injury (SCI) and 41 patients with no apparent deficits). Canal compromise was noted in 51 patients (31 patients greater than 25% and 8 greater than 50% compromise). Canal compromise greater than 25% had a Positive Predictive Value (PPV) for SCI of = 74.2% and PPV of greater than 50% canal compromise was 100%. Spinal cord compression had a PPV = 84.6% and a Negative Predictive Value (NPV) = 92.1%. Spinal cord compression had a 91.6% sensitivity and 85.3% specificity in predicting SCI. Spinal cord edema had a PPV = 92.3%, NPV = 76.4%, Sensitivity = 66.7%, and Specificity = 95.1%. Eleven patients had intramedullary hemorrhage and all had neurological deficits (PPV =100%, NPV = 62.1%).

Conclusion: This is the first study to correlate MRI findings with the presence of neurological deficits in thoracic spinal
injuries. Several findings were associated with a high likelihood for neurological deficits with thoracic spinal injury, including (1) >50% spinal canal compromise, (2) presence of spinal cord compression, (3) presence of spinal cord edema, and (4) presence of intramedullary spinal cord hemorrhage. In attempting to predict the absence of SCI, the absence of spinal cord compression was the best predictor of no neurological deficits.

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Trends in the Surgical Treatment of C2 Fractures
Ali A. Baaaj, Tien V. Le, Fernando L. Vale
Introduction: The second cervical vertebra is the most commonly fractured level in cervical spine trauma. With advancements in surgical technique and technology, we hypothesized that there is an increasing trend of surgical intervention in cases of C2 fractures on a national level.

Methods: Data were abstracted from the Nationwide Inpatient Sample (NIS) for the years 2005 through 2009. The NIS is maintained by the Agency for Healthcare Research and Quality and represents a 20% random stratified sample of all discharges from nonfederal hospitals within the United States. Patients with C2 fractures that underwent spinal fusion were identified using the appropriate ICD-9-CM codes. The number of discharges, length of stay (LOS), hospital charges, and total national charges were analyzed.

Results: 137,000 records were obtained for analysis. During this 5-year period, there was an 18% increase in the number of admissions for C2 fractures (24,508 in 2005 to 28,837 in 2009), but an 85% increase in the number of spinal fusions during the same time period (1,317 in 2005 to 2,436 in 2009). Furthermore, there was a 57% increase in the surgical rate during this 5-year period (5.4% in 2005 to 8.5% in 2009). Hospital charges associated with spinal fusions for C2 fractures increased by 32% but the total national bill increased by 145%.

Conclusion: Analysis of a national healthcare database confirms our hypothesis of increased trends of surgical intervention in the cases of C2 cervical spine fractures. We believe that advancements in spinal technique and technology are contributing factors. Given the associated increases in costs, however, our efforts to make these interventions more cost-effective needs to continue.

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Placement of Thoracic Transvertebral Pedicle Screws Using Three-Dimensional Image Guidance
Eric W. Nottemeier, Stephen M. Pirris
Introduction: Originally described by Abdu[1], transvertebral pedicle screws have been used successfully in the treatment of high-grade L5-S1 spondylolisthesis.[2,3] An advantage of transvertebral pedicle screws is purchase of multiple cortical layers across two vertebrae, thereby increasing the stability of the construct.[4] The use of transvertebral pedicle screws at spinal levels other than L5-S1 has not been reported. The authors report their initial experience with placement of thoracic transvertebral pedicle screws using cone beam computed tomography (cbCT)-based, three-dimensional (3D) image guidance.

Methods: Seven patients underwent placement of 26 thoracic transvertebral pedicle screws. Image guidance was used to place the screws across the thoracic pedicle from inferior to superior with the screw crossing the cortical endplates of the disc space above (Figs. 1-2). An intraoperative cbCT scan was accomplished in every patient to confirm adequate screw placement. Screw position and breach were assessed on intraoperative cbCT scans or postoperative CT scans.

