SAVE THE DATE!
Orlando, Florida • February 17-20, 2010
26th Annual Meeting of the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves

Thank you to our 2009 Annual Meeting Corporate Supporters:

- Neurosurgical Education Ambassador – Biomet Spine
- Power of Networking Ambassador – Stryker
- Neurosurgical Leadership Ambassador – Medtronic
- Resident Education Partner – DePuy Spine, a Johnson & Johnson Company

Benefactor:
Synthes Spine

Supporters:
Aesculap Implant Systems – Anulex Technologies, Inc. – ArthroCare – Integra – NuVasive – Spine Wave – TranS1, Inc.
**PROGRAM AT-A-GLANCE**

**Sage Court**

**Opening Reception**
6:00 – 8:00 PM

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**Special Course II** – New Developments in Arthroplasty
Grand Canyon 13

**Scientific Session III** – Biomechanics: Its Use in Surgical Decision Making
Grand Canyon 10

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**March 11**
8:00 AM – 6:00 PM
Registration
East Registration

8:00 AM – 6:00 PM
Speaker Ready Room
Pinnacle Peak 3

1:30 – 5:30 PM
Special Course I – Coding Update and Review
Grand Sonoran D

Special Course II – New Developments in Arthroplasty
Grand Canyon 13

Special Course III – Biomechanics: Its Use in Surgical Decision Making
Grand Canyon 10

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**March 12**
6:00 AM – 6:00 PM
Registration
East Registration

6:00 AM – 6:00 PM
Speaker Ready Room
Pinnacle Peak 3

6:30 – 7:00 AM
Continental Breakfast

6:30 – 7:00 AM
Case Presentations
Grand Sonoran E

7:00 – 9:30 AM
Scientific Session I – Past Evidence: Lessons Learned, Dealing with the Aging Spine
Grand Sonoran E

9:00 AM – 7:00 PM
Exhibit Hall Open
Grand Canyon 1–8

9:30 – 10:15 AM
Beverage Break and What’s New Sessions
Grand Canyon 1–8

10:15 AM – 12:35 PM
Oral Platform Presentations I
Grand Sonoran E

12:35 – 1:25 PM
Lunch with Exhibitors and What’s New Sessions
Grand Canyon 1–8

1:30 – 5:00 PM
Scientific Session II – Present Appraisal: What’s New Trials and Their Implications
Grand Sonoran Salons E

3:00 – 3:45 PM
Beverage Break and What’s New Sessions
Grand Canyon 1–8

3:45 – 5:15 PM
Oral Poster Presentations I and II
Grand Sonoran Salons E and Grand Canyon 9–10

5:15 – 6:45 PM
Reception with the Exhibitors
Grand Canyon 1–8

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**March 13**
6:00 AM – 6:00 PM
Registration
East Registration

6:00 AM – 6:00 PM
Speaker Ready Room
Pinnacle Peak 3

6:30 – 7:00 AM
Continental Breakfast

6:30 – 7:00 AM
Case Presentations
Grand Sonoran E

7:00 – 9:00 AM
Scientific Session III (Part I) – Present Appraisal: The Tethered Cord from Child to Adult from Asymptomatic to Symptomatic
Grand Sonoran E

Grand Sonoran E

9:00 AM – 12:00 Noon
Exhibit Hall Open
Grand Canyon 1–8

9:30 – 10:15 AM
Beverage Break and What’s New Sessions
Grand Canyon 1–8

10:15 AM – 12:15 PM
Oral Platform Presentations II
Grand Sonoran E

12:30 – 2:30 PM
Annual Business Meeting
Grand Sonoran E

Luncheon Symposium I – Revision Spine Surgery and Management of Complications
Grand Canyon 12

Luncheon Symposium II – Critical Review and Analysis of the SPORT Trials Implications for Your Practice
Grand Canyon 12

Luncheon Symposium III – Treatment of Primary and Metastatic Spine Tumors
Grand Canyon 13

1:30 – 5:30 PM
Special Course VII – Peripheral Nerve Exposures and Nerve Repair Techniques
Grand Canyon 9

Special Course VIII – Evaluation and Management of the Spine Trauma Patient
Grand Canyon 10

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**March 14**
6:00 AM – 12:30 PM
Registration
East Registration

6:00 AM – 12:30 PM
Speaker Ready Room
Pinnacle Peak 3

6:30 – 7:00 AM
Continental Breakfast and Case Presentations
Grand Sonoran E

7:00 – 8:30 AM
Scientific Session IV – Future Advocacy: CMS, the Spine and Spine Care in Alternative Health Systems
Grand Sonoran E

8:30 – 10:55 AM
David Cahill Memorial Controversies Sessions
Grand Sonoran E

9:00 AM – 12:00 Noon
Exhibit Hall Open
Grand Canyon 1–8

9:30 – 10:15 AM
Beverage Break and What’s New Sessions
Grand Canyon 1–8

10:55 – 11:15 AM
Mayfield Awards/Presentations
Grand Sonoran E

11:15 AM – 12:35 PM
Oral Poster Presentations III and IV
Grand Sonoran E and Grand Canyon 9–10

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**Daily Events**

**March 11 – 14, 2009 JW Marriott Desert Ridge Resort & Spa Phoenix, Arizona**

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

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**Special Thanks to Our 2009 Annual Meeting Corporate Supporters!**
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The AANS/CNS Section on Disorders of the Spine and Peripheral Nerves welcomes you to the 2009 Annual Meeting. We are pleased you could join us here at the JW Marriott Desert Ridge Resort & Spa in Phoenix, Arizona. This year’s twenty-fifth anniversary meeting has been designed to deliver maximum educational value as we explore the theme: The Backbone of Spinal Surgery: Evidence, Appraisal, and Advocacy.

The Scientific Program Committee has worked tirelessly over the course of the past year to put together a high-impact program featuring some of the world’s leading spine and peripheral nerve experts. Our Scientific Sessions explore the past, present and future of spine and peripheral nerve surgery to help attendees examine what we’ve learned as a specialty and build on these experiences for the future.

The program also includes three Luncheon Symposia covering topics from complication avoidance to treatment of spine tumors, as well as eight Special Courses, highlighting contemporary neurosurgical and non–surgical approaches, essential practice management solutions and critical patient advocacy issues. Two of these Special Courses are designed specifically for nurses, nurse practitioners and physician assistants/physician extenders. We hope you will find time in your schedule to attend these outstanding elective courses.

You’ll find additional educational opportunities within our exhibit hall, which features over 70 exhibitors displaying the latest medical technology innovations. Visit with our corporate partners during the breaks to learn more about the surgical products and services available to improve your practice. And be sure to join us for daily What’s New sessions, each featuring a different product.

In addition to these outstanding educational offerings, the Annual Meeting offers several networking opportunities you won’t want to miss, beginning with our Wednesday evening Opening Reception at Sage Court. The Thursday evening Reception with the Exhibitors offers another chance to catch up with your colleagues and corporate contacts, while also taking another look at the latest in spine surgical products and services. And for Residents and recent graduates, our Young Neurosurgeons’ Dinner offers a chance to connect with other young neurosurgeons, as well as a special presentation by Dr. Paul C. McCormick.

Of course, all of this is set against the backdrop of one of Phoenix’s most luxurious resorts, the JW Marriott Desert Ridge Resort & Spa, which offers endless opportunities for recreation and respite. From the bentgrass greens of the desert–style Palmer Signature golf course to an outdoor massage on one of Revive Spa’s private balconies, you and your spouse are sure to find the perfect escape. And the whole family will love the more than four acres of shimmering waterways and miles of hiking and biking trails.

Thank you again for joining us at the 2009 Annual Meeting. We hope you will take time to enjoy both the science and the scenery as you enjoy the company of your friends and colleagues.

Sincerely,

Daniel K. Resnick, MD
Chairperson

Charles Kuntz, IV, MD
Annual Meeting Chairperson

Paul G. Matz, MD
Scientific Program Chairperson

2009 ANNUAL MEETING COMMITTEE

Annual Meeting Chairperson
Charles Kuntz, IV

Scientific Program Chairperson
Paul G. Matz

Exhibit Chairperson
Praveen V. Mummaneni

2009 Scientific Abstract Review Committee
James P. Burke
Ira M. Goldstein
Ryan Philip Jewell
Paul G. Matz
Ehud Mendel
Daniel M. Sciubba
Michael P. Steinmetz
Marjorie C. Wang
Michael Y. Wang

2009 Scientific Advisory Committee
James P. Burke
Joseph S. Cheng
Ira M. Goldstein
Robert F. Heary
Langston T. Holly
R. John Hurlbert
Ryan Philip Jewell
Charles Kuntz, IV
Paul G. Matz
Ehud Mendel
Eric A. Potts
Richard P. Schlenk
Daniel M. Sciubba
Allen H. Maniker
Marjorie C. Wang
Michael Y. Wang
Eric L. Zager

2009 Poster Awards and Grading Committee
Zoher Ghogawala
Ryan Phillip Jewell
Patrick Pritchard
Michael P. Steinmetz
Marjorie C. Wang
Daniel K. Resnick, MD
Associate Professor and Vice Chairman
Department of Neurological Surgery
University of Wisconsin School of Medicine

A native of Philadelphia, Dr. Resnick received his undergraduate degree from Princeton University and MD from the University of Pennsylvania. After an internship at Pennsylvania Hospital he did his residency training at the University of Pittsburgh. While at the University of Pittsburgh, Dr. Resnick developed an interest in spinal cord injury which led to research culminating in a master's degree in neuroscience. This interest in spinal cord injury and early exposure to complex spinal surgery under Dr. William Welch and Dr. Donald Marion led to an interest in spinal surgery. Dr. Resnick was able to arrange a clinical rotation at the University of New Mexico where he focused on biomechanics and spinal anatomy under the tutelage of Dr. Edward Benzel. Following residency training, Dr. Resnick migrated to Madison, Wisconsin where he has risen through the academic ranks and is now a tenured associate professor and vice chairman for academic affairs. Dr. Resnick is an author of over 130 peer reviewed manuscripts (published or in press), 60 book chapters, and numerous position statements, editorials, and commentaries. He is an editor of four textbooks of spinal surgery and remains active in spinal cord injury research. In addition to his role in the governance of the spine section, Dr. Resnick is currently Treasurer of the Congress of Neurological Surgeons, Chairman of the Washington Committee’s Quality Improvement Workgroup, Chairman of the Clinical Research Committee and a member of the board of directors of the North American Spine Society.

Dr. Resnick is grateful for the love, support and companionship he receives from his wife Nicole and their four awesome children, Leah, Sabrina, Talia, and Eli. When not actively juggling professional and family responsibilities, Dr. Resnick is an avid cyclist and musician.

Presidential Address
Thursday, March 12, 8:55 AM
The Backbone of Spinal Surgery – Evidence, Appraisal and Advocacy

A Special Message from the Chairman
AANS/CNS Section on Disorders of the Spine and Peripheral Nerves
The First 25 Years
A Video History.

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, to improve patient care, to support meaningful basic and clinical research, to provide leadership in undergraduate and graduate continuing education, and to promote administrative facilities necessary to achieve these goals.
Paul McCormick was born and raised in Rockville, Maryland. He attended Columbia University in New York where he played both varsity football and baseball. He was captain of the 1977 Columbia football team. He graduated with a BA in English from Columbia College in 1978.

He received his MD degree from Columbia University College of Physicians and Surgeons in 1982. Following a surgical internship at Columbia Presbyterian Medical Center he spent a year at the National Institutes of Health (NIH) in Bethesda, Maryland as a research fellow in the Surgical Neurology branch. He returned to Columbia in 1984 where he completed his neurosurgical residency training at the Neurological Institute of New York. Following residency, he performed a one-year spine fellowship at the Medical College of Wisconsin. Dr. McCormick returned to the Neurological Institute in July 1990 as full time Assistant Professor of Neurological Surgery at Columbia University College of Physicians and Surgeons.

Dr. McCormick’s research, clinical, and teaching interests have focused on the evaluation and management of disorders of the spine and spinal cord as well as outcomes assessment. He has particular expertise in the microsurgical treatment of spinal cord tumors and vascular malformations. He has written or co-authored over 130 publications in peer reviewed journals and books. He has written or edited eight books and special edition supplements. He has been the principal investigator in numerous clinical trials at Columbia and has received several research grants.

In 1998, because of his focused research interests in patient treatment outcomes and methods of assessment, Dr. McCormick enrolled in the Executive MPH program in Health Policy and Management at Columbia’s Mailman School of Public Health, while maintaining his full time clinical, research, and teaching responsibilities at Columbia. He was awarded his Masters of Public Health (MPH) degree in October 2000 and also received the Award for Academic Excellence given to the graduate with the highest grade point average. In July 2001, Dr. McCormick was promoted to the rank of Professor of Clinical Neurosurgery at Columbia University College of Physicians and Surgeons. Dr. McCormick was appointed as Herbert and Linda Gallen Professor of Neurosurgery in July, 2006. He was awarded the prestigious John Jay award for professional achievement by Columbia University in 2007.

Dr. McCormick currently serves on the Editorial Board of *Spine, Neurosurgery, The Journal of Neurosurgery, The Spine Journal,* and *Journal of Neuro-Oncology.* He is also active in the national leadership of Neurosurgery. He has served as Vice President of the Congress of Neurological Surgery (CNS) and Chairman of the Joint Section on Disorders of the Spine and Peripheral Nerves. He currently serves on the Board of Directors of the American Association of Neurological Surgeons (AANS) and is a Director of the American Board of Neurological Surgery (ABNS). He is a member of the American Academy of Neurological Surgeons and Society of Neurological Surgeons.

Dr. McCormick met his extraordinary wife Doris, a registered nurse, during his internship year at Columbia. They have been married for 24 years and have 3 incredibly great children: Paul (20), Kyle (16), and Kaleigh Quinn (9).
Sanford Larson Research Award

The Larson Award, sponsored by DePuy Spine, a Johnson & Johnson Company, 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, 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. Applicants should be residents in training or ABNS eligible fellows and 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.

Past Sanford Larson Research Award Recipient:
2008 – Omar N. Syed, MD

Justin M. Brown, MD

Dr. Brown received his bachelor’s at Vanderbilt University with a major in neuroscience. He earned his medical degree from the Eastern Virginia Medical School in Norfolk, VA, then went on to complete a surgical internship and neurological residency at Baylor College of Medicine, in Houston, TX. He then moved to St. Louis, MO, where he completed a peripheral nerve surgery fellowship with Dr. Susan E. Mackinnon in the Division of Plastic and Reconstructive Surgery at Washington University School of Medicine.

Dr. Brown is now the associate director for the Center for Nerve Injury and Paralysis as well as an assistant professor in the Department of Neurological Surgery and Division of Plastic and Reconstructive Surgery at Washington University. He is also a member of a scientific collaboration, the International Society for Restorative Neurology, which is actively exploring strategies for restoring function in central nervous system disorders, such as spinal cord injury.

Justin M Brown, MD is happily married to Karen S. Brown, MD, his wife of 5 years and they have two sons, Anthony, who is 2 years old and Joseph, who is now 7 months old.

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. Applicants should be residents in training or ABNS eligible fellows and 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.

Past Ronald I. Apfelbaum Research Award Recipient:
2008 – Vassilios Dimopoulos, MD

Mohammed Farid Shamji, MD, PhD

Mohammed Farid Shamji is a mid-level neurosurgery resident at The Ottawa Hospital, Canada. He completed a combined Bachelor’s/Master’s degree in Chemistry at Yale University (1999) followed by medical training at Queen’s University (2003). He then completed his junior neurosurgical training at The Ottawa Hospital before interrupting residency to complete a doctoral PhD degree in Biomedical Engineering at Duke University (2005-2008) under the guidance of Professor Lori A. Setton. He has since returned to clinical training in Ottawa and is at the end of his PGY4 year.