Results: A total of 26 transvertebral pedicle screws were placed into thoracic levels spanning from T1 to T12. No complications resulted from instrumentation placement or the use of image guidance. Additionally, no screws had to be replaced or repositioned after intraoperative review of the cbCT scans. Review of intraoperative cbCT and postoperative CT scans revealed all screws to be across the superior disc space with the tips in the superior vertebral body (Fig. 3). Six pedicle screws were placed using the in-out-in technique in patients with narrow pedicles leaving 20 screws that underwent breach analysis, none of which was noted to have a breach. A noticeable increase in insertional torque of the transvertebral pedicle screws were observed by the authors as compared to standard pedicle screws that were placed contralaterally or at other levels in the same patient.

Conclusion: Placement of thoracic transvertebral pedicle screws can be accomplished safely and accurately with the use of image guidance. A formal biomechanical study is planned to quantify the possible increased biomechanical stability to a construct that these screws may provide.

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Disseminated Myxopapillary Ependymomas of Lumbosacral Spine: A Preliminary Series of Eight Cases
Patrick R. Maloney, Jeffrey T. Jacob, Michelle J. Clarke, William E. Krauss, Caterina Giannini
Introduction: Myxopapillary ependymomas (MPEs) account for 13% of all ependymomas with a predilection for the lumbosacral region (1,2). While gross total resection (GTR) is the gold standard, patients may have dissemination at presentation, making GTR impractical (3-5). The management following resection in those with disseminated disease remains controversial (6,7).

Methods: From August 1988 to September 2011, nine patients were identified having undergone treatment for disseminated MPE at our institution, 8 of whom had follow-up greater than 1 year for which results were analyzed. All patients had undergone primary surgical resection of all visible tumor in the operative bed; however disseminated disease was noted in the lumbosacral cisterns at the time of the initial surgery. Patients with simple biopsies were excluded. Available surgical/pathological reports, clinical and radiological outcomes in patients with disseminated MPEs were reviewed.

Results: Average age at pathologic diagnosis was 29 (range 17-46). Six patients (67%) had undergone initial treatment at an outside institution. All had evidence of disseminated disease seeding the cisterns and tracking along the lumbosacral roots at the time of the initial surgery per operative notes or imaging. Following surgery, 1 patient (11%) was observed, 3 patients (33%) received upfront radiation, and 5 patients (83%) had progression requiring treatment either by radiation (n = 3) or further surgery (n = 2). The respective mean and median time to progression in those who received radiation was 89 and 62 months vs. 26 and 28 months in those who did not receive any form of radiation. Collectively, 7 out of 8 patients (88%) had continued progression of disease following their initial management during the follow-up period. The mean and median follow-up for the entire cohort was 128 and 88 months respectively.

Conclusion: Management of disseminated...
MPE remains challenging. Close follow-up with or without adjuvant treatment is advised.

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**Inhibition of Epidural Fibrosis by an HSP20-mimetic (AZX100) in the Rabbit Model of Laminctomy: A Pilot Study**

Randall W. Porter, Roger S. Crowther, Mark C. Preul

**Introduction:** AZX100, a synthetic peptide comprising a fragment of a heat shock-related protein HSP20 conjugated to a protein transduction domain, inhibits fibroblast production of pro-fibrotic growth factors, including connective tissue growth factor (CTGF). This pharmacologic profile led us to evaluate AZX100 effectiveness on the severity of epidural fibrosis in the rabbit laminctomy model.

**Methods:** New Zealand rabbits had laminctomies (~ 10 x 15 mm) performed at T4-5, and before closing were implanted with osmotic pumps delivering vehicle (saline) or 5.0, 50.0 or 500 microg of drug per day between days 7-28 post-surgery (n = 3 per group). Two rabbits received laminctomies but were not implanted with pumps (no intervention). After sacrifice at 28 days, histologic sections were prepared, stained with H & E or trichrome, and evaluated, blinded, by a veterinary pathologist for fibrosis (1), fibroblast and inflammatory cell density (2) and bone regeneration.

**Results:** Drug vehicle and no intervention Groups had similar mean epidural fibrosis scores (3.0 and 2.5, respectively, maximum score = 3). Fig. 1 is a representative vehicle control photomicrograph showing diffuse adherence of dura mater to scar tissue filling the laminctomy site. Five and 50 microg/day treated Groups had similar fibrosis scores: 2.3 and 2.7, respectively. A notable reduction in epidural fibrosis (mean = 0.3) was seen in the 500 microg per day treatment Group. The difference was not significant, because of the small group size. Fig. 2, from a 500 microg/day treated animal, shows the striking absence of fibrosis at the dura mater. No differences were seen in scores for fibroblast or inflammatory cell density. In all specimens, bone regeneration was noted as Grade 1 or 2, with no consistent drug-related effect.

**Conclusion:** These pilot data show that AZX100 can strikingly reduce epidural fibrosis in a relevant surgical model, and should undergo further study.

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**The Schwannomatosis International Database**

Allan J. Belzberg, Amanda Bergner, Jaishri Blakeley

**Introduction:** Schwannomatosis is a recently recognized disorder, with diagnostic criteria first published in 2005. Little is known about the natural history. Given the limited number of patients identified with the disorder, this is a challenging undertaking and a collaborative effort is desirable to allow for pooling of data from multiple centers.

**Methods:** The specific aims of this project were: (1) coordinate national and international experts in schwannomatosis to formulate key research questions, (2) translate key questions into specific data points, (3) design a web-based database to collect data across international treatment centers.

**Results:** A collaboration of international schwannomatosis experts from fifteen institutions in eight countries was established. The Schwannomatosis International Database (SID) was designed and built around core questions. The data points were chosen specifically to provide adequate information to researchers while remaining de-identified to protect patient confidentiality. The database is a platform from which multiple research endeavors can be launched, assisting researchers to identify subjects who might be appropriate for their studies. A steering committee has been established for this collaboration and by-laws have been ratified. Individual researchers with a question in the field of schwannomatosis can submit a letter of intent to the SID Steering Committee. The review will be reviewed and, if approved, the database will be queried to connect the researcher with the centers that manage the patient(s) of interest. Currently, 14 centers are participating representing 6 countries.

**Conclusion:** This project has increased communication and collaboration within the schwannomatosis community of experts. It will also facilitate connections between researchers studying schwannomatosis and patients wanting to participate in research. Suggestions for trial design and evaluation of relevance to the schwannomatosis community will be evaluated through the process of steering committee review of letters of intent. The methodology can be easily adapted to other medical conditions.

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**Percutaneous Placement of Thoracic Intrav- and Extraperdicular Screws: Clinical and Radiographic Results**

Justice Agyei, John W. German

**Introduction:** Intrapedicular (IP) and extrapedicular (EP) screw placement are recognized as viable options for stabilization of the thoracic spine. Only one small series of percutaneous screw placement has been published.

**Methods:** A retrospective review was undertaken of 31 consecutive patients who underwent thoracic screw placement. Information abstracted from the medical records included: age, sex, height, weight, spinal diagnosis, pre- and post-operative neurologic status, complications, and office follow-up. All patients underwent CT imaging within 48 hours of surgery and screw placement was assessed. Results are reported as mean ± standard deviation.

**Results:** Thirty-one consecutive patients (age 48.8 ± 20.5 years, 15 males & 16 females, BMI 26.8 ± 8.7) with thoracic and/or thoracolumbar instability underwent placement of percutaneous IP or EP screws between T2 and T12. The underlying spinal diagnoses included trauma (n = 21), infection (n = 2), cancer (n = 6), and disk herniation (n = 2). Two patients required further surgery related to the initial procedure for evacuation of an epidural hematoma (n = 1) and debridement of a deep wound infection (n = 1). No patient required revision of their spinal instrumentation. Of the 99 thoracic screws placed 55.6% were IP and 44.4% were EP. Grading of screw placement was follows: IP: grade 1: 61.8%, grade 2: 36.4%, and grade 3 1.8%, EP grade 1: 63.6%, grade 2: 34.1%, and grade 3 2.3%. The two grade three screws both occurred at T4. One cancer patient developing increased paraparesis two days after surgery but refused further intervention. At last follow-up (8.8 ± 7.6 months) no patient had clinical or radiologic evidence of instrumentation failure. Overall outcomes at last follow-up appeared acceptable for the group including ODI (40.9 ± 21.4), Back VAS (4.1 ± 2.1), SF-12 PCS (34.0 ± 10.5), and SF-12 MCS (44.4 ± 9.0).