The focus of Dr. Shamji’s doctoral training was in developing thermally-responsive drug delivery systems to sustain release and activity of bioactive anticytokine therapeutics upon injection delivery to anatomically defined compartments. He has evaluated such systems for anti-IL1 and anti-TNF agents, including his own genetically engineered fusion proteins, with the goal of minimizing systemic drug exposure. A neurosurgical application of this work is the treatment of the inflammatory component of disc-herniation lumbar radiculopathy, with Dr. Shamji’s previous work including evaluation of gait abnormalities and immune activation in an animal disease model. This award will support investigation into the therapeutic efficacy of anticytokine drug depots upon application to an animal model of disc-herniation radiculopathy.
**David Kline Research Award**

The Kline Award, sponsored by Integra, 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. 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.

**Wilson Z. Ray, MD**

Dr. Ray is currently a fifth year resident in neurosurgery at Washington University in St. Louis. He received his undergraduate and medical training at the University of Iowa. He is spending two years conducting research in the lab of Dr. Susan Mackinnon, in collaboration with Dr. Thomas Tung. His focus will be on T-helper cell differentiation in promoting nerve allograft survival.

**The Cahill Fellowship**

The Cahill Fellowship, sponsored by Synthes, is awarded annually to one United States 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 and 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.

**Ann Margaret Parr, MD, PhD**

Ann M. Parr completed her medical school training at Queen’s University in Kingston, Ontario. She began her clinical neurosurgical residency at the University of Manitoba and in 2003 moved to the University of Toronto to pursue her research interests, investigating the role of stem cells in spinal cord injury in the laboratory of Dr. Charles Tator. Dr. Parr received her PhD from the University of Toronto in 2007. She plans to complete her residency training this year and has been accepted for a spine fellowship at the University of Miami. Dr. Parr is dedicated to pursuing a career as a surgeon-scientist in an academic center, and hopes to someday apply the results of her research in a clinical setting.

**Cloward Fellowship**

The Cloward Fellowship, sponsored by Medtronic, is awarded annually to one United States 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 and 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.

**Marie-Noëlle Hébert-Blouin, MD**

Dr. Marie-Noëlle Hébert-Blouin completed her medical degree and neurosurgery residency at McGill University. She is presently undergoing a six-month fellowship with Dr. Robert J Spinner at the Mayo Clinic in peripheral nerve surgery and completing her master’s degree in neurological sciences on the use of tissue-engineering techniques for the design of alternatives to autologous nerve graft. The Cloward fellowship will allow her to extend her clinical and research training in peripheral nerve surgery for another six months. During the award period, her focus will be on the use of new imaging techniques in various peripheral nerve pathologies. She plans to return to McGill where she will join Dr. Line Jacques performing peripheral nerve surgery.
Crockard Fellowship

The Crockard International Fellowship, is sponsored by DePuy Spine, a Johnson & Johnson Company, and is awarded annually to a neurosurgical resident or neurosurgeon from outside of the United States 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.

Past Crockard International Fellowship Recipient:
2008 – Louis Moscote, MD

Jau–Ching Wu, MD

Dr. Wu received his medical degree from the National Yang Ming University School of Medicine in Taiwan in 2001. He then completed his neurosurgery training at the Taipei Veterans General Hospital in 2007. In 2008, he completed a spinal surgery fellowship at the Taipei Veteran’s General Hospital and then joined the attending staff of this organization, the largest training hospital in Taiwan with over 3,000 beds. Currently, he is pursuing a Ph.D. at the National Yang Ming University School of Medicine. Dr. Wu has also been involved in human clinical trials directed by Dr. Henrich Cheng to repair spinal cord injuries using peripheral nerve grafts with fibroblast growth factors. Dr. Wu has great interest in new concepts in spinal surgery, including minimally invasive and motion preservation procedures; he is therefore looking forward to the fellowship with Dr. Praveen Mummaneni as well as other outstanding spinal surgeons at UCSF Spine Center.

Bassem I. Awad, MBBCh

Dr. Bassem Ibrahim Awad received his medical degree (MBBCh) from the University of Mansoura, School of Medicine, Egypt. He is currently an assistant lecturer of neurosurgery at the Mansoura University Hospital, Egypt. He is planning to spend a 3 month period for a fellowship in the Cleveland Clinic Spine Center under the supervision of Dr. Edward Benzel and Dr. Michael Steinmetz. He aims at expanding his experience in the most advanced and updated surgical techniques in minimally invasive spine surgery, particularly thoracoscopic and laparoscopic surgery. He also is planning to participate in the spinal cord injury and biomechanics laboratory research in collaboration with Dr. Lars Gilbertson.

The 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.

Ramesh Teegala, MBBS, MCh

Dr. Ramesh Teegala received his MBBS and Master of Surgery (General Surgery) Degrees form Institute of Medical Sciences, Banaras Hindu University, VARANASI, one of the premium medical institutions of India. He then completed his Neurosurgical residency (MCh) from All India Institute of Medical Sciences (AIIMS), New Delhi. After obtaining his MCh degree he worked as senior research fellow at AIIMS and subsequently joined as an Assistant Professor of Neurosurgery at Amrita Institute of Medical Sciences (AIMS), Kochi. During this period he mainly concentrated on complex spine and skull base surgeries. He worked as a co investigator of one national and an international clinical trial. Currently he took charge of establishing a neurosurgical department at a medical school in Andhra Pradesh. He is actively doing minimal invasive neurosurgical procedures. He has a visiting surgeon’s fellowship with Prof. Gaab, Hanover, Germany to acquire additional skills of neuroendoscopy. He is trying hard to develop his career in minimal invasive and functional neurosurgery. During this period he has operated nearly 1500 neurosurgical procedures independently and presented at many national and international conferences. He has 8 national and international publications to his credit.
Resident Awards

The Mayfield Awards are presented annually by the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves to 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 to the related information to their abstract in the call for abstract process. Two awards are available, one for clinical research and one for basic science research. Each recipient will receive a $1,000 cash award and an honorarium up to $2,000 to cover the expenses of attendance at the Annual Meeting of the Section.

2009 Mayfield Basic Science Award
Daniel L. Master, MD

Dr. Master completed his undergraduate education at Georgetown University and received his medical degree from the University of Connecticut School of Medicine. He began his clinical Orthopaedic Surgery residency at University Hospitals Case Medical Center in 2006 and, following his first year of post-graduate training, he completed a one year Allen Research Fellowship. Dr. Master has now returned to clinical residency and his main interests are in spinal cord injury, denervation, peripheral nerve regeneration, and functional electrical stimulation.

2009 Mayfield Clinical Science Award
Matthew B. Maserati, MD

Dr. Maserati, a graduate of Dartmouth College and Columbia University College of Physicians and Surgeons, is currently a fourth year resident in neurosurgery at the University of Pittsburgh Medical Center. Following the completion of his senior clinical year, he will pursue an in-residency spinal neurosurgery fellowship, including a clinical research investigation into the phenomenon of adjacent level disease.

Mayfield Award Recipients 1984-2008

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
2008 Outcomes Committee Award

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 award is a gift from the David and Jean Wallace Fund. The recipient, selected by the Outcomes Committee, will receive a $2,000 honorarium to help cover the expenses of attendance at the Joint Section Annual Meeting.

Michael G. Fehlings, MD, PhD, FRCSC, FACS

Dr. Fehlings is the Medical Director of the Krembil Neuroscience Center and heads the Spinal Program at the Toronto Western Hospital. Dr. Fehlings is also a Professor of Neurosurgery at the University of Toronto and Director of the University of Toronto Neuroscience Program. He holds the Krembil Chair in Neural Repair and Regeneration, is a Senior Scientist in the Division of Genetics and Development at the Toronto Western Research Institute, a Scientist at the McEwen Centre for Regenerative Medicine and a McLaughlin Scholar in Molecular Medicine. In the fall of 2008, Dr. Fehlings was appointed the inaugural Director of the University of Toronto Neuroscience Program and Co-Director of the newly formed University of Toronto Spinal Program.

Dr. Fehlings combines an active clinical practice in complex spinal surgery with a translationally oriented research program focused on discovering novel treatments for spinal cord injury. This is reflected by the publication of over 600 articles chiefly in the area of spinal cord injury and complex spinal surgery. Dr. Fehlings leads a multi-disciplinary team of researchers funded by a Canadian Institutes of Health Research (CIHR) New Emerging Team grant which is examining the application of stem cells, nanotechnology and tissue engineering for spinal cord repair and regeneration. Dr. Fehlings is the Scientific Director and Acute Care and Treatment Practice Network Lead of the pan-Canadian Spinal Cord Injury Translational Research Network formed in collaboration with the Rick Hansen Foundation. He is also a principal investigator in the Christopher and Dana Reeve Foundation North American Clinical Trials Network and is co-chair of the internationally renowned Spine Trauma Study Group.

Dr. Fehlings is active in many medical societies and journal editorial boards including Journal of Neurosurgery, Journal of Neurotrauma and Spine where he holds the position of Deputy Editor. His commitment to patients with neurotrauma is further reflected in his volunteer work for ThinkFirst, a charitable organization which is focused on preventing brain and spinal cord injuries in children.

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

NeuroSurgical Education Ambassador

for providing an educational grant in support of the 2009 Annual Meeting.
### CURRENT OFFICERS 2008–2009

**Chairperson**
Daniel K. Resnick  
**Chairperson Elect**
Christopher I. Shaffrey  
**Secretary**
Michael W. Groff  
**Treasurer**
Christopher E. Wolfla  
**Immediate Past Chairperson**
Joseph T. Alexander  
**Members–at–Large**
- Gregory R. Trost  
- Mark R. McLaughlin  
- Eric L. Zager

### 2007–2008

**Chairperson**
Joseph T. Alexander  
**Chairperson Elect**
Daniel K. Resnick  
**Secretary**
Daniel K. Resnick  
**Treasurer**
Christopher E. Wolfla  
**Immediate Past Chairperson**
Charles L. Branch, Jr.  
**Members–at–Large**
- Kevin T. Foley  
- Gregory R. Trost  
- Christopher I. Shaffrey

### PAST OFFICERS 2006–2007

**Chairperson**
Charles L. Branch, Jr.  
**Chairperson Elect**
Joseph T. Alexander  
**Secretary**
Daniel K. Resnick  
**Treasurer**
Christopher E. Wolfla  
**Immediate Past Chairperson**
Robert F. Heary  
**Members–at–Large**
- Kevin T. Foley  
- Daniel H. Kim  
- Gregory R. Trost

### 2005 – 2006

**Chairperson**
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**Chairperson Elect**
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**Secretary**
Daniel K. Resnick  
**Treasurer**
Timothy C. Ryken  
**Immediate Past Chairperson**
Gerald E. Rodts, Jr.  
**Members–at–Large**
- Joseph T. Alexander  
- Daniel H. Kim

### 2004 – 2005

**Chairperson**
Gerald E. Rodts, Jr.  
**Chairperson Elect**
Robert F. Heary  
**Secretary**
Charles L. Branch, Jr.  
**Treasurer**
Timothy C. Ryken  
**Immediate Past Chairperson**
Regis W. Haid, Jr.  
**Members–at–Large**
- Joseph T. Alexander  
- Ronald I. Apfelbaum  
- Daniel H. Kim

### 2003 – 2004

**Chairperson**
Regis W. Haid, Jr.  
**Chairperson Elect**
Gerald E. Rodts, Jr.  
**Secretary**
Charles L. Branch, Jr.  
**Treasurer**
Timothy C. Ryken  
**Immediate Past Chairperson**
Nevan G. Baldwin  
**Members–at–Large**
- H. Louis Harkey, III  
- Srinath Samudrala  
- Lloyd Zucker

### 1999 – 2000

**Chairperson**
Vincent C. Traynelis  
**Chairperson Elect**
Curtis A. Dickman  
**Secretary**
Nevan G. Baldwin  
**Treasurer**
Curtis A. Dickman  
**Immediate Past Chairperson**
Curtis A. Dickman  
**Members–at–Large**
- H. Louis Harkey, III  
- Srinath Samudrala  
- Lloyd Zucker

### 1998 – 1999

**Chairperson**
Stephen M. Papadopoulos  
**Chairperson Elect**
Vincent C. Traynelis  
**Secretary**
Vincent C. Traynelis  
**Treasurer**
Curtis A. Dickman  
**Immediate Past Chairperson**
Richard G. Fessler  
**Members–at–Large**
- Charles L. Branch, Jr.  
- Mark N. Hadley  
- John E. McGillicuddy

### 1997 – 1998

**Chairperson**
Richard G. Fessler  
**Chairperson Elect**
Stephen M. Papadopoulos  
**Secretary**
Vincent C. Traynelis  
**Treasurer**
Curtis A. Dickman  
**Immediate Past Chairperson**
Edward C. Benzel  
**Members–at–Large**
- Charles L. Branch, Jr.  
- Mark N. Hadley  
- John E. McGillicuddy

### 1996 – 1997

**Chairperson**
Edward C. Benzel  
**Chairperson Elect**
Richard G. Fessler  
**Secretary**
Stephen M. Papadopoulos  
**Treasurer**
Peter M. Klara  
**Immediate Past Chairperson**
Arnold H. Menezes  
**Members–at–Large**
- Gary L. Rea  
- Nancy Epstein  
- John E. McGillicuddy  
- Kevin T. Foley  
- Mark N. Hadley
CURRENT AND PAST OFFICERS 1980-2009

1995 – 1996
Chairperson
Arnold H. Menezes
Chairperson Elect
Edward C. Benzel
Secretary
Stephen M. Papadopoulos
Treasurer
Peter M. Klara
Immediate Past Chairperson
Russell L. Travis
Members–at–Large
Nancy Epstein
John E. McGillicuddy
Gary L. Rea
Ex–Officio Members
Kevin T. Foley
Mark N. Hadley

1994 – 1995
Chairperson
Russell L. Travis
Chairperson Elect
Arnold H. Menezes
Secretary
Stephen M. Papadopoulos
Treasurer
Peter M. Klara
Immediate Past Chairperson
Russell L. Travis
Members–at–Large
Edward C. Benzel
Nancy Epstein
Gary L. Rea

1993 – 1994
Chairperson
Edward C. Tarlov
Chairperson Elect
Arnold H. Menezes
Secretary
Stephen M. Papadopoulos
Treasurer
Russell L. Travis
Immediate Past Chairperson
Edward C. Tarlov
Members–at–Large
Edward C. Benzel
Nancy Epstein
Gary L. Rea

1990 – 1991
Chairperson
Edwards C. Connolly
Chairperson Elect
Carole A. Miller
Secretary
Volker K. H. Sonntag
Treasurer
Russell L. Travis
Members–at–Large
Arnold H. Menezes
Donald J. Prolo

1989 – 1990
Chairperson
Edward S. Connolly
Chairperson Elect
Carole A. Miller
Secretary
Volker K. H. Sonntag
Treasurer
Russell L. Travis
Members–at–Large
Arnold H. Menezes
Donald J. Prolo

1988 – 1989
Chairperson
Stewart B. Dunsker
Secretary
Carole A. Miller
Treasurer
Edward C. Tarlov
Members–at–Large
Phanor L. Perot, Jr.
Volker K. H. Sonntag

1987 – 1988
Chairperson
Stewart B. Dunsker
Secretary
Carole A. Miller
Treasurer
Edward C. Tarlov
Members–at–Large
Phanor L. Perot, Jr.
Volker K. H. Sonntag

1986 – 1987
Chairperson
George W. Sypert
Secretary
Henry H. Schmidek
Treasurer
Edward S. Connolly
Member–at–Large
Carole A. Miller

1985 – 1986
Chairperson
Russell W. Hardy
Secretary
Henry H. Schmidek
Treasurer
Edward S. Connolly
Member–at–Large
George W. Sypert

1984 – 1985
Chairperson
Russell W. Hardy, Jr.
Secretary
Stewart B. Dunsker
Treasurer
Edward S. Connolly
Member–at–Large
Henry H. Schmidek

1983 – 1984
Chairperson
Sanford J. Larson
Secretary
Stewart B. Dunsker
Treasurer
Edward S. Connolly

1982 – 1983
Chairperson
Sanford J. Larson
Secretary
Stewart B. Dunsker
Treasurer
Edward S. Connolly
Member–at–Large
Henry H. Schmidek