**Conclusion:** Both IP and EP screw fixation can be performed safely using a percutaneous approach to the thoracic spine.
438
Nanosolutions for Spinal Cord Injury, How Far Have We Got?
Mario Ganau, Lara Prisco, Francesco Lupidi, Laura Ganau, Roberto Spinelli, Roberto Foroni

Introduction: An estimated 10,000-12,000 Spinal Cord Injuries (SCI) occur every year in the US, and 1/4 of a million Americans are currently living with SCI. Accounts of SCI and their treatment date back to ancient times, even though our patients have, nowadays as in the past, only little chances of recovery from such a devastating injury. Then, will it be possible in the future to repair a damaged spinal cord? Probably the solution is only a matter of research and development.

Methods: Understanding the cellular and molecular mechanisms involved in both the working and the damaged spinal cord could point the way to therapies that might: 1) prevent secondary damage, 2) encourage axons to grow in injured areas, and 3) reconnect vital neural circuits within the spinal cord and CNS. In this review we describe the nanotechnological research strategies pursued in this field and their groundbreaking advances to date.

Results: Biosynthetic/biodegradable conduits carrying extracellular matrix molecules or cell lines, and supplemented with neurotrophic growth factors have yielded encouraging results in experimental SCI. Poly-β-hydroxybutyrate conduits in combination with alginate and fibronectin provide neuroprotection for axotomized descending neurones. A poly(lactic-co-glycolic acid) scaffold seeded with neural stem cells has been developed that promotes axonal regeneration across the gap. Single-walled carbon nanotubes functionalized with polyethylene glycol have been shown to increase the length of neurites in vitro, and axons in vivo, without increasing reactive gliosis in experimental SCI. To recreate the optimal conditions for vehiculation of a step forward is required, to this regard nanorobots could assist the body in the healing process by transporting “all that is needed” from and to the right places at the right time.

Conclusion: This review offers a clear overview concerning the nanotechnologically driven research strategies for SCI. The nanosolutions herein described seem promising to cover the existing gap between hope and reality.

439
Pedicle Guide for Thoracic Pedicle Screw Placement
Kingsley O. Abode-Iyamah, Luke Stemper, Shane Rachman, Kelly Schneider, Kathryn Sick, Patrick W. Hitchon

Introduction: The placement of thoracic pedicle screws is challenging requiring intra-operative imaging. While increasing accuracy, these modalities increase intra-operative time, radiation to patient, surgeon, and cost. We have designed a pedicle screw guide (PSG) for placement of thoracic pedicle screws to potentially provide increased accuracy compared to free hand screw placement.

Methods: Two spines were imaged to measure the angle between the long axis of the pedicle and the sagittal plane from T1-T12. The cortex at the junction of the transverse process and the superior facet was penetrated using an awl. The PSG was used to make a 20 mm pilot hole into the pedicle along the trajectory calculated from the CT scans. On one side from T1-T12, pedicle screws were placed freehand based on clinical experience. On the other, pedicle screws were placed using the PSG. After placement of the screws, CT scans were obtained and grading of medial violation was recorded. The degree of violation was recorded for each pedicle (1: no violation, 2: <2 mm violation, 3: >2 mm violation).

Results: Two specimens were used with a total of 48 pedicles. Of the total 48 pedicle screws there were a total of 11 pedicle violations. Of these violations, 3 (12.5%) were with the use of PSG, all of which were grade 2. There were 8 violations (33%) with the free hand technique. The percent error from the pre-instrumentation CT trajectory angle was 62.3% (±39.5) and 34.3% (±23.3) (P = 0.002) for freehand and guide assisted respectively.

Conclusion: Free hand placement of thoracic pedicle screw challenging due to the unique anatomy the thoracic spine. While intra-operative imaging technique increases accuracy there is radiation risk to the surgeon. The use of the pedicle guide screw increases accuracy while decreasing the risk of radiation.

440
Minimal Invasive Vertebral Augmentation in Geriatric Patients with High Comorbidity
Basar Atalay, Mehmet Volkan Harput, Kaan Cumhur Yaltirik, Ozge Koner, Ayce Atalay

Introduction: Geriatric population is under risk for highly morbid Vertebral compression fractures (VBC). The purpose is to determine, levels involved, comorbid factors, and outcome of treatment of VBC by vertebroplasty and kyphoplasty in geriatric age group.

Methods: A total of 32 patients with an average age of 76.63 ± 9 years were enrolled. Traumatic, pathologic or osteoporotic fractures were treated. Patients had undergone Vertebral augmentation (VA) under sedo-analgiesia. Visual analog scales (VAS), percent of compression, and Cobb’s were measured. Comorbidity index was calculated. Time of mobilization post surgery, length of hospital stay were evaluated.

Results: In 68.8% osteoporotic fracture, 18.7% pathological fracture, and 12.5% traumatic fracture was identified. 22 patients (68.8%) had single, 10 (31.2%) had multiple level fractures. L1 was the most commonly involved level: 59.4% of the patients (n = 19) underwent vertebroplasty, 37.5% (n = 12) kyphoplasty and 3.1% (n = 1) were treated by both vertebroplasty and kyphoplasty. Mean time of total anesthesia time was 68.28 ± 25.05 minutes. 15 (46.9%) patients were immediately mobilised within 12 hours. 17 (53.1%) patients were mobilised between 12 to 24 hours. Preoperative mean VAS was 72.58 ± 12.64 postoperative mean VAS was 20.97 ± 18.14 (P = 0.0001). Preoperative Cobb angle of the compressed segment was 9.51 ± 6.57 and the post operative Cobb angle was 7.64 ± 5.89 (P = 0.209).

Preoperative compression ratio revealed 20.55 ± 19.96 % and postoperative compression ratio was 15.44 ± 17.05 % (P = 0.109). Mean length of stay in the hospital was 1.32 ± 0.67 day. Mean follow-up time was 18.04 ± 11.69 months. Charlson comorbidity score was 3.06 ± 1.8. Mean VAS difference between patients with high and low comorbidity was similar between groups (P = 0.38).

Conclusion: Vertebroplasty and kyphoplasty can be safely done in the geriatric patient group with multiple comorbid factors. Even patients with high comorbidity scores can benefit from these procedures. VA procedure is a minimally
invade technique and can be performed under sedoanalgesia combined with local anesthetic infiltration which enables early mobilization and a short hospital stay.

441 Direct Lateral vs. Transpedicular Corpectomy for Spinal Metastasis
Emam Saleh, Tsz Lau, Timothy Miller, Frank D. Vrionis, Nam Du Tran
Introduction: Primary or metastatic spinal tumors can cause pain and neurologic deficit due to spinal instability, spinal misalignment and/or compression of neural elements. Surgical management of vertebral body tumors may include posterior transpedicular or direct lateral (retropleural or retroperitoneal) approaches. Lateral approaches provide direct access to the anterior or middle columns for decompression and/or reconstruction without disruption of the posterior elements. The purpose of this study is to compare the clinical outcomes between lateral or posterior approaches for thoracic and lumbar corpectomy in the cancer population.

Methods: Retrospective chart review on 33 consecutive patients who had undergone thoracic or lumbar (T5-L4) corpectomy plus instrumentation using expandable cage at our institution between January 2010 and August 2011. All patients had either primary or metastasis disease causing intractable pain, neurological deficits, and/or instability. Patient demographics, surgical blood loss, surgical duration, complications, length of hospital stay and functional outcome were analyzed.

Results: 19 patients underwent a direct lateral retropleural or retroperitoneal approaches while 14 patients underwent a posterior transpedicular approach for thoracic or lumbar corpectomy. The average blood loss was 350cc per level for lateral approaches and 660cc per level for posterior approach. The average surgery duration was 3 hours for lateral approaches and 3.6 hours for posterior approaches. The average length of hospital stay was shorter for patients that had undergone lateral approaches (5 vs. 7 days). There were no neurological complications for both groups. All patients had improvements in their functional outcome

Conclusion: Direct lateral approaches for midthoracic to lumbar spinal malignancy are safe with low complication rates. Intraoperative blood loss, surgical duration per level and length of hospital stay are favorable when compared to posterior transpedicular approaches. For selected patients with anterior and/or middle column malignancy, lateral approach is a feasible option.