1981 – 1982
Chairperson
Sanford J. Larson
Secretary
Stewart B. Dunsker
Treasurer
Edward S. Connolly
Member–at–Large
Henry H. Schmidek

Chairperson
Sanford J. Larson
Secretary
Stewart B. Dunsker
Treasurer
Edward S. Connolly
Member–at–Large
Philip R. Weinstein
<table>
<thead>
<tr>
<th>Year</th>
<th>Chairs</th>
</tr>
</thead>
</table>
PAST PROGRAM COMMITTEES 1985-2008

1985 – 1986
Nevan G. Baldwin
Brian G. Cuddy
Kevin T. Foley
Allan H. Friedman
Regis W. Haid, Jr.
H. Louis Harkey, III
Patrick W. Hitchon
James P. Hollowell
Richard K. Osenbach
Allan H. Friedman
Noel I. Perin
Robert B. Snow
Richard H. Tippets
Dennis G. Vollmer

1986 – 1987
Bennett Blumenkopf
Charles L. Branch, Jr.
David W. Cahill
Richard G. Fessler
Stephen M. Papadopoulos
Gary L. Rea

1987 – 1988
Melville P. Roberts
Richard Saunders
Volker K. H. Sonntag
Russell L. Travis
Harold A. Wilkinson

1988 – 1989
John C. Godershy
Patrick W. Hitchon
Arnold H. Menezes
Carole E. Miller
Russell L. Travis

1989 – 1990
Bennett Blumenkopf
Paul D. Dernbach
Nancy Epstein
Edward C. Tarlov

1990 – 1991
Joy Aprin
Benjamin G. Benner
Lawrence F. Borges
Nancy Epstein
Emily D. Friedman

1991 – 1992
Bennett Blumenkopf
Charles L. Branch, Jr.
David W. Cahill
Richard G. Fessler
Stephen M. Papadopoulos
Gary L. Rea

1992 – 1993
Charles L. Branch, Jr.
David W. Cahill
Curtis A. Dickman
Richard G. Fessler
Regis W. Haid, Jr.
Robert J. Martin
John E. McGillicuddy
Stephen M. Papadopoulos
Noel I. Perin
Gary L. Rea
Moris Senegor

1993 – 1994
David W. Cahill
Curtis A. Dickman
Richard G. Fessler
Peter G. Gianaris
H. Louis Harkey, III
Paul C. McCormick
Russ P. Nockels
Moris Senegor
Vincent C. Traynelis

1994 – 1995
Charles L. Branch, Jr.
David W. Cahill
Paul R. Cooper
Curtis A. Dickman
Michael G. Fehlings
Regis W. Haid, Jr.
H. Louis Harkey, III
James P. Hollowell
Peter M. Klara
John J. Knightly
John E. McGillicuddy
Eugene Rossitch, Jr.
Charles B. Stillerman
Vincent C. Traynelis

1995 – 1996
Bennett Blumenkopf
Charles L. Branch, Jr.
David W. Cahill
Richard G. Fessler
Stephen M. Papadopoulos
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1996 – 1997
Eugene Rossitch, Jr.
Charles B. Stillerman
Vincent C. Traynelis

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

Power of Networking Ambassador for providing an educational grant in support of the 2009 Annual Meeting.
WEDNESDAY, MARCH 11

1:30 – 5:30 PM Grand Sonoran D
Special Course I – Coding Update and Review

Additional $200 for medical registrants. Includes lunch.

Directors: Robert R. Johnson, II, Joseph S. Cheng
Faculty: John J. Knightly, Peter D. Angevine, Karin R. Swartz, Justin Brown, R. Patrick Jacob

Course Description: This course will provide up-to-date information on current issues in spine coding. Coding scenarios will be reviewed for the correct coding of routine as well as complex spinal procedures.

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

1:30 – 2:00 PM
Introduction and New Codes
Joseph S. Cheng

2:00 – 2:30 PM
Surgical Modifiers
John J. Knightly

2:30 – 3:00 PM
22000 Series
Peter D. Angevine

3:00 – 3:30 PM
63000 Series
Karin R. Swartz

3:30 – 3:45 PM
Beverage Break

3:45 – 4:15 PM
Peripheral Nerve Coding
Justin Brown

4:15 – 4:45 PM
CPT/RUC Process
R. Patrick Jacob

4:45 – 5:30 PM
Coding Scenarios
Robert R. Johnson, II

1:30 – 5:30 PM Grand Canyon 13
Special Course II – New Developments in Arthroplasty

Additional $200 for medical registrants. Includes lunch.

Directors: Regis W. Haid, Jr., Praveen V. Mummaneni

Course Description: The focus of this course is to review the indications and contraindications of Cervical and Lumbar Arthroplasty. The results of IDE studies, as well as longer term follow-up will be discussed. Complications, revisions and reoperations will be examined. A comparison between arthroplasty and arthrodesis will be elucidated. Different devices, the tribology, and biomechanics will be reviewed.

Learning Objectives: Upon completion of this course, participants should be able to:
- Have an understanding of the indications and contraindications for arthroplasty.
- Discuss the associated complications and management strategies for them.
- Gain a better understanding of the biology and biomechanics of the devices.

1:30 – 1:40 PM
Introduction

1:40 – 2:00 PM
Tribology of Artificial Discs
Regis W. Haid

2:00 – 2:20 PM
Cervical Arthroplasty: Indications and Contraindications, FDA Status
Vincent C. Traynelis

2:20 – 2:40 PM
Cervical Arthroplasty: Prodisc C, IDE Results
William R. Taylor

2:40 – 3:00 PM
Cervical Arthroplasty: Prestige, IDE Results and 3 Year Follow-up
Praveen V. Mummaneni

3:00 – 3:30 PM
Cervical Arthroplasty: Bryan, IDE Results
Stephen M. Papadopoulos

3:30 – 3:45 PM
Beverage Break

3:45 – 4:05 PM
What is the Current Role of Lumbar Arthroplasty, Indications and Contraindications: Uses and Misuses
Kevin T. Foley

4:05 – 4:25 PM
Outcomes of Currently Available Lumbar Devices
Rick C. Sasso

4:25 – 5:30 PM
Fusion Is Better than Arthroplasty: True or False?
Richard G. Fessler
MEETING AGENDA WEDNESDAY, MARCH 11

1:30 – 5:30 PM Grand Canyon 12

Special Course III – Biomechanics: Its Use in Surgical Decision Making

Additional $200 for medical registrants. Includes lunch.

Directors: Edward C. Benzel, Richard P. Schlenk, Marc Eichler
Faculty: Lars Gilbertson, PhD

Course Description: This course seeks to use biomechanics as a foundation for decision making in complex spinal surgery. The course will review the biomechanics in lumbar spinal disease and also review the biomechanics associated with implants.

Learning Objectives: Upon completion of this course, participants should be able to:
- Understand the biomechanical foundations of clinical decision making.
- Understand the biomechanical theory associated with spinal implants including motion sparing devices.
- Understand the clinical application of biomechanical theory.

1:30 – 1:40 PM
Introduction
Edward C. Benzel

1:40 – 2:20 PM
Biomechanics: The Fundamentals
Lars Gilbertson, PhD

2:20 – 3:10 PM
Spinal Column Failure, Spine Instrumentation and the Fundamentals of Decision Making
Edward C. Benzel

3:10 – 3:30 PM
Discussion
Marc Eichler

3:30 – 3:45 PM
Beverage Break

3:45 – 4:15 PM
Short or Long, Front or Back, Rigid or Non–Rigid?
Richard P. Schlenk

4:15 – 4:30 PM
Discussion
Marc Eichler

4:30 – 5:00 PM
Biomechanics and the Spine Surgeon: Putting It All Together
Marc Eichler

5:00 – 5:30 PM
Discussion
Lars Gilbertson, PhD, Edward C. Benzel

1:30 – 5:30 PM Grand Canyon 11

Special Course IV – Pediatric Craniocervical

Additional $200 for medical registrants. Includes lunch.

Directors: Douglas L. Brockmeyer, Francesco T. Mangano
Faculty: Pediatric Symposia

Course Description: This course will serve as a symposium for those with an interest in pediatric craniocervical abnormalities and disease. It seeks to examine issues related to management of pediatric craniocervical disease including surgical and non–surgical treatment, complication management, and disease pathophysiology.

Learning Objectives: Upon completion of this course, participants should be able to:
- Discuss appropriate management of complex pediatric craniospinal disorders.
- Discuss appropriate research strategies to further the care of patients with craniospinal disorders.
- Understand the mechanism involved in the pathophysiology and progression of pediatric craniocervical disease.

1:30 – 3:30 PM
Roundtable Discussion and Presentations

3:30 – 3:45 PM
Beverage Break

3:45 – 5:30 PM
Roundtable Discussion and Presentations

1:30 – 5:30 PM Grand Canyon 10

Special Course V – Surgical Management of the Aging Spine: Deformity, Stenosis, Listhesis, Disc

Additional $200 for medical registrants. Includes lunch.

Directors: Charles L. Branch, Jr., Gregory R. Trost
Faculty: Tyler R. Koski, Michael P. Steinmetz, Darryl J. Dirisio, Frank LaMarca

Course Description: This course seeks to examine degenerative spinal disease from the perspective of aging. It will look at basic spinal pathology and determine what effects diseases of the aging play on surgical and non–surgical management of the spine.

Learning Objectives: Upon completion of this course, participants should be able to:
- Determine which diseases of the aging (e.g. osteoporosis) may profoundly affect treatment of degenerative spinal conditions.
- Determine how diseases of the aging shift treatment protocols for degenerative spinal diseases.
- Discuss modification that may be employed for the surgical management of the aging spine.
1:30 – 1:45 PM  
**Aging Population Demographics/How Old is Too Old?**  
Michael P. Steinmetz

1:45 – 2:15 PM  
**Assessment and Medical Management of Osteoporosis**  
Gregory R. Trost

2:15 – 2:30 PM  
**Biomechanics and Pathophysiology of the Aging Spine**  
Michael P. Steinmetz

2:30 – 3:00 PM  
**Management of Spondylolisthesis in the Aging Spine**  
Tyler R. Koski

3:00 – 3:30 PM  
**Management of Deformity in the Aging Spine**  
Frank LaMarca

3:30 – 3:45 PM  
**Beverage Break with Exhibitors**

3:45 – 4:15 PM  
**Geriatric Spine Trauma**  
Darryl J. Dirisio

4:15 – 4:45 PM  
**Vertebroplasty/Kyphoplasty for Osteoporotic Compression Fracture**  
Richard P. Schlenk

4:45 – 5:00 PM  
**Case Presentations**  
Charles L. Branch, Jr., Gregory R. Trost, Tyler R. Koski, Michael P. Steinmetz, Darryl J. Dirisio, Frank LaMarca, Richard P. Schlenk

**Learning Objectives:** Upon completion of this course, participants should be able to:
- Discuss current trends, possible future scenarios, and current preventive evidence for surgical site infections.
- Describe clinical evaluation including use of laboratory and imaging studies.
- Analyze non-surgical and surgical decision making and management.

1:30 – 2:00 PM  
**Risk Factors including Immunosuppression Obesity and DM**  
Andrea L. Strayer, MSN, CNRN, ACNP

2:00 – 2:40 PM  
**Non-surgical Decision Making/Management**  
Joseph S. Cheng

2:40 – 3:05 PM  
**MRSA + Patient in the OR**  
Tina Lisman, PAC

3:05 – 3:30 PM  
**Prevention of Surgical Wound Infection**  
Connie Rios, NP

3:30 – 3:45 PM  
**Beverage Break**

3:45 – 4:15 PM  
**Evaluation: Clinical, Labs, Images**  
Margaret Black, NP

4:15 – 5:00 PM  
**Surgical Decision Making/Management**  
Allan D. Levi

5:00 – 5:30 PM  
**What does the Future Hold?**  
Andrew N. Nemecsk

**Physician attendees will not be awarded CME credit for this course. Nursing contact hours will be provided through AANN. The American Association of Neuroscience Nurses is accredited as a provider of continuing nursing education by the American Nurses Credentialing Center’s Commission on Accreditation.**

**Physician Assistants/Physician Extenders will receive credit for attendance. Each physician assistant/physician extender will need to contact his or her individual membership association and certification board to determine the requirements for accepting credits. All attendees will receive a confirmation of attendance.**
Opening Reception

Take in spectacular views of the mountains and watch the sunset while enjoying a wonderful assortment of hors d’oeuvres and refreshments as you visit with old friends and new colleagues at the Opening Reception. The reception will be held on the beautiful landscaped lawn of Sage Court at the JW Marriott Desert Ridge Resort & Spa. Each medical attendee and spouse/guest registered for the meeting will receive one complimentary ticket. Additional tickets will be available for purchase in the registration area during registration hours, from 8:00 AM – 6:00 PM. Resort casual attire is recommended for this event.

Session Description: This Scientific Session will review the history of the Joint Section on its 25th Anniversary with attention to the reasons for development of a professional subspecialty society. It will also examine how aging affects the treatment of common spine and peripheral nerve maladies. Senior surgeons will give their perspectives on the treatment of spine and peripheral nerve disorders and the affects of aging.

Learning Objectives: Upon completion of this course, participants should be able to:
- Understand the history and evolution of the spine section.
- Evaluate the current treatment of common cervical and lumbar degenerative spine disorders.
- Understand how aging affects treatment of spine disorders.
- Understand how aging affects treatment of peripheral nerve disorders.

7:00 – 7:20 AM
History of the Spine Section: 25 Years of Growth
Stewart B. Dunsker

7:20 – 7:40 AM
Cervical Disease: Treating Spondylotic Myelopathy
Mark N. Hadley

7:40 – 8:00 AM
Treatment of Spondylolisthesis in the Osteoporotic Spine
Vincent C. Traynelis

8:00 – 8:20 AM
Management of Geriatric Spinal Deformity
Christopher I. Shaffrey

8:20 – 8:40 AM
Lessons Learned in 30 Years of Peripheral Nerve Surgery and the Influence of Aging
John E. McGillicuddy

8:40 – 8:55 AM
Panel Discussion
Stewart B. Dunsker, Mark N. Hadley, Vincent C. Traynelis, Christopher I. Shaffrey, John E. McGillicuddy

9:10 AM
Meritorious Award Winner
Paul C. McCormick

Meritorious Award Presentation
The Nature and Use of Evidence in Spinal Surgery
MEETING AGENDA THURSDAY, MARCH 12

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

9:30 – 10:15 AM Grand Canyon 1-8
Beverage Break with Exhibitors

What’s New Session I
Moderator: Daniel M. Sciubba

10:15 AM – 12:35 PM Grand Sonoran E
Oral Platform Presentations I

Moderators: Robert F. Heary, Ira M. Goldstein

10:15 – 10:23 AM
100. Proton Magnetic Resonance Spectroscopy to Evaluate Spinal Cord Axonal Injury in Cervical Spondylotic Myelopathy
Langston T. Holly, Bonnie Freitas, David L. McArthur, Noriko Salamon

10:23 – 10:31 AM
101. The Clinical Application of Modest Hypothermia after Spinal Cord Injury
Allan D. Levi, Barth A. Green, Michael Y. Wang, Dalton Dietrich, Ted Ian Brindle, Steven Vanni, Gizelda T. Casella, Gina Elhammady, Jonathan R. Jagid

10:31 – 10:39 AM
102. Comparison of Patient and Surgeon Ratings of Global Outcome after Lumbar Spinal Surgery
Francois Porchet, Friederike Lattig, Dieter Grob, Frank Kleinstick, Deszö Jeszenszky, Viktor Bartanusz, Anne F. Mannion

10:39 – 10:45 AM
Discussion

10:45 – 10:53 AM
103. Stimulus–Evoked EMG Testing of Percutaneous Pedicle Screws is Marginally Effective for the Intraoperative Detection of Radiographic Breaches
Michael Y. Wang, Sarah Woodrow, Praveen V. Mummaneni

10:53 – 11:01 AM
104. Ballon Kyphoplasty Improves Both Disability Scores and Pain Among Cancer Patients with Vertebral Compression Fractures: A Randomized Trial

11:01 – 11:09 AM
105. Cervical Facet Degeneration after Total Disc Replacement
Luiz Pimenta, Juliano Lhamby, Juliano Fratezi, Etevaldo Coutinho, Leonardo Oliveira

11:09 – 11:15 AM
Discussion

11:15 – 11:23 AM
106. An Analysis of Hospital Cost Differences between Minimally Invasive and Open Posterior Interbody Fusion Surgery
Rikin Trivedi, Sarah Woodrow, Michael Y. Wang

11:23 – 11:31 AM
107. Adjuvant Treatment with Locally Delivered OncoGel Delays the Onset of Paresis after Surgical Resection or Radiotherapy of Experimental Spinal Column Metastasis

11:31 – 11:39 AM

11:39 – 11:45 AM
Discussion

11:45 – 11:53 AM
Kai–Ming G. Fu, Justin S. Smith, Charles A. Sansur, David K. Hamilton, William Donaldson, Joseph Perra, Ram Mudiyan, Theodore Choma, Reinhard Zeller, Hilali Noordeen, Dennis Knapp, Sigurd Berven, Michael Goytan, Oheneba Boachie–Adjei, Christopher I. Shaffrey

11:53 AM – 12:01 PM
110. Complications in the Surgical Treatment of 2,258 Adults with Isthmic Spondylolisthesis: A Report from the Scoliosis Research Society Morbidity and Mortality Committee
Justin S. Smith, Charles A. Sansur, David K. Hamilton, Kaiming Fu, William Donaldson, Joseph Perra, Ram Mudiyan, Theodore Choma, Reinhard Zeller, Hilali Noordeen, Dennis Knapp, Sigurd Berven, Michael Goytan, Oheneba Boachie–Adjei, Christopher I. Shaffrey

12:01 – 12:09 PM
111. Is the Use of BMP in TLIF Cost Effective?
Sanjay S. Dhall, Daniel C. Lu, Gerald E. Rodts, Jr., Regis W. Haid, Jr., Praveen V. Mummaneni

12:09 – 12:15 PM
Discussion

12:15 – 12:23 PM
112. Effect of Teriparatide [rhPTH(1,34)] and Calcitonin on Intertransverse Process Fusion in a Rabbit Model
Ronald A. Lehman, Anton E. Dmitriev, Mario J. Cardoso, Christen L. Christensen, JoLyne W. Raymond, Melvin D. Helgeson, Timothy R. Kuklo, K. Daniel Riew

12:23 – 12:31 PM
113. Healthcare Burden of Cervical Spine Fractures in the United States: Analysis of a Nationwide Database over a 10–Year Period
Ali A. Baaj, Juan S. Uribe, Fernando L. Vale

12:31 – 12:35 PM
Discussion
### Scientific Session II – Present Appraisal: New Trials and Their Implications

**Moderators:** Andrew T. Dailey, Peter C. Gerszten

**Session Description:** This Scientific Session will critically review the clinical trials for the treatment of spinal metastasis that have been published over the last few years. The results of these trials will be summarized and critically evaluated in reference to implications for practice. This session will also look at new treatments and new technologies and examine ways for the practitioner to gauge the utility of a treatment.

**Learning Objectives:** Upon completion of this course, participants should be able to:
- Critically evaluate the methodology (including study design and analysis) used in the clinical trials discussed.
- Discuss the results of the clinical trials that were reviewed.
- Distill how those clinical trials will affect similar patients seen in the practitioner’s clinical practice.
- Critically appraise new treatments and technologies with attention to the likelihood for success and failure.

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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</thead>
</table>
| 1:30 – 1:45 PM | Review of Randomized Controlled Trials  
Zoher Ghogawala                                    |
| 1:45 – 2:00 PM | Critical Appraisal of Results  
Michael G. Kaiser                                      |
| 2:00 – 2:15 PM | Clinical and Economic Implications for Treatment  
Neill M. Wright                                        |
| 2:15 – 2:30 PM | Appraising New Treatments: Nerve Transfer  
Allen H. Maniker                                         |
| 2:30 – 2:45 PM | Successes and Pitfalls in Gauging New Technology  
J. Patrick Johnson                                       |
| 2:45 – 3:00 PM | Panel Discussion  
Zoher Ghogawala, Michael G. Kaiser, Neill M. Wright, Allen H. Maniker, J. Patrick Johnson |
4:20 – 4:25 PM
206. Repeat Decompression Surgery for Recurrent Spinal Metastases
Ilya Lauffer, Andrew Hanover, Eric Lis, Yoshiya Yamada, Mark H. Bilsky

4:25 – 4:30 PM
207. CT Scan Analysis of Pedicle Screw Placement: Measurement of Breach is Not Reliable
Amer F. Samdani, Randal Betz, John P. Gaughan, Stewart Bailey, Courtney Brown, Jahangir Asghar, Patrick Cahill, Linda P. D’Andrea, Maurice Bourlion

4:30 – 4:35 PM
208. Comparison of Open and Minimally Invasive Fusions for Treatment of Degenerative Spondylolisthesis
Irie Dunne, Jessin Blossom, Tyler J. Kenning, Matthew Armand Adamo, John W. German

4:35 – 4:40 PM
209. The Contribution of the Rib Cage to the Stability of the Thoracic Spine
Leonardo B. C. Brasiliense, Bruno C. R. Lazaro, Phillip M. Reyes, Nicholas Theodore, Neil R. Crawford

4:40 – 4:45 PM
Discussion

4:45 – 4:50 PM
210. Failure Analysis of Absorbable Cervical Plates
Vikas V. Patel, Celeste Abjornson, Simon Turner, Howard B. Seim, Amy Lyons, Christian M. Puttlitz

4:50 – 4:55 PM
211. Facet Fate and Adjacent Level Disease in Lumbar Arthroplasty: Comparison Between Anterior and Lateral TDR–12–Months Follow–up
Luiz Pimenta, Juliano Lhamby, Juliano Fratezi, Etevaldo Coutinho, Thomas Schaffa, Leonardo Oliveira

4:55 – 5:00 PM
212. FlexiCore® Total Disc Replacement vs. Fusion for Lumbar Degenerative Disc Disease: Two–Year Outcomes from Five Study Sites in a Prospective Randomized Controlled Trial
Eric J. Woodard, Charles S. Theofilos, Rick C. Sasso, James Zucherman

5:00 – 5:05 PM
213. Assessment of Potential Predictors of Need for Mechanical Ventilation and the Occurrence of Extubation Failure in Patients with Traumatic Spinal Cord Injury
Julio C. Furlan, Deepa Kattail, Niall D. Ferguson, Michael G. Fehlings

5:05 – 5:10 PM
214. Safety of Moderate Hypothermia in Elective Surgery for Spinal Tumors
Michael Y. Wang, Barth A. Green, Allan D. Levi, Steven Vanni, Jeremiah N. Johnson, Matthew Cummock

5:10 – 5:15 PM
Discussion
4:30 – 4:35 PM
223. Multistaged Reduction with Magerl External Fixator and 360 Fusion for High Grade Spondylolisthesis and Spondyloptosis
Vishal Kakar, Jabir Nagaria, Michael Grevitt, John Webb

4:35 – 4:40 PM
Babak Arvin, Sukhvinder Kalsi-Ryan, Julio C. Furlan, David Mercier, Eric M. Massicotte, Branko Kopjar, Michael G. Fehlings

4:40 – 4:45 PM
Discussion

4:45 – 4:50 PM
Matthew F. Gornet, Brett A. Taylor, Timothy R. Kuklo, Russ P. Nockels, Todd Hopkins Lanman

4:50 – 4:55 PM
226. The Role of Cannabinoids in Chronic Neuropathic Pain Development Following Contusive Spinal Cord Injury
Sharad Rajpal, Clayton Sweeney, Tiffany A. Gerovac, Bradley Alcock, Shannon McChesney, Amy Patel, Jessica Tilghman, Gurwattan Miranpuri, Daniel K. Resnick

4:55 – 5:00 PM
227. The Majority of Initial Coronal Imbalance Following Fusion Surgery for AIS Improves within Six Months
Amer F. Samdani, Jahangir Asghar, Daniel M. Sciuibaba, Patrick Cahill, David Clements, Darryl Antonacci, Randal Betz, Harms Study Group

5:00 – 5:05 PM
228. Difference in Fusion Rates for One vs. Two Screws in Elderly Odontoid Fractures
Andrew T. Dailey, Michael Finn, Meic H. Schmidt, David J. Hart, Ronald I. Apfelbaum

5:05 – 5:10 PM
229. Association of Autoimmune Cytokines with Gait Abnormalities and Mechanical Sensitivity in Radiculopathy

5:10 – 5:15 PM
Discussion

5:15 – 6:45 PM Grand Canyon 1-8
Reception with the Exhibitors

Join us for this special event in the exhibit hall! Attendees will have the opportunity to interact with exhibiting companies while enjoying cocktails and hors d’oeuvres with colleagues.
MEETING AGENDA FRIDAY, MARCH 13

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

8:00 – 9:00 AM Grand Sonoran E

Scientific Session III – Part 2
Future Advocacy: What the Future Holds for Neural Injury

Moderators: Eric L. Zager, James S. Harrop

Session Description: This Scientific Session will critically examine controversial issues in patients with acute spinal cord injury from the standpoint of surgical therapy and neurocritical care. The session will also explore the current status of functional restoration with regard to stem cells and robotics. Neural regeneration through the clinical use of pluripotent progenitor (stem) cells will be critically evaluated. The session will explore the feasibility of functional restoration through the used of robotics.

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

» Critically evaluate options for decompression of the spine with respect to appropriate timing.
» Understand and evaluate the current status of critical care treatment of the patient with spinal cord injury.
» Discuss the future direction of neural stem cell therapy for spinal cord injury.
» Appraise the use of robotics for functional restoration of neural injury.

8:00 – 8:12 AM
Cervical Spinal Cord Contusion: Early Decompression or Not?
Michael P. Steinmetz

8:12 – 8:24 AM
Early ICU Therapy Controversies: Reduction, Steroids, Hypertensive Therapy, Hypothermia
Michael Y. Wang

8:24 – 8:36 AM
Neural Repair Through Stem Cells: Reality or Dream?
Michael G. Fehlings

8:36 – 8:48 AM
Functional Restoration Through Robotics
James M. Ecklund

8:48 – 9:00 AM
Panel Discussion
Michael P. Steinmetz, Michael Y. Wang, Michael G. Fehlings, James M. Ecklund

9:00 – 9:30 AM Grand Sonoran E

Fellowship Awards and Clinical Trials Awards

Moderators: Joseph S. Cheng, Peter C. Gerszten, Zohar Ghogawala

9:30 – 10:15 AM Grand Canyon 1-8

Beverage Break with Exhibitors

What’s New Session IV
Moderator: Maxwell Boakye

10:15 – 12:15 PM Grand Sonoran E

Oral Platform Presentations II

Moderators: Eric J. Woodard, Gregory R. Trost

10:15 – 10:23 AM
114. 3-Year and 5-Year Follow Up from the Prospective, Randomized US FDA IDE Trial of the Prestige Cervical Disc Arthroplasty
Praveen V. Mummaneni, Regis W. Haid, Jr., Vincent C. Traynelis, Thomas A. Zdeblick, J. Kenneth Burkus

10:23 – 10:31 AM
115. Perioperative Macrophage Depletion Improves Functional Recovery Following Moderate Contusion SCI in Adult Rats
Christopher A. Iannotti, Megan Clark, Michael P. Steinmetz

10:31 – 10:39 AM
116. Delayed Symptomatic Pleural Effusions Associated with rhBMP-2 Use In Ventral Thoracic Spinal Fusion Surgery
Philip A. Uter, David Gwinn, Edward C. Benzel, Ajit A. Krishnaney

10:39 – 10:45 PM
Discussion

10:45 – 10:53 AM
117. Myotome Project: Investigation of Human Myotomal Distribution Using Invivo Stimulation
Subu N. Magge, Clemens M. Schirmer, Christopher Martin, Jeffrey E. Arle, Peter K. Dempsey, Edward C. Tarlov, Rees Cosgrove, Jay L. Shils

10:53 – 11:01 AM
118. Postoperative Infection of the Instrumented Spine: A Review of 1,332 Procedures Over 5 Years

11:01 – 11:09 AM
119. Fractionated Radiosurgery in the Treatment of Spinal Metastases
Rizwan Ahmed, Khalid A. Sethi, Christine Snyder

11:09 – 11:15 AM
Discussion

11:15 – 11:23 AM
120. Surgical Results of Lumbar Microdiscectomy in the Pediatric Population
Kevin S. Cahill, Mark R. Proctor

11:23 – 11:31 AM
121. CerviCore® Disc Replacement vs. Fusion for Single-Level Cervical Radiculopathy: One-Year Outcomes from Four Study Sites in a Prospective Randomized Controlled Trial
Neill Marshall Wright, J.J. Abitbol, Nevan G. Baldwin, Jim A. Youssef

11:31 – 11:39 AM
122. Impact of Body Habitus on Perioperative Complications During Fusion of the Lumbar Spine
Mohammed F. Shamji, Stephen Parker, Chad Cook, Ricardo Pietrobon, Christopher Brown, Robert E. Isaacs

11:39 – 11:45 AM
Discussion
11:45 – 11:53 AM
123. The Total Facet Arthroplasty System® (TFAS®) in the Treatment of Spinal Stenosis: Worldwide Experience with Longest Follow-up of 36 Months
Khalid Sethi, Antonio Castellvi, Scott Webb, Courtney Brown, Bart Sachs, Charles H. Wingo, Michael Halperin, Guillermo Bajares, Alejandro Perez-Oliva, Radu Prejbeanu, Ioan Branea

11:53 AM – 12:01 PM
124. Short-term Morbidity and Mortality Associated with Correction of Thoracolumbar Fixed Sagittal Plane Deformity

12:01 – 12:09 PM
125. Diffusion Tensor Imaging in Spinal Trauma: Functional Correlates and Spatiotemporal Changes During Recovery
Shekar N. Kurpad, Brian Schmit, Benjamin Ellingson, John L. Ulmer

12:09 – 12:15 PM
Discussion

12:15 – 12:30 PM
Annual Business Meeting

12:30 PM
Lunch on your own.

12:30 – 12:35 PM
Complications of Cervical Surgery
Michael G. Fehlings

1:00 – 1:25 PM
Complications of Thoraco-Lumbar Surgery
Patrick W. Hitchon

1:30 – 1:45 PM
Beverage Break

1:45 – 2:25 PM
Complications of Minimally Invasive and Lumbar Surgery
Kurt M. Eichholz, Christopher J. Barry

2:25 – 2:30 PM
Discussion and Wrap-up
Timothy C. Ryken, Michael W. Groff, Patrick W. Hitchon, Michael G. Fehlings, Robert F. Heary, Christopher J. Barry, Kurt M. Eichholz

12:30 – 12:55 PM
Complications of Cervical Surgery
Michael G. Fehlings

1:00 – 1:25 PM
Complications of Thoraco-Lumbar Surgery
Patrick W. Hitchon

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Discussion and Wrap-up
Timothy C. Ryken, Michael W. Groff, Patrick W. Hitchon, Michael G. Fehlings, Robert F. Heary, Christopher J. Barry, Kurt M. Eichholz

12:30 – 2:30 PM
Grand Canyon 12
Luncheon Symposium II - Critical Review and Analysis of the SPORT Trials: Implications for your Practice

12:30 – 2:30 PM
Grand Canyon 11
Luncheon Symposium I - Revision Spine Surgery and Management of Complications

Additional $200 for medical registrants. Includes lunch.

Directors: Iain H. Kalfas, Eric J. Woodard
Faculty: Zoher Ghogawala, Michael G. Kaiser, Mark R. McLaughlin, Joseph T. Alexander

Course Description: This course will critically review the SPORT and other randomized trials investigating lumbar disc disease, spondylolisthesis, and lumbar stenosis. It will analyze the utility and problems in study design including “intention-to-treat” and “as observed” formats.