442 Participant Satisfaction with Simulation of Minimally Invasive Spine Surgery Using Virtual Reality and Haptics
Introduction: The purpose of this study was to evaluate participant satisfaction while performing a percutaneous spinal procedure on a head- and hand-tracked high-resolution and high-performance virtual reality and haptic technology workstation. We also aim to collect data on performance and accuracy.

Methods: 134 neurosurgery fellows and residents trained on an ImmersiveTouch system (63 on Thoracic 9,10 and 11 and 71 on Lumbar 2,3 and 4 virtual models). A virtual Jamshidi needle was percutaneously inserted into a virtual patient’s pedicle derived from a computed tomography data set. An entry point on bone surface and a target point within bone were predetermined by a spine neurosurgeon. Participants were allowed up to five minutes of practice attempts. They were then asked to repeat what they practiced. Accuracy (average Euclidean distance from predefined entry and target points) was measured for each insertion. Every participant was requested to fill an anonymous form asking whether they were satisfied with the realism of the simulation, and if not explain why.

Results: 108/134 participants filled the feedback form, 105 were satisfied and 3 were dissatisfied with the realism of the simulation experience. Those dissatisfied cited inability to see the image in 3D. There were 268 measured attempts to insert the virtual needle, 248 successful, and 20 breached bone, 9 out of 126 (7.14%) failed in the thoracic group, and 11/142 (7.5%) failed in the lumbar group (NS). Mean accuracy score of successful attempts was 13.83 mm (SD 6.74 mm).

Conclusion: Satisfaction with the realism of the simulation is high. We plan a more detailed questionnaire in future studies. The accuracy of pedicle needle placement achieved by participants using the simulator is comparable to that reported in recent literature, further evidence of simulation realism.

443 Characterizing Spine Injuries in Rollover Crashes
Babak Cohen, Dale Halloway, Waqar Malik, Narayan Yoganandan, Frank A. Pintar, Dennis J. Maiman
Introduction: Rollovers are less than three percent of motor vehicle crashes, yet account for more than 28% of fatal crashes with more than 10,000 deaths annually. Spine and head injuries are still the most prevalent in rollovers. This study intended to identify the most frequent spine injuries during rollover crashes to delineate patterns associated with certain scenarios.

Methods: The US-DOT-NHTSA Crash Injury Research and Engineering Network (CIREN) database was used to study single vehicle rollover crashes involving front occupant adults. CIREN contains detailed documentation of both medical and engineering data for each crash. Arrested rolls or ejected occupants were excluded. Variables included gender, BMI, vehicle type, occupant seating position, number of quarter turns, side-slip angle, seatbelt usage, and airbag deployment. The criterion provided 38 cases, 30 had injuries between C1 and T2.

Results: In both passenger cars and SUVs the occupant on the far side of the roll had a higher incidence and severity of injuries than the near side occupant (17 vs 13). Facet fractures were the most common injury type and twice as common in far sided crashes and in cars compared to SUVs. Vertebral lamina fractures were evenly distributed among occupants, but were more common in SUVs. Vertebral pedicle fractures were more frequent in near side occupants. Most fractures in the C4 and lower vertebrae were facet fractures, while above C4 were mostly vertebral body fractures. There was no significant correlation between vertebral fractures, injuries, MAIS scores, side-slip angles, and number of quarter turns.

Conclusion: The location of the occupant in the vehicle, type of vehicle, and angle of the roll seem to have significant influence on the severity and location of spine injury in a rollover crash. This study reinforces the concept that occupant position with respect to the type of roll induces differing mechanisms of spine injury.
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**444**

**Parieto-occipito-cervical Instrumentation and Fusion of a Patient with an Unstable Cranio-cervical Junction After Both a Posterior Fossa Cranietomy and Left Transcondylar Cranietomy**

Amandip Singh Gill, Joseph Chia Yu Hsieh, Abhishek Chaturbedi, Daniel S. Yanni, Mark E. Linskey, J. Patrick Johnson, Samer Ghostine

**Introduction:** Skull base surgeries for resection of complex tumors emphasize bone drilling to minimize brain retraction. Trans-condylar approaches to resect ventral foramen meningioma is well described, and is notorious for destabilizing the cranio-cervical junction.