Learning Objectives: Upon completion of this course, participants should be able to:
- Discuss the results for the SPORT trials with respect to lumbar disc disease, spondylolisthesis, and lumbar stenosis.
- Understand the basis for different trial designs such as “intention to treat” and “as observed”.
- Evaluate how the results may impact clinical decision making and patient care.

12:30 – 1:00 PM
SPORT Trials: Background, Design, Statistical Analysis
Zoher Ghogawala
1:00 – 1:30 PM
SPORT Trial: Lumbar Discectomy
Joseph T. Alexander

1:30 – 1:45 PM
Beverage Break

1:45 – 2:10 PM
SPORT Trial: Lumbar Stenosis
Michael G. Kaiser

2:10 – 2:25 PM
SPORT Trial: Lumbar Spondylolisthesis
Mark R. McLaughlin

2:25 – 2:30 PM
Discussion

12:30 – 2:30 PM
Grand Canyon 13

Luncheon Symposium III - Treatment of Primary and Metastatic Spine Tumors

Additional $200 for medical registrants. Includes lunch.

Directors: Ehud Mendel, Ziya L. Gokaslan
Faculty: Mark H. Bilsky, Peter C. Gerszten, Laurence D. Rhines, Jean-Paul Wolsinsky, Daryl R. Fourney, Meic H. Schmidt, Dean Chou

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.
- Review 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 – 12:45 PM
Case Presentation – Metastatic Disease with High Grade Stenosis
Mark H. Bilsky

12:45 – 1:00 PM
Case Presentation – Metastatic Disease to C1–2 Subluxation/Instability
Jean-Paul Wolsinsky

1:00 – 1:15 PM
Case Presentation – Minimally Invasive Treatment of a Metastatic Lesion to the Thoracic Spine
Meic H. Schmidt

1:15 – 1:30 PM
Case Presentation – En Bloc Resection
Laurence D. Rhines

1:30 – 1:45 PM
Beverage Break

1:45 – 2:00 PM
Vertebroplasty with Stereotactic Radiosurgery for a Metastatic Lesion
Peter C. Gerszten

2:00 – 2:15 PM
Case Presentation – Metastatic Disease with Deformity Requiring 360° Fixation
Dean Chou

2:15 – 2:30 PM
Case Presentation – Metastatic Disease with Lymphoma and a Need for Pre-Operative Biopsy
Daryl R. Fourney

1:30 – 5:30 AM
Grand Canyon 9

Special Course VII – Peripheral Nerve Exposures and Nerve Repair Techniques

Complimentary to Section Resident Members.

Additional $200 for medical registrants. Includes lunch.

Directors: Allen H. Maniker, Robert J. Spinner
Faculty: Robert L. Tiel, Eric L. Zager, Allan J. Belzberg, John E. McGillicuddy, Rajiv Midha, Line Jacques

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:
- Understand 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.
- Review 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.

1:30 – 2:00 PM
Nerve Grafting and Conduits
Rajiv Midha

2:00 – 2:30 PM
Supraclavicular Brachial Plexus
Allan J. Belzberg
2:30 – 3:00 PM  
**Infraclavicular Brachial Plexus**  
John E. McGillicuddy

3:00 – 3:30 PM  
**Nerve Transfers**  
Allen H. Maniker

3:30 – 3:45 PM  
**Beverage Break**

3:45 – 4:15 PM  
**Median Nerve**  
Line Jacques

4:15 – 4:40 PM  
**Ulnar Nerve**  
Eric L. Zager

4:40 – 5:05 PM  
**Radial Nerve**  
Robert L. Tiel

5:05 – 5:30 PM  
**Lower Extremity**  
Robert J. Spinner

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1:30 – 5:30 PM  
**Special Course VIII – Evaluation and Management of the Spine Trauma Patient**

Special Course for Nurses, Nurse Practitioners and Physician Assistants/Physician Extenders.

Additional $110 for medical registrants. Includes lunch.

**Directors:** Gregory R. Trost, Andrea L. Strayer, MSN, CNRN, ACNP  
**Faculty:** Richard P. Schlenk, Michael P. Steinmetz, Marc Eichler, Denise Brost, NP, Connie Rios, NP

**Course Description:** This course will provide practical, current didactic information on spine trauma with particular emphasis on update on medical therapies and intensive care after a complete injury; radiographic interpretation and classification schemes; facet fractures, ligamentous injury and upper cervical spine injuries. 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.

**Learning Objectives:** Upon completion of this course, participants should be able to:
- Analyze current evidence regarding steroid therapy and hypothermia after SCI.
- Describe radiographic evaluation following spinal trauma and classification of fracture types.
- Describe radiographic evidence as well as care considerations for facet fractures, ligamentous injury, and upper cervical spine including odontoid fractures.
- Discuss ICU care considerations following a complete SCI.
Meeting Agenda: Saturday, March 14

6:30 – 6:55 AM

Grand Sonoran E

Case Presentations

Moderators: Brian R. Subach, Kurt M. Eichholz

6:55 – 7:00 AM

Grand Sonoran E

Meeting Announcements

7:00 – 8:30 AM

Grand Sonoran E

Scientific Session IV – Future Advocacy: CMS, the Spine and Spine Care in Alternative Health Systems

Moderators: Christopher I. Shaffrey, William E. Krauss

Session Description: This Scientific Session will critically examine the cost of treating spine and peripheral nerve disease from the perspective of CMS. It will then explore the treatment of spine and peripheral nerve disease in other health care systems: the military, the Canadian healthcare system, the Japanese healthcare system.

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

- Critically evaluate the utility of correcting geriatric spinal deformities.
- Understand treatment options for the patient with asymptomatic cervical stenosis who has spinal cord abnormalities on MRI.
- Critically evaluate the utility of fusion for recurrent lumbar disc herniation.
- Discuss with MIS leads to better outcomes.

7:00 – 7:15 AM

Delivering Effective Spine Care to Patients Through the 21st Century

Stephen L. Ondra

7:15 – 7:35 AM

CMS and Spine: CMS and the Cost of Spinal Degenerative Disease

Steve Phurrough, MD, MPA

7:35 – 7:50 AM

Lessons from the Military System

Michael K. Rosner

7:50 – 8:05 AM

Lessons from the Canadian System

R. John Hurlbert

8:05 – 8:20 AM

Lessons from the Japanese System

Junichi Mizuno

8:20 – 8:30 AM

Panel Discussion

Steve Phurrough, MD, MPA, Steve Ondra, Michael K. Rosner, R. John Hurlbert, Junichi Mizuno

8:30 – 10:55 AM

Grand Sonoran E

David Cahill Memorial Controversies Sessions

Spine and Peripheral Nerve

Moderators: Joseph T. Alexander, Robert E. Isaacs

Session Description: This Scientific Session will involve a debate presentation format. Controversial clinical management decisions will be presented. Experts will argue their perspectives with regard to the management scenarios for difficult spine and peripheral nerve cases.

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

- Critically evaluate the utility of correcting geriatric spinal deformities.
- Understand treatment options for the patient with asymptomatic cervical stenosis who has spinal cord abnormalities on MRI.
- Critically evaluate the utility of fusion for recurrent lumbar disc herniation.
- Discuss with MIS leads to better outcomes.

8:30 – 8:50 AM

MIS Outcomes: Better or Not

Faculty: Edward C. Benzel vs. Richard G. Fessler

8:50 – 9:10 AM

Asymptomatic Cervical Stenosis with Signal Change: Treat or No Treat

Faculty: Regis W. Haid, Jr. vs. Michael W. Groff

9:10 – 9:30 AM

Recurrent Disc: Fuse or No Fusion

Faculty: Volker K. Sonntag vs. Charles L. Branch, Jr.

9:30 – 10:15 AM

Grand Canyon 1-8

Beverage Break with Exhibitors

What’s New Session V

Moderator: Tanvir Choudhri

10:15 – 10:35 AM

Geriatric Scoliosis: Surgical Correction or Nonoperative Management

Faculty: Christopher E. Woffla vs. Tyler R. Koski

10:35 – 10:55 AM

Wrong Level Spine Surgery: Is it a “Never” Event or Not?

Faculty: John O’Toole vs. William E. Krauss
10:55 – 11:15 AM  Grand Sonoran E

**Mayfield Awards/Presentations**

*Moderators:* Praveen V. Mummaneni, Peter C. Gerszten

**Mayfield Basic Science Award**

10:55 – 11:00 AM
126. Involuntary, Electrically Excitable Nerve Transfer for Denervation: Results from an Animal Model
   Daniel L. Master, Thomas Cowan, Sreenath Narayan, Robert Kirsch, Harry Hoyen

11:00 – 11:05 AM
127. Occipital Condyle Fractures: Clinical Decision Rule and Surgical Management

**Mayfield Clinical Science Award**

11:00 – 11:05 AM
127. Occipital Condyle Fractures: Clinical Decision Rule and Surgical Management

11:05 – 11:10 AM
128. Key Predictors of Outcome in Patients Undergoing Surgical Treatment for Cervical Spondylotic Myelopathy: Analysis of a Prospective Multicenter Study in 285 Patients with One-Year Follow-up
   Michael G. Fehlings, Branko Kopjar, Tim Yoon, Paul M. Arnold, Alexander R. Vaccaro, Eric J. Woodard, Darrel S. Brodke, Jens Chapman, Christopher I. Shaffrey, Michael Janssen, Rick C. Sasso

11:10 – 11:15 AM
Discussion

**Outcomes Committee Award**

11:05 – 11:10 AM
128. Key Predictors of Outcome in Patients Undergoing Surgical Treatment for Cervical Spondylotic Myelopathy: Analysis of a Prospective Multicenter Study in 285 Patients with One-Year Follow-up
   Michael G. Fehlings, Branko Kopjar, Tim Yoon, Paul M. Arnold, Alexander R. Vaccaro, Eric J. Woodard, Darrel S. Brodke, Jens Chapman, Christopher I. Shaffrey, Michael Janssen, Rick C. Sasso

11:10 – 11:15 AM
Discussion

11:15 AM – 12:35 PM  Grand Sonoran E

**Oral Poster Presentations III**

(Concurrent Session)

*Moderators:* Nicholas Theodore, Patrick R. Pritchard

11:15 – 11:20 AM
230. Comparative Pull-Out Force of Misplaced Pedicle Screws in the Thoracic Spine: How Much Strength is Lost?

11:20 – 11:25 AM
231. Measurement of the Occipital Condyle–C1 and C1–C2 Joint Interval in Normal Adults
   Zohny Zohny, Brian T. Jankowitz, Dean B. Kostov, Erin Sauber–Schatz, Anthony Fabio, David O. Okonkwo

11:25 – 11:30 AM
232. Rebalancing of the Spine after Total Disc Replacement: Contributing Factors and Impact on Sagittal Alignment
   Frank Phillips, Domagoj Coric, Mark J. Krinock, Harold Hess, James Yue, Nicholas Wharton, John Hipp

11:30 – 11:35 PM
Discussion

11:35 – 11:40 AM
233. Diagnostic Tractography Features of Intramedullary Tumors
   Eve C. Tsai, Fahad A. Alkhayerf, Abdulaziz S. Al–Ali, John Sinclair, Brien G. Benoit, Alain Berthiaume, Thanh Binh Nguyen

11:40 – 11:45 AM
234. Osteogenic Protein 1 Promotes Neuroprotection and Plasticity in an In Vitro Spinal Cord Injury Model
   Ernest Vallorz, Megan Clark, Michael P. Steinmetz

11:45 – 11:50 AM
235. The Efficacy of Mesenchymal Stem Cells in Thoraco–Lumbar Spine Fusion Surgery for Trauma: A Retrospective Review of Operated Cases
   Roland A. Torres, Robert Edward Lieberson, Sherveen Parivash

11:50 – 11:55 AM
Discussion

11:55 AM – 12:00 PM
236. Enhanced Stabilization of C–1 Lateral Mass/C2 Pedicle Screw Fixation Construct via Crosslink: A Biomechanical Study
   John F. Hamilton, Carl Laurysen, Hamid Miraliakbar, Mary Bilancini

12:00 – 12:05 PM
237. The Role of Magnetic Resonance Neurography in Management of Patients with Suspected Neurogenic Thoracic Outlet Syndrome
   Matthew Tate, Benjamin Lee, Leslie Gillum, Nicholas M. Barbaro, John Engstrom, Philip R. Weinstein, Cynthia Chin

12:05 – 12:10 PM
238. Neurological Outcome after Surgical Management of Adult Tethered Cord Syndrome

12:10 – 12:15 PM
Discussion

12:15 – 12:20 PM
239. Immediate and Long-term Outcomes for Multilevel Anterior Cervical Fusions
   Tyler Kenning, Doniel Drazin, Constantine Plakas, Mark Calayag, Edward Gifford, Karen Petronis, Darryl J. Dirisio

12:20 – 12:25 PM
240. Multilevel ACDF with and Without BMP: A Comparison of Outcomes and Dysphagia Rates
   Daniel C. Lu, Luis M. Tumialan, Dean Chou, Praveen V. Mummaneni
### Meeting Agenda Saturday, March 14

<table>
<thead>
<tr>
<th>Time</th>
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Anirban Deep Bbanerjee, Sampath Somanna |
| 12:30 – 12:35 | Discussion                                                              |
| 11:15 – 12:35 | Oral Poster Presentations IV (Concurrent Session)                       |
Marie–Noëlle Hébert–Blouin, Kimberly K. Amrami, Bernd W. Scheithauer, Robert J. Spinner |
| 11:20 – 11:25 | Discussion                                                              |
| 11:25 – 11:30 | Does the Presence of Low Back Pain Influence the Outcome of Lumbar Decompression Surgery in Spinal Stenosis?
Francois Porchet, Frank Kleinstück, Dieter Grob, Viktor Bartanusz, Friederike Lattig, Deszö Jeszenszky, Anne F. Mannion |
| 11:30 – 11:35 | Discussion                                                              |
| 11:35 – 11:40 | Interspinous Implants for Degenerative Lumbar Spine Disease: Experience with DIAM and APERIUS Devices
Anthony P. Fabrizi, Marcelo Galarza, Raffaella Maina |
| 11:40 – 11:45 | Predictors for Success or Failure of Conservative Treatment in Thoracolumbar Burst Fractures
Nader Suhail Dahdaleh, Youssef R. Karam, Chandan G. Reddy, Patrick W. Hitchen |
| 11:45 – 11:50 | Age as a Potential Determinant of Disability Following Traumatic Spinal Cord Injury: Analysis of the Third National Acute SCI Study (NASCIS–3) Dataset
Julio C. Furlan, Michael Bracken, Michael G. Fehlings |
| 11:50 – 11:55 | Discussion                                                              |
| 11:55 AM – 12:00 | Wound Infection Following Surgery for Neuromuscular Scoliosis: Risk Factors and Treatment Outcomes
Daniel L. Master, Connie Poe–Kochert, Jochen Son–Hing, Douglas Armstrong, George Thompson |
| 12:00 – 12:05 | Do Expandable Cages Improve Segmental Stability Following a Lumbar Corpectomy? An In Vitro Biomechanical Study
Anton E. Dmitriev, Melvin D. Helgeson, Mario J. Cardoso, Frederick L. Stephens, Ronald A. Lehman, Patrick B. Cooper, Michael K. Rosner |
| 12:05 – 12:10 | Biomechanical Importance of the Anterior Longitudinal Ligament in a Corpectomy Model
Melvin D. Helgeson, Anton E. Dmitrievc, Mario J. Cardoso, Frederick L. Stephens, Ronald A. Lehman, Patrick B. Cooper, Michael K. Rosner |
| 12:10 – 12:15 | Discussion                                                              |
| 12:15 – 12:20 | Two–and Five–Year Lumbar Index–Level Motion Following Arthroplasty: Impact of Heterotopic Ossification
Michael P. Steinmetz, David Gwinn |
| 12:25 – 12:30 | Discussion                                                              |
| 12:30 – 12:35 | Your Opinion Counts! Please remember to complete an online course evaluation for each Scientific Session, Special Course and Luncheon Symposia you attend. Your feedback is critical in helping the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves plan future education and Annual Meetings. Course evaluations are available online at www.spinesection.org and will be e-mailed to you following the Annual Meeting. |
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Neill M. Wright

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Faculty Presentations including Non–FDA Approved Investigational Drugs or Devices.