**Methods:** A 46-year old man with a history of a suboccipital craniectomy at age 12 for a posterior fossa astrocytoma resection followed by chemo and radiation therapy presented to our multi-disciplinary complex spine center with severe myelopathy. MRI of his brain revealed a large 4.4 x 4.3 cm ventral foramen magnum meningioma extending to the left jugular tubercle and occipital condyle and inferiorly to C2. The approach necessitated drilling of greater than 80% of the condyle to properly visualize and resect the tumor.

**Results:** A custom plate-rod system was secured to the parietal bone via 4 bicortical screws. Because of prior radiation to the posterior fossa resulting in atrophy of subcutaneous tissue, the rods were fashioned closely to the bone intraoperatively over the occipital and mastoid convexities and attached to the bicortical screws.

**Conclusion:** We present a unique technique to stabilize the cranio-cervical junction in the setting of absence of occipital bone and crano-atlantal instability.

**446**

**Factors That Predict Hospital and Surgical Costs and Recovery Rates for Lumbar Laminctomy**

Sandra Venegopal, Patricia Zadnik, Camilo A. Molina, Mari L. Groves, Ali Bydon, Ziya L. Gokaslan, Jean-Paul Wolinsky, Timothy F. Witham, Daniel M. Sciuha

**Introduction:** Modern treatment of Chance fractures has entailed open pedicle screw fixation and fusion for instability. External bracing required many months of bed-rest and strict physical limitations. Recently, percutaneous pedicle screw stabilization has allowed for internal bracing, but require removal after healing occurred. We present a minimally invasive stabilization and fusion to treat Chance fractures.

**Methods:** A 22-year-old male status post motor vehicle collision presented with multiple solid organ injuries and Chance fractures of both L2 and L3 with ligamentous injury at both levels. He was neurologically intact with severe back pain. Given his active lifestyle and ligamentous injury, decision was made to proceed with stabilization and fusion.

**Results:** We chose a minimally-invasive approach both for the faster recovery time as well as the decreased risk of bleeding in the face of a liver laceration. The Mazor robot assisted in placing screw trajectories across the fractured pedicles at both levels, allowing for precise placement of hardware. Screws were then compressed to close the fracture gap. A percutaneous facet/transverse-process reaming device was next used to decorticate bone posterolaterally and a funnel-device was used to spread allograft posterolaterally to promote arthrodesis. The patient was ambulating within 24 hours and was discharged within 48 hours. At 6 months post-op, patient remains neurologically intact without back pain and has returned to work.

**Conclusion:** We present a technique and case illustration using robotic guidance for minimally-invasive percutaneous stabilization and fusion of the lumbar spine in the setting of 2 adjacent chance fractures. Such fusions have traditionally been accomplished via large open procedures, bringing with them commensurate risk and complication. Image-guided percutaneous techniques offer the option for internal bracing and fusion with small risk and recovery times. Robotic guidance allows for placement of screws accurately through the fractured segments.

**447**

**Spontaneous Regression of Lumbar Herniated Disc: Two Case Reports and Review of the Literature**

Kee Duk Kim, Eric S. Kim

**Introduction:** The spontaneous regression of lumbar disc herniations is a well-documented phenomenon. However, the exact mechanism is still unknown. With MRI, the size of herniated disc material may be determined and the tear in the annulus fibrosis classified. Furthermore, immunophenotypic studies have also demonstrated regression by means of phagocytosis involving angiogenesis. Formation of granulation tissue and
vascularization are believed to exhibit peripheral enhancement of herniated discs using Gd-enhanced MRI. We report two cases of spontaneous regression of lumbar herniated disc and characterize factors that are favorable for disc regression.

Methods: A literature search was performed for case reports of lumbar herniated disc regression as well as related imaging and immunohistologic studies. Case reports, including two of our own, were analyzed retrospectively for factors associated with regression.