Scientific Session I: Past Evidence: Lessons Learned, Dealing with the Aging Spine
Charles Kuntz, IV
Vincent C. Traynelis

Scientific Session IV: Future Advocacy: CMS, the Spine, and Spine Care in Alternative Health Systems
Edward C. Benzel
Junichi Mizuno

Special Course I - Coding Update and Review
Justin Brown

Special Course II - New Developments in Arthroplasty
Rick C. Sasso
Vincent C. Traynelis

Special Course III - Biomechanics: Its Use in Surgical Decision Making
Edward C. Benzel

Special Course V - Surgical Management of the Aging Spine: Deformity, Stenosis, Listhesis, Disc
Frank LaMarca

Special Course VI - Evaluation and Management of the Patient with a Spinal Infection
Joseph S. Cheng
Andrew N. Nemecek

Special Course VII - Peripheral Nerve Exposures and Nerve Repair Techniques
Robert L. Tiel

Special Course VIII - Evaluation and Management of the Spine Trauma Patient
Fran Feldkamp
Connie Rios

Case Presentations
Frank LaMarca – Thursday
Patrick R. Pritchard – Friday
Kurt M. Eichholz – Saturday

Oral Poster Presentations II
Marjorie C. Wang

Luncheon Symposium I - Revision Spine Surgery and Management of Complications
Christophre J. Barry
Kurt M. Eichholz
Timothy C. Ryken

Luncheon Symposium III - Treatment of Primary and Metastatic Spine Tumors
Daryl R. Fournet
Meic H. Schmidt
**Exhibit Hall**

*The Exhibit Hall, located in the Grand Canyon 1–8, will feature:*

More than 70 exhibiting companies displaying state-of-the-art equipment, products and services.

**Lunch in the Exhibit Hall**: Plan to spend your Thursday lunch break mingling with exhibitors between What’s New Session presentations.

**Reception with the Exhibitors**: Join us Thursday evening for another great social networking opportunity! Take this time to browse the aisles of the Exhibit Hall and visit your favorite companies or perhaps encounter some fresh faces on the exhibit floor, all 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**: This state-of-the-art format lets attendees browse 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.

**Exhibit Hall Hours**

**Thursday, March 12**

9:00 AM – 7:00 PM

**Friday, March 13**

9:00 AM – 12:00 Noon

**Saturday, March 14**

9:00 AM – 12:00 Noon

**Beverage Break and What’s New Session Hours**

**Thursday, March 12**

9:30 – 10:15 AM

12:35 – 1:25 PM*  
3:00 – 3:45 PM

**Friday, March 13**

9:30 – 10:15 AM

**Saturday, March 14**

9:30 – 10:15 AM

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

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{as of 2/12/09}

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<thead>
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<td>P: 561–627–1080</td>
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www.regentsurgicalhealth.com
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F: 757–534–7087
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Booth 705

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F: 216–241–2820
www.rbsurgical.com
Booth 204

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F: 603–742–1488
www.tissuelink.com
Booth 201

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P: 760–727–8399
F: 760–727–8809
www.seaspine.com
Booth 800

Signus Medical, LLC
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Chanhassen, MN 55317
P: 952–294–8700
F: 952–975–0465
www.signusmedical.com
Booth 212

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2744 Loker Avenue West
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Carlsbad, CA 92010
P: 760–607–0121
F: 760–607–0125
www.spinalelements.com
Booth 209

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www.spinesurginnovation.com
Booth 109

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F: 910–332–1701
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Minneapolis, MN 55439
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101. The Clinical Application of Modest Hypothermia after Spinal Cord Injury
Allan D. Levi, Bartha A. Green, Michael Y. Wang, Dalton Dietrich, Ted Ian Brindle, Steven Vanni, Gizelda T. Casella, Gina Elhammady, Jonathan R. Jagid

Introduction: There is widespread interest in the use of hypothermia in the treatment of central nervous system injury. While there is considerable experience in the use of cooling for a variety of brain pathologies, limited data exists after spinal cord injury. In the last few years, technological advances in the induction and maintenance of cooling have been achieved and can potentially allow more rapid evaluation of this form of treatment.

Methods: We report a series of 14 patients with an average age of 39.4 years (range from 16 to 62) with acute, complete spinal cord injuries who underwent a protocol using an intravascular cooling catheter to achieve modest (33 degrees Celsius) systemic hypothermia.

Results: There was an excellent correlation between intravascular and intrathecal cerebrospinal fluid temperature. The average time between injury and induction of hypothermia was 7.4 ± 0.27 h (mean ± SEM), time to target temperature was 2.72 ± 0.42 h, the duration of cooling at target temperature was 47.6 ± 3.1 h, the average total length of time of cooling was 93.6 ± 4 h. No patient received methylprednisolone and the average time to surgical decompression was 18.5 h. There was a strong correlation between temperature and heart rate. Most documented adverse events were respiratory in nature. Six of the 14 patients who all presented with physiologically complete (ASIA A) forms of spinal cord injury were incomplete at final follow-up (52 weeks) ASIA B (3) / ASIA C (2) / ASIA D (1).

Conclusion: We were able to effectively deliver systemic cooling using the cooling catheters with minimal variation in body temperature. The study represents the largest, modern series of hypothermia treatment of acute spinal cord injury with intravascular cooling techniques and provides needed baseline data for larger controlled, prospective multi-center trials.

102. Comparison of Patient and Surgeon Ratings of Global Outcome after Lumbar Spinal Surgery
François Porchet, Friederike Lattig, Dieter Grob, Frank Kleinstück, Desző Jeszenszky, Viktor Bartanusz, Anne F. Mannion

Introduction: Patient-orientated measures are becoming increasingly popular in the assessment of outcome and are considered to provide a less biased assessment of the surgical result than traditional surgeon-based ratings. The present study quantified the level of agreement between patients’ and doctors’ global outcome ratings after lumbar spine surgery.

Methods: 937 German-speaking patients (60.5 ± 15.6 y, 540 F, 397 M) who had undergone lumbar spine surgery 3-months earlier rated global outcome of the operation on a Likert scale (operation helped a lot and made things worse). They also completed the Core Outcome Measures Index and rated their overall satisfaction with treatment. The surgeon completed a SSE Spine-Tango Follow-up form, blind to the patient’s evaluation, rating the outcome with the McNab criteria (excellent and poor).

Results: There was a significant correlation (Rho = 0.58, P < 0.0001) between the surgeons’ and patients’ ratings. However, their ratings matched exactly in only 50.7% of the cases, the surgeon gave better ratings than the patient (“overrated”) in 25.3% cases and worse ratings (“underrated”) in 24.0% cases. There were significant differences between the 6 surgeons in the degree to which their ratings matched those of the patients, with senior surgeons “overrating” significantly more often than junior surgeons (p < 0.001). “Overrating” was significantly more prevalent for patients with a poor self-rated outcome (measured as global outcome, COMI score or satisfaction, each p < 0.001). In a multivariate model controlling for age and gender, “low satisfaction” and “senior surgeon” were the most significant unique predictors of surgeon “overrating” (p < 0.0001, adjusted R^2 = 0.20).

Conclusion: The study highlights the potential bias in studies that rely solely on surgeon ratings of outcome and indicates the importance of collecting data from both the patient and the surgeon in order to provide a balanced view of the outcome of spine surgery.

103. Stimulus-Evoked EMG Testing of Percutaneous Pedicle Screws is Marginally Effective for the Intraoperative Detection of Radiographic Breaches
Michael Y. Wang, Sarah Woodrow, Praveen V. Mummaneni

Introduction: Percutaneous pedicle screws have recently become popularized for lumbar spinal fixation. However, successful anatomic hardware placement is highly dependent upon intraoperative imaging. In traditional open surgery stimulus-evoked EMG responses can be useful for detecting pedicle screw breaches. The use of insulated screw extensions for percutaneous screw placement has allowed for EMG testing in minimally invasive surgery, however, no reports on the reliability of this
testing modality have been published.

**Methods:** 229 lumbar percutaneous pedicle screws were placed in 54 patients. Levels of instrumentation included L1 (N = 4), L2 (N = 20), L3 (N = 24), L4 (N = 71), L5 (N = 82) and S1 (N = 28). Intraoperative EMG stimulation thresholds were obtained from an insulated tap, with data compared to post-operative fine-cut CT scans to assess pedicle screw placement. Data was collected prospectively and analyzed retrospectively.

**Results:** There were 4 pedicle breaches (3 medial and 1 lateral, 3 grade I and 1 grade II) visualized on post-operative CT scans, one of which was symptomatic. In two instances intraoperative thresholds were the sole basis for screw trajectory re-adjustment, which resulted in proper placement on post-operative imaging. 15 screw trajectories were associated with a threshold of less than 12 mA. However, all breaches were associated with thresholds of over 12 mA. The sensitivity of an EMG threshold <12 mA was 0.0, and the specificity was 0.95. The positive predictive value was 0.0, and the negative predictive value was 0.93. Nevertheless, utilizing a threshold of any decreased stimulus (<20 mA) would have detected 75% of breaches, with a mean threshold of 16.25 mA.

**Conclusion:** While this data is limited by the low number of radiographic breaches, it appears that tap stimulation with an insulating sleeve may not be reliable for detecting low-grade radiographically breached pedicles using specific stimulation thresholds (<12 mA). Imaging-based modalities remain more reliable for assessing percutaneous pedicle screw trajectories until more robust and sensitive electromyographic testing methods can be devised.

104. **Ballon Kyphoplasty Improves Both Disability Scores and Pain Among Cancer Patients with Vertebral Compression Fractures: A Randomized Trial**


**Introduction:** Vertebral compression fractures (VCFs) are a common source of morbidity among patients with cancer and are frequently treated by balloon kyphoplasty. This randomized study shows that patients with cancer-related VCFs treated with balloon kyphoplasty have a marked reduction in spine related disability and pain at one month compared to non-surgical treatment. These improvements in disability and pain with balloon kyphoplasty were both statistically and clinically significant and were achieved without an increase in adverse events.

105. **Cervical Facet Degeneration after Total Disc Replacement**

Luiz Pimenta, Juliano Lhamby, Juliano Fratezi, R Evaldo Coutinho, Leonardo Oliveira

**Introduction:** Information and classifications about lumbar facet joint degeneration after lumbar total disc replacement are available. We intend to show our experience and propose a CT scan based classification to evaluate a degenerative facet joint disease after cervical arthroplasty in five-year follow-up.

**Methods:** After five-year follow-up for total disc replacement in a consecutive series of 158 patients with a total of 272 Porous Coated Motion total cervical disc replacement from C3-4 to C7-T1, we analyzed the facet degeneration in four grades in the operated levels using CT scan, and we compared with pre-operative images. CT scan, X-rays (AP, lateral and dynamic images) and clinical outcomes were collected pre-operatively, 1, 3, 6, 12, 24, 36 and 48 months post-operatively. The Neck Disability Index (NDI) and Visual Analog Scale (VAS) were used to assess pain and functional outcomes.

**Results:** From all operated levels, we found 8.09% (22 levels) of degenerated facets. Analyzing the CT scan images, we found four different stages of facet degeneration. Thus, we propose a CT scan classification for facet degeneration, using these four degeneration grades. Based on this classification, 54.55% (12 levels) of all degenerated levels had grade I, 31.82% (7 levels) with grade II, 9.09% (2 levels) with grade III and 4.54% (1 level) had grade IV of facet degeneration. All patients with grade III and IV had a worsening in NDI and VAS outcomes assessment.

**Conclusion:** The degenerative facet joint disease in the cervical spine after cervical arthroplasty exists. In our proposed classification, the majority of patients belong to grade I and II. We didn’t find a relationship between the CT scan facet degeneration and clinical results in these stages, except in grade III and IV that outcomes scales had a worsening.

106. **An Analysis of Hospital Cost Differences between Minimally Invasive and Open Posterior Interbody Fusion Surgery**

Rikin Trivedi, Sarah Woodrow, Michael Y. Wang

**Introduction:** Minimally invasive spine (MIS) procedures are being promulgated as similar to open procedures in outcome but associated with less pain and disability. However, there is little data assessing the cost-effectiveness of MIS surgery.

**Methods:** This study is a retrospective analysis of hospital charges for one- and two-level MIS and open posterior interbody fusion at an academic medical center. Overall hospital charges and surgical episode related charges, length of stay, and discharge status were obtained from the hospital finance department, and adjusted for multi/single level surgeries.

**Results:** 58 patients (25 males and 33 females, median age 57 yrs) treated over 14-months were identified with 69 treated levels. One-level procedures accounted for 89% of MIS vs. 67% of open surgeries. Mean length of stay was 4.3 and 6.7 days in the MIS and open cases, respectively. When controlled for the number of levels this result was not statistically significant (P = 0.19). With respect to hospital charges, single-level MIS surgeries were associated with an average of $72,214 compared to $78,931 for open surgery (P = 0.07). The differences were larger for two-level surgery, with mean charges totaling $113,224 for MIS surgery vs. $138,906 for open surgery, a difference that was not statistically significant (P = 0.25). The cost per night was higher ($18,085 vs. $14,561) in the MIS group (P = 0.045). For single-level surgeries discharge was to inpatient rehabilitation in 9% with MIS and 21% with open surgery. For two-level surgeries, the rates were 0% and 29%, respectively.

**Conclusion:** While hospital setting, patient selection and physician expectation play roles in determining hospital charges and length of stay, this pilot study shows trends for quicker discharge, reduced hospital charges and lower transfer rates to inpatient rehab with MIS surgery. Moreover, these trends are more strongly associated with multi-level surgeries.
107. Adjuvant Treatment with Locally Delivered OncoGel Delays the Onset of Paresis after Surgical Resection or Radiotherapy of Experimental Spinal Column Metastases

Introduction: The optimal management of spinal column metastatic disease is controversial. Local chemotherapy delivery systems allow targeted high-dose adjuvant therapy. We evaluated whether injection of OncoGelTM (Paclitaxel-releasing biodegradable polymer) into tumor resection cavity at time of surgery would improve efficacy of surgical resection with or without radiotherapy in a rat model of spinal column metastases.

Methods: Fisher-344 rats underwent trans-abdominal approach for implantation of CRL-1666 breast adenocarcinoma cell line within L6-vertebral body. Experiment 1: 7 days after tumor implantation, animals underwent (n = 8/group): 1) Control: no treatment, 2) Surgery alone: L6-corpectomy, or 3) Surgery + OncoGel: L6-corpectomy with OncoGelTM implantation into resection cavity. Experiment 2: 7 days after tumor implantation, animals underwent (n = 8/group) 1) Control: no treatment, 2) Surgery + XRT, L6-corpectomy followed by XRT (total 20 Gy), or 3) Surgery + XRT + OncoGel, L6-corpectomy with OncoGelTM implantation followed by XRT. Experiment 3: 7 days after tumor implantation, animals underwent (n = 8/group) 1) Control: no treatment, 2) XRT alone: XRT (total 20 Gy), or 3) XRT + OncoGel: intra-tumoral OncoGelTM injection followed by XRT (total 20 Gy). Daily hind-limb function was assessed using the Basso-Beattie-Bresnahan (BBB) scale (range: 0-21).

Results: Experiment 1: Both treatment groups delayed onset of paresis compared to Control (Figure 1A). Compared to Surgery alone, Surgery + OncoGel resulted in superior median BBB-scores post-treatment day nine (21 vs 19, p < 0.001) through fourteen (11 vs 8, p < 0.005). Experiment 2: Both treatment groups delayed onset of paresis compared to Control (Figure 1B). Compared to Surgery alone, Surgery + XRT + OncoGel resulted in superior median BBB-scores post-treatment day thirteen (21 vs 19, P < 0.001) through seventeen (12 vs 8, P < 0.005). Median time-to-paralysis was maximized by addition of OncoGelTM to surgery + XRT: Control (8.5 days), Surgery alone (13.5 days), Surgery + OncoGel (16 days), Surgery + XRT (17 days), Surgery + XRT + OncoGel group (19 days). Experiment 3: Compared to XRT alone, XRT + OncoGel resulted in superior median BBB-scores post-treatment day seven (21 vs 18, p < 0.001) through eleven (13 vs 8, p < 0.005). Median time-to-paralysis was improved in XRT + OncoGel group (13 days) vs. XRT alone (10 days, p < 0.001).

Conclusion: In a rat model of spinal metastatic disease, local delivery of OncoGelTM increased efficacy of surgery and radiotherapy in prevention of neurological decline. These results suggest that OncoGelTM may be effective adjuvant therapy in both operative and non-operative management of metastatic spinal column tumors.


Introduction: Definitions of complications in spine surgery are not clear. We assess a large group of practicing spine surgeons, and through their responses offer a simple definition of spine surgery operative complications. To validate this assessment, we revised our survey to make it appropriate for a lay audience and repeated the assessment with a cohort of spine surgery patients.

Methods: We surveyed a cohort of practicing spine surgeons via email. Surgeons were presented with various complication scenarios and asked to grade presence or absence of a complication, as well as complication severity with responses limited to “major complication” and “minor complication/adverse event.” We administered a similar assessment, modified for lay persons, to patients in a spine surgery clinic.

Results: Complete responses were received from 229 surgeons. We obtained completed surveys from 197 patients. Overall, there was consistent agreement between physicians and patients in presence or absence of a complication in the majority of scenarios (8 of 11 scenarios with at least 70% agreement that a complication was present, 73% of scenarios reviewed).

Conclusion: Comparison of responses of spine surgeons and spine surgery patients, we found significant agreement on presence of a complication in the majority of scenarios reviewed. Physicians were consistently more critical than surgeons when differences in reporting were found. Reconciling differing opinions of complication severity may require modification of patient expectations.
common among patients greater than 60 years old (p = 0.002).

**Conclusion:** The results from this analysis of the SRS MandM database provide surgeons with useful information for pre-operative counseling of patients contemplating surgical intervention for degenerative lumbar stenosis.

### 110. Complications in the Surgical Treatment of 2,258 Adults with Isthmic Spondylolisthesis: A Report from the Scoliosis Research Society Morbidity and Mortality Committee

Justin S. Smith, Charles A. Sansur, David K. Hamilton, Kaiming Fu, William Donaldson, Joseph Perra, Ram Mudiay, Theodore Choma, Reinhard Zeller, Dennis Knapp, Hilali Noordeen, Sigurd Berven, Michael Goytan, Oheneba Boachie-Adjei, Christopher I. Shaffrey

**Introduction:** The Scoliosis Research Society (SRS) prospectively collects morbidity and mortality (MandM) data from its members. The purpose of this study was to use this database to assess the incidences of complications for the surgical treatment of isthmic spondylolisthesis (IS) and to assess whether surgical approach impacted the rate of complications.

**Methods:** The SRS MandM database was queried to identify all cases of surgically treated IS reported from 2004-2007. Inclusion criteria included: age > 21 years, no prior surgery for IS and treatment with no prior surgery for IS and treatment with IS and treatment with some osteoporosis medications, including bisphosphonates, can interfere with bone healing. Although prescribed frequently in the treatment of osteoporosis, the effect of teriparatide and calcitonin on spinal fusion has not been fully elucidated.

**Methods:** Fifty-one New Zealand white (NZW) rabbits underwent a posterolateral LS-L6 intertransverse process arthrodesis using autogenous iliac crest bone graft. The rabbits were randomly divided into three groups. All animals received daily subcutaneous injections of: Group I (n = 17) 1cc of saline placebo, Group II (n = 17) 10mcg/kg/d of teriparatide, Group III (n = 17) 14IU/animal of calcitonin during the 8-week post-operative period. Post-mortem analyses included manual palpation, radiographic, biomechanical and histologic assessment (performed by two independent veterinary pathologists). Three random 10x fields were examined/graded within the cephalad, middle and caudal regions of each section (828 fields). Fusion quality was graded using the Emery histological scale (0-7 based on fibrous/bone content of the fusion mass).

**Results:** Histologic fusion rates for teriparatide averaged 86.7% and was significantly greater than the autograft control group (62.5%)(p = 0.033). Radiographically, there was a strong trend towards teriparatide being superior to the calcitonin group (85.7% versus 56.3%, respectively, p = 0.07). The average Emery grading score was 5.99 + 1.46SD for the autograft group and 6.26 + 0.93SD for the Forteo group (p = 0.031). Although not significant, the Forteo group showed less motion in both flexion/extension (I-8.8 + 1.5, II-75 + 1.3 and III-8.7 + 1.3) and axial rotation (I-1.3 + 1.1, II-1.7 + 0.8, III-2.1 + 0.7)(p = 0.118).

**Conclusion:** Our results suggest that Forteo enhances spinal fusion while calcitonin has a neutral effect. The teriparatide group had the best histologic fusion rate and Emery scores, while the calcitonin group was similar to the saline controls. Although not significant, the Forteo group had a strong trend towards superior radiographic fusion over the calcitonin group.

### 111. Is the Use of BMP in TLIF Cost Effective?

Sanjay S. Dhall, Daniel C. Lu, Gerald E. Rodts, Regis W. Haid Jr., Praveen V. Mummaneni

**Introduction:** The use of rH-BMP2 adds to the implant cost for TLIF. We retrospectively reviewed our data to assess if the use of rH-BMP2 offered advantages over the use of iliac crest bone graft (ICBG).

**Methods:** Fifty-four adult nonsmokers with spondylosis and DDD or grade I spondylolisthesis underwent one level TLIFs with either BMP (36) or ICBG (18). Fusion was assessed by dynamic radiographs and/or CT. Operative times, estimated blood loss (EBL), length of stay (LOS), complications, readmissions and clinical outcome were assessed.

**Results:** Mean EBL was 811 cc in the ICBG group as compared to 311 cc in the BMP group (p < 0.01). Mean operative time was 269 minutes in the ICBG group and 239 minutes in the BMP group (p = 0.20). LOS was on average 1 day longer in the ICBG group (6.1 days) than the BMP group (5.1 days) (p = 0.13). The total complication rate requiring further surgery was the same (11.2%) for both groups (p = 0.9). Mean modified Prolo score improved from 10 to 17 in the ICBG group, and 11 to 18 in the BMP group (p = 0.7). Mean follow-up was 28 months for the ICBG group and 22 months for the BMP group. Mean time to fusion in the BMP group was 3.6 months and 6.9 months in the ICBG group.

**Conclusion:** The use of BMP adds to the cost of hospitalization but does not appear to statistically decrease the length of stay or complication rates. BMP does increase the cost of hospitalization but does not appear to statistically decrease the length of stay or complication rates. BMP does increase the cost of hospitalization but does not appear to statistically decrease the length of stay or complication rates. BMP does increase the cost of hospitalization but does not appear to statistically decrease the length of stay or complication rates. BMP does increase the cost of hospitalization but does not appear to statistically decrease the length of stay or complication rates. BMP does increase the cost of hospitalization but does not appear to statistically decrease the length of stay or complication rates. BMP does increase the cost of hospitalization but does not appear to statistically decrease the length of stay or complication rates. BMP does increase the cost of hospitalization but does not appear to statistically decrease the length of stay or complication rates. BMP does increase the cost of hospitalization but does not appear to statistically decrease the length of stay or complication rates.
Research and Quality and represents a 20% random stratified sample of all discharges from nonfederal hospitals within the United States. Patients with c-spine fractures and spinal cord injury (SCI) were identified using the appropriate ICD-9 codes (806.00-806.09). Discharges, length of stay (LOS), hospital charges, discharge pattern, age and gender distribution were analyzed.

**Results:** A yearly average of 3,741 patients with c-spine fractures and SCI were identified. There was a decrease in the LOS from 1997 (20.2) to 2006 (17.6). Hospital charges, however, nearly doubled during this time-period from $84,722 in 1997 to $147,063 in 2006. There was a moderate increase in the percentage of patients admitted from the emergency department (68% in 1997 to 80% in 2006). The mortality rate was stable at 12% and the percentage of patients requiring rehabilitation or nursing home care after discharge was near 50%. 40% of the patients were in the 18-44 age group, and more than 70% of patients were male. **Conclusion:** Hospital charges associated with the management of c-spine fractures have increased dramatically over the last 10 years without an appreciable decrease in mortality or in the need for post-discharge rehabilitation and skilled nursing care assistance.

**114. 3-Year and 5-Year Follow-up from the Prospective, Randomized US FDA IDE Trial of the Prestige Cervical Disc Arthroplasty**

Praveen V. Mummaneni, Regis W. Haid Jr., Vincent C. Traynelis, Thomas A. Zdeblick, T. Kenneth Burkus

**Introduction:** We present 3-5 year results of the prospective, randomized US FDA IDE trial of ACDF versus arthroplasty with the PRESTIGE device.

**Methods:** 541 patients with single-level cervical disc disease with radiculopathy or myelopathy were prospectively randomized and enrolled at 32 sites to 1 of 2 treatment groups: 276 patients underwent ACD and arthroplasty with the PRESTIGE ST device and 265 patients underwent ACDF. Of the original 541 patients, 247 have now reached 3 years of follow-up and 111 have reached 5 years follow-up.

**Results:** The NDI and Neck Pain scores were significantly better in the arthroplasty group at 3 years (P < 0.01 and P = 0.044 respectively) but were similar at 5 years (P = 0.214 and P = 0.895 respectively). There was no statistical difference between groups for the SF36 PCS, SF 36 MCS or VAS Arm Pain Scores at 3 years or 5 years. At latest follow-up, the PRESTIGE arthroplasty devices did maintain a mean of 7.1 degrees of motion on flexion and extension X-rays (versus 0 degrees for ACDF patients). At latest follow-up, there were fewer second surgeries in the PRESTIGE group compared to the ACDF group.

**Conclusion:** The PRESTIGE ST Cervical Disc maintains physiologic segmental motion at up to 5 years after implantation and is associated with improved NDI and Neck Pain scores as well as reduced secondary surgical procedures compared with ACDF.
117. Myotome Project: Investigation of Human Myotomal Distribution Using Invivo Stimulation
Subu N. Magge, Clemens M. Schirmer, Christopher Martin, Jeffrey E. Arle, Peter K. Dempsey, Edward C. Tarlov, Rees Cosgrove, Jay L. Shils
Introduction: Considerable overlap exists in nerve root innervation of various muscles. Knowledge of the myotomal innervation is essential for the interpretation of neurological exam findings and neurosurgical decision making. This study investigates the myotomal innervation patterns of cervical and lumbar nerve roots via in vivo stimulation during surgeries for spinal decompression.
Methods: Patients undergoing cervical and lumbar surgeries where nerve roots are exposed in the normal course of surgery were included in the study. Electromyography (EMG) electrodes were placed in the muscle groups that are generally accepted to be innervated by the roots under study. This included levels above and below the spinal levels undergoing decompression. After decompression, a unipolar Prass neural stimulator probe was placed directly on the nerve root sleeve and constant current stimulation in increments of 0.1 mA was carried out. Current was raised until at least a 100 μV amplitude triggered EMG response was noted in one or more muscles. All muscles that responded were recorded.
Results: 1111 Nerve roots in 89 patients (mean age 56 ± 14 years) were stimulated, and 1096 stimulations met quality criteria. 282 stimulations were performed on cervical roots (C3-T1) and 814 on lumbar roots (L1-L2). The table shows the percentage contribution of individual root levels in large muscles commonly affected by spinal stenosis. In addition to finding similarities to standard reported myotomal distributions, we found additional levels in 15-20% of stimulations.
Conclusion: We present the largest dataset of direct intraoperative nerve root stimulations during decompressive surgery to demonstrate the relative contribution of root level motor input to various muscle groups. Compared to the classic neuroanatomy, a significant number of roots innervate a broader range of muscle than expected which may account for the variability of presentation between patients with identical number and location of compressed roots.

118. Post-Operative Infection of the Instrumented Spine: A Review of 1,332 Procedures Over 5 Years
Introduction: Deep seated infections following spinal surgery may substantially add to post-operative morbidity for patients. In cases in which spinal instrumentation is used, it is not currently clear whether instrumentation should be removed to help clear infection. In this study, we examined the outcomes of patients undergoing instrumented spinal fusion with post-operative infections and compared those patients who had spinal implants removed to those whose implants were kept in place.
Methods: A retrospective review of all patients undergoing instrumented spinal fusion between 2002 and 2006 at a single institution were reviewed, and the medical records were examined to identify patients that developed a post-operative subfascial infection. Characteristics of the patients, procedures, infections, and management were compiled. Association of variables with surgical site infection was assessed via a logistical regression analysis.
Results: A total of 1,332 patients at our institution underwent spine surgery and implantation of spinal hardware. Thirty-seven (2.8%) developed a post-operative subfascial infection. All patients underwent at least one debridement procedure, during which 9 patients (24%) had the infected implants removed. Posterior surgical approach was independently associated with an increased likelihood of post-operative infection, and lumbar location was associated with a decreased likelihood of infection. Mean duration of antibiotic use for all infected patients, regardless of whether the implanted hardware was removed or not, was 6 weeks, and there was no difference in clearance of infection between groups. Patients with hardware removed had a longer inpatient stay, however, 4 patients (11%) who had their instrumentation left in situ underwent revision surgery for pseudoarthrosis during follow-up.
Conclusion: Subfascial infections following instrumented spinal surgery can be effectively managed with debridement and intravenous antibiotics. In our experience, leaving spinal implants within the patient was not associated with poorer clearance of infection.

119. Fractionated Radiosurgery in the Treatment of Spinal Metastases
Rizwan Ahmed, Khalid A. Sethi, Christine Snyder
Introduction: To determine the clinical outcome of fractionated radiosurgery in the management of spinal metastatic tumors with regards to pain assessment and changes in tumor size.
Methods: During this study period, 153 cases were treated at a single center out of which 43 patients underwent fractionated radiosurgery. Lesion location comprised of 12 cervical, 16 thoracic, 5 lumbar, 4 sacral and 6 paraspinal regions. Patients’ pain scores and MRIs were obtained and analyzed before and after the procedure with a mean follow-up of 10.2 months.
Results: The median prescription dose of patients who did not have previous radiation therapy was 2500 cGy in 5 fractions, to the 77.8% isodose line, and the median tumor volume was 56.7 cm3. In cases with previous radiation the median dose was 2000 cGy and the median tumor volume was 107.2 cm3. Radio graphical analysis of tumor size was available for 38 patients at 9 months. Of which 39% of the tumors were stable in size, while 43% documented decrease in size. Three patients had progression of local and systemic disease, despite radiation and chemotherapy. 83% of patients showed decrease in pain symptoms in a median follow-up of 9.8 months.
Conclusion: Fractionated radiosurgery in the treatment of spinal metastases proves to be an effective treatment modality for pain palliation as well as decrease in tumor size.

120. Surgical Results of Lumbar Microdiscectomy in the Pediatric Population
Kevin S. Cahill, Mark R. Proctor
Introduction: Lumbar disc herniation is a surgically treatable cause of low back pain and disability in the pediatric population. The objective of this study was to determine the surgical results of lumbar microdiscectomy performed by a single surgeon at Children’s Hospital Boston over a ten-year period.
Methods: A series of 87 consecutive cases of lumbar microdiscectomy performed by the senior author from 1998 to 2008 were reviewed. Presenting symptoms, physical exam findings and pre-operative MRI findings were derived from the medical records. Immediate operative results including operative duration, blood loss, length of stay and complications were determined. Long-term need for repeat surgery was obtained from the medical records.
Results: This series represents the largest surgical series of pediatric discectomy in the
modern era. The mean patient age was 16 years (range 12-18) and 59% were female. Pre-operative physical exam was notable for motor deficits in 24%, sensory changes in 42%, loss of reflex in 22% and a positive straight leg raise in 95% of patients. Conservative management was the first line of treatment in all patients and the mean duration of symptoms to surgical treatment was 12.3 months. Surgery was performed at L3/4 in 6.9%, L4/5 in 45.9%, L5/S1 in 36.7% and at multiple levels in 10.3% of patients. The mean operative time was 110 minutes and the mean post-operative length of stay was 1.3 days. Complications were rare. Post-operative infection occurred in 1%, CSF leak in 3%, and new post-operative neurologic deficit in 1%. 6% of patients needed repeat lumbar surgery and one patient ultimately progressed to lumbar fusion.