Results: Rim enhancement was the strongest positive indicator for a faster rate of resorption [1] while the extent of nucleus pulposus migration predicted the degree of resorption[2]. An extruded-type resulted in regression in almost all cases in 100% of cases reviewed by Splendiani et al[3]. Breach of the posterior longitudinal ligament induces an immune response leading to chemokine action and dehydration. Contrastingly, smaller disc bulges in which the annulus fibrosus was intact did not undergo substantial regression.

Conclusion: Given that cauda equina syndrome and motor weakness are absent, conservative treatment may be favorable for patients presenting with sequestered- or migrated-type disc herniations. While the rate of regression is not yet predictable, MR imaging is still valuable in classifying the nature of a disc herniation and may aid in decision for surgery.

449 Readability of Patient Education Materials for the Secondary Damage Following Spinal Cord Injury
Nitin Agarwal, David R. Hansberry, Robert F. Heary

Introduction: The use of online materials by healthcare consumers to access medical information presents unique challenges. Most Americans have access to the Internet and frequently turn to it as a first-line resource. Therefore it is imperative that this information be written at a level that the average American can understand, which is about a seventh grade reading level.

Methods: The readability of online patient education materials was evaluated. Materials provided by the National Institute of Health (NIH) and, in particular, the National Institute of Neurological Disorders and Stroke (NINDS) were assessed using the Flesch Reading Ease and Flesch-Kincaid Grade Level evaluations with Microsoft Office Word software. Unnecessary formatting was removed and the readability was evaluated with the Spelling and Grammar function.

Results: The average Flesch-Kincaid Grade Level was 13.6 with no section lower than 12.8, indicating that most Americans would not be able to fully comprehend this material. Additionally, the Flesch Reading Ease had an average value of 31.5, a number that also suggest this language is too complex for the average American.

Conclusion: Results indicate that the language used on materials provided by the NIH and NINDS are perhaps too advanced for the average American. Website revisions might be beneficial for improved patient education and ultimately clinical results.

450 Hospital and Surgeon Variation in Complications and Repeat Surgery Following Incident Lumbar Fusion for Common Degenerative Diagnoses
Brook I. Martin

Introduction: To identify factors that account for variation in complication and reoperation rates across hospitals and surgeons performing lumbar spinal fusion surgery.

Methods: Discharge registry including all non-federal hospitals in Washington State from 2004-2007. We identified adults (n = 5,864) undergoing an initial inpatient lumbar fusion surgery for degenerative conditions without significant comorbidity. We identified whether or not each patient had a subsequent spine operation or complication within 90 days. Controlling for patient characteristics and comorbidity, a generalized logistic regression model with hospital and surgeon random-effects was used to examine the rates of complications and reoperation.

Results: Complications within 90 days of an initial fusion occurred in 4.8% of patients, and 2.2% had a reoperation. Surgeon effects account for 45% of the variation in hospital complication rates, and 75% of the variation in reoperation rates. Operative features accounted for 37% and 19% of the variation in surgeons’ complication and reoperation rates, respectively.

Conclusion: To improve the safety of lumbar spinal fusion surgery, quality improvement efforts that focus on surgeons, including their discretionary use of operative features, may be more important than those that target hospitals.
The AANS/CNS Section on Disorders of the Spine and Peripheral Nerves gratefully acknowledges DePuy Spine Inc., a Johnson & Johnson company, for providing an educational grant in support of the 2012 Annual Meeting.

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# PROGRAM AT-A-GLANCE

## WEDNESDAY  
**MARCH 7, 2012**

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<td>8:00 AM</td>
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<td>1:30 – 5:30 PM</td>
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## THURSDAY  
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## SATURDAY  
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<td>NEUROSURGICAL EDUCATION AMBASSADOR:</td>
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<td>ANNUAL MEETING SUPPORTERS:</td>
<td>Stryker, NuVasive, Stryker, K2M, Spineology</td>
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2013 ANNUAL MEETING OF THE AANS/CNS SECTION ON DISORDERS OF THE SPINE AND PERIPHERAL NERVES

March 6-9, 2013
JW Marriott Desert Ridge
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