Conclusion: The treatment of pediatric lumbar disc herniation with microdiscectomy is a safe procedure with low operative complications. Nuances of the presentation, treatment options and surgery in the pediatric population will be discussed.

121. CerviCore® Disc Replacement vs. Fusion for Single-Level Cervical Radiculopathy: One-Year Outcomes from Four Study Sites in a Prospective Randomized Controlled Trial


Introduction: Anterior cervical discectomy and fusion (ACDF) is a highly successful procedure for radiculopathy, but it reduces motion and may accelerate adjacent segment level degeneration. This study compares CerviCore® to the gold standard of ACDF, for single-level treatment of cervical radicular symptoms, C3-C7.

Methods: Functionality was assessed with NDI and neck pain was measured with VAS.

Results: Functionality was assessed with NDI and neck pain was measured with VAS.

Conclusion: The efficacy of the CerviCore® in the treatment of cervical radiculopathy is confirmed with similar short-term outcomes compared to the gold standard ACDF.

122. Impact of Body Habitus on Perioperative Complications during Fusion of the Lumbar Spine

Mohammed F. Shamji, Stephen Parker, Chad Cook, Ricardo Pietrobon, Christopher Brown, Robert E. Isaacs

Introduction: Lumbar spine fusion is performed for various indications in patients ranging from the young and healthy to aged and frail. Population trends are currently toward obese body habitus,[1,2] with associated health risks and surgical morbidity. No large-scale study has evaluated how body habitus impacts on mortality, complication rates, and resource utilization for lumbar spine fusion. Such information is important for patient selection and to confirm safety of such procedures in this population.

Methods: Data for 244,170 patients who underwent lumbar spine fusion for degenerative disease was collected from the Nationwide Inpatient Sample database (1988-2004), and subjects were grouped by surgical approach (anterior, lateral, posterior) and body habitus (normal, obese, morbidly obese).

Multivariate logistic regression evaluated group effects on selected post-operative complications, length of stay, resource utilization and discharge disposition.

Results: This study confirms that body habitus impacts on the perioperative morbidity sustained by patients undergoing lumbar spine fusion. Heterogeneity exists for race, geography and number of diseased levels between normal, obese and morbidly obese patients (p < 0.001), but multivariate analysis reveals that higher BMI associates with more transfusions and higher likelihood of requiring assisted living (alpha = 0.05). Furthermore, morbidly obese patients undergoing posterior surgery sustained more wound complications and post-operative infections (p < 0.001).

Conclusion: Early results suggest that the TFAS device successfully allows motion, provides stability and allows for clinically significant reduction of pre-operative symptoms and improvement in function that is durable in patients with follow-up beyond 36 months.

123. The Total Facet Arthroplasty System® (TFAS®) in the Treatment of Spinal Stenosis: Worldwide Experience with Longest Follow-up of 36 Months

Khalid Sethi, Antonio Castellvi, Scott Webb, Courtney Brown, Bart Sachs, Charles H. Wingo, Michael Halperin, Guillermo Bajares, Alejandro Perez-Oliva, Radu Prejbeanu, Ioan Branea

Introduction: The Total Facet Arthroplasty System® (TFAS®) is being evaluated as a motion-restoring, articulating joint prosthesis.

Methods: 158 patients (85 female, 73 male) were implanted with the TFAS device and followed in a prospective clinical trial. Follow-up occurred at 1, 3, 6, 12, 24 and 36 months. Data collected included radiographs, the Zurich Claudication Questionnaire (ZCQ), visual analog scales (VAS) for back and leg pain and radiographic status.

Results: The average age is 65.1 years. Five patients have at least 36-month follow-up, ten patients have 24-month follow-up, forty six patients have 12-month follow-up, fifty-five have six-months follow-up, nine have three-months follow-up and four have one-month follow-up. Post-operative radiographic analysis of the TFAS device demonstrates motion in all patients at the instrumented level. Clinically, 87% of these patients have significantly improved ZCQ symptom scores and 82% have significantly improved VAS function scores compared to pre-operative scores as of their most recent post-operative follow-up evaluation. Of those patients having at least 36 months of follow-up, 100% have shown clinically significant improvement ZCQ symptom and function and 80% have shown clinically significant improvement in leg and back pain VAS scores compared to their pre-operative scores, demonstrating durability of observed clinical outcomes.

Conclusion: Early results suggest that the TFAS device successfully allows motion, provides stability and allows for clinically significant improvement in function and quality of life in patients with follow-up beyond 36 months.

124. Short-term Morbidity and Mortality Associated with Correction of Thoracolumbar Fixed Sagittal Plane Deformity


Introduction: The reported morbidity and
mortality for the treatment of thoracolumbar fixed sagittal plane deformity (FSPD) is varied and based on studies with small sample sizes. To better assess the complication rate in this patient population, the morbidity and mortality (MandM) database of the Scoliosis Research Society (SRS) was retrospectively reviewed.

Osteotomy type and age were examined to assess influence on complication rate. **Methods:** The SRS MandM database was queried to identify cases of thoracolumbar FSPD from 2004-2007. Complications were analyzed based on kyphosis subtype, osteotomy type and age. Age was stratified into < 60, > 60. The subtypes of FSPD were post-surgical, degenerative, post-infection, dysplastic and uncategorized. Osteotomy type was categorized into: pedicle subtraction, Smith-Petersen, three column resection, anterior diskectomy with corpectomy, unspecified or no osteotomy. **Results:** 578 cases of FSPD were identified. There were 410 post surgical (70.9%), 120 degenerative (20.8%), 6 post-infection (1.0%), 2 dysplastic (0.3%) and 40 uncategorized (6.9%) cases. Osteotomies were performed in 402 cases (69.6%). There were 215 pedicle subtraction osteotomies (37.2%), 135 Smith-Petersen osteotomies (23.3%), 19 anterior diskectomy with corpectomy procedures (3.3%), 18 three column resections (3.1%) and 15 unspecified osteotomies (2.6%). There were a total of 137 complications (23.7%). There were 3 deaths (0.5%). The most common complications were dural tears: 34 (5.3%), wound infection: 23 (3.9%), implant failure: 10 (1.7%), wound hematomas: 9 (1.6%), epidural hematomas: 8 (1.4%), pulmonary embolus: 7 (1.2%) and deep venous thrombosis: 4 (0.7%). Age > 60 was not associated with significantly higher complication rate (P = 0.30). Complication rate was significantly higher in cases where an osteotomy was performed (P = 0.006). The complication rates in pedicle subtraction osteotomies (31.2%) and vertebral column resections (44.4%) were significantly higher when compared to Smith Petersen osteotomies (20.0%) (P = 0.022,0.020). **Conclusion:** The complication rate for treatment of FSPD is 23.7%. Complication rate is significantly higher in patients undergoing pedicle subtraction osteotomies and vertebral column resections. Age over 60 does not influence the rate of complications. 

**125. Diffusion Tensor Imaging in Spinal Trauma: Functional Correlates and Spatiotemporal Changes during Recovery**

Shekar N. Kurpad, Brian Schmit, Benjamin Ellingson, John L. Ulmer

**Introduction:** In the spinal cord, DTI has been used to evaluate pathologies including multiple sclerosis and acute trauma; however, a detailed study documenting the spatial distribution of diffusion measurements along with functional correlates during recovery from spinal trauma has not been performed. **Methods:** The objective of the current study was to evaluate the diffusion properties of various sensory-related white matter tracts across the length of the spinal cord using high-resolution DTI of excised rat spinal cords at 9.4-T following trauma and correlating these with characteristics of sciatic nerve stimulated spinal evoked potentials (SpSEPs) in vivo. **Results:** In select ascending sensory tracts, results indicated a decrease in diffusion anisotropy at the location of traumatic lesion, a significant decrease in longitudinal diffusion for 4-8 mm rostral to the lesion site, re-elevation of longitudinal diffusion for 6-10 mm immediately rostral to the depressed longitudinal diffusion region, followed by a decrease in longitudinal diffusion in the high cervical regions. Transverse diffusion was elevated at the lesion site, and unchanged distal to the lesion for up to 15 weeks post-injury. Functional electrophysiology revealed a high correlation between medial spinothalamic tract (MSTT) diffusion measurements and the very early components (< 10 ms post-stimulus) of the SpSEP. Diffusion measurements in the dorsal columns showed a high correlation with very early components of the SpSEP up to 2 weeks post-injury, then a high correlation with early components (> 10 ms and < 100 ms post-stimulus) after 2 weeks. Lateral spinothalamic tract (LSTT) diffusion measurements correlated significantly with the late components (> 100 ms post-stimulus) of the SpSEP. The late components of the SpSEP were highly correlated with overall sensory tract diffusion measurements during recovery. **Conclusion:** DTI of the spinal cord illustrates distinct spatial patterns of diffusion across the length of the spinal cord that change during recovery, indicating DTI may be able to track the progression and spatial extent of spinal cord injury. Additionally, diffusion measurements may be able to predict electrophysiological function, illustrating the possibility of using spinal cord DTI as a prognostic tool.
regeneration. Paralyzed nerve transfer combined with FES is a viable method for re-innervation in the setting of SCI.

127. Occipital Condyle Fractures: Clinical Decision Rule and Surgical Management

Introduction: Several classification systems have been published for occipital condyle fractures. Based on the experience with occipital condyle fractures at our institution, we propose that classification is cumbersome and contributes little to the clinical decision-making process, while the identification of cranio-cervical misalignment and neural element compromise is paramount and sufficient for the planning of treatment.

Methods: We performed a retrospective review of 24,745 consecutive trauma presentations to a single level-one trauma center over a 6-year period, identifying 106 patients with 106 occipital condyle fractures. All patients were evaluated by the spine trauma service and underwent imaging of the cranio-cervical junction with reconstructed CT. Patient characteristics, fracture characteristics including fracture classification according to the two major classification systems initial management, and status at follow-up were recorded.

Results: The incidence of OCF in our trauma population was 0.4%. Two patients had evidence of cranio-cervical misalignment on reconstructed CT imaging at the time of admission, both of whom underwent occipital-cervical fusion. One patient underwent occipital-cervical fusion for an unrelated C1-2 fracture. The remainder of those surviving to discharge, whose fractures represented all fracture sub-types, received treatment with a rigid cervical collar or counseling alone. None, including 4 patients with bilateral OCCF, were found on follow-up to have developed delayed cranio-cervical instability or misalignment, or to require further neurosurgical intervention for an occipital condyle fracture. No cases of delayed cranial neuropathy were identified.

Conclusion: Beyond the identification of cranio-cervical misalignment on admission CT with reconstructions, further classification of occipital condyle fractures is unnecessary. Management should consist of upfront occipito-cervical fusion or halo fixation in cases demonstrating occipito-cervical misalignment or of immobilization in a rigid cervical collar, followed by delayed clinical and/or radiographic evaluation in a spine trauma clinic, if misalignment is not present.

128. Key Predictors of Outcome in Patients Undergoing Surgical Treatment for Cervical Spondylotic Myelopathy: Analysis of a Prospective Multicenter Study in 285 Patients with One-Year Follow-up
Michael G. Fehlings, Branko Kopjar, Tim Yoon, Paul M. Arnold, Alexander R. Vaccaro, Eric J. Woodard, Darrel S. Brodke, Jens Chapman, Christopher I. Shafray, Michael Janssen, Rick C. Sasso

Introduction: The key predictors of outcome in patients with cervical spondylotic myelopathy (CSM) remain unclear. We hypothesized that the duration of myelopathic symptoms and baseline status would impact on the extent of functional improvement following surgical treatment of CSM.

Methods: We used data from a large multicenter prospective clinical study of 285 prospectively enrolled patients at 13 sites across North America. We applied stepwise multiple regression to model associations between the changes in key outcome variables (mJOA, NDI, Nurick score and SF36) and self-reported duration of myelopathic symptoms while adjusting for important baseline characteristics.

Results: Complete one-year follow-up data were obtained in 252 (88.4%) subjects and demonstrated a strongly positive overall impact of either anterior or posterior surgery on mJOA, Nurick, NDI and SF36 scores (p < 0.001). The median reported duration of the myelopathic symptoms was 12 months (range 1 to 432 months). After adjusting for covariates we found a significant negative association between the duration of myelopathic symptoms and the degree of recovery in mJOA, Nurick scores and the SF36 Physical Component Score (Fig 1). Patients with symptoms less than 6 months in duration experienced significantly greater improvement in the mJOA, Nurick score and SF36 PCS scores than patients with symptoms exceeding two years. The key predictors of improvement in mJOA scores were age, baseline mJOA, baseline SF36PCS and MCS scores (Fig 2).

Conclusion: The data from this large prospective clinical study suggest that the chronicity of myelopathic symptoms negatively affects outcomes following surgical treatment. Moreover, neurological outcomes can be predicted by age and baseline SF36PCS and SF36MCS scores.
the nationwide usage of BMP has increased since the clinical introduction in 2002. Compared to the estimated 2002 utilization in 0.67% of all spinal fusions, BMP was utilized in an estimated 23.6% and 36.4% of primary and revision fusions, respectively, in 2006. Lumbar and cervical fusions for degenerative disease and disc herniation represented the majority of cases. Increased rates of complications following use in lumbar or posterior cervical fusion were not seen. Increased rates of wound related complications such as seroma, hematoma, dysphagia and hoarseness were seen following use in anterior cervical fusions. The unadjusted odds ratio for any complication following BMP use in anterior cervical fusion was 1.54 (95% CI 1.22-1.96). Following multivariate adjustment for patient and operative characteristics, the odds ratio for any complication decreased to 1.40 (95% CI 1.11-1.77).

Conclusion: BMP has been rapidly incorporated into the clinical practice of spinal fusion nationally. BMP use was not associated with increased rates of inpatient complications following use in lumbar or posterior cervical fusions. Increased rates of local complications were seen following anterior cervical use.

204. Accuracy of Spine Radiosurgery Delivery Using Cone Beam CT Image Guidance in Patients with Spinal Instrumentation
Edward A. Monaco, Peter C. Gerszten, Mubina Quader, Josef Novotny, Jong Oh Kim, John Flickinger, Saiful Huq
Introduction: Cone beam CT (CBCT) image guidance technology has been adopted for spine radiosurgery delivery. Concern has been raised of the ability to accurately perform spine radiosurgery in...
Methods: The positioning deviations of 20 spine radiosurgery treatments in patients with spine instrumentation were evaluated using the Elekta Synergy S with a beam modulator and CBCT image guidance combined with a robotic couch that allows positioning correction in 3 translational and 3 rotational directions. To measure patient movement, three quality assurance CBCTs were performed and recorded: before, halfway and after radiosurgery treatment. The positioning data and fused images of planning CT and CBCT from the treatments were analyzed to determine intra-fraction patient movements. From each of three CBCTs, three translational and three rotational coordinates were obtained.

Results: Prescribed dose for the cohort was 12-18 Gy (mean 14 Gy), 9-14 beams utilized (mean 10 beams). At the halfway point, the translational variations and standard deviation were 0.6 ± 0.7, 0.4 ± 0.4 and 0.5 ± 0.5 mm in the lateral (X), longitudinal (Y) and AP (Z) directions, respectively. The magnitude of the 3D vector (X,Y,Z) was 1.1 ± 0.7 mm. Similarly, the variations after treatment were 0.4 ± 0.4, 0.4 ± 0.4 and 0.5 ± 0.6 mm along X, Y and Z directions, respectively; the 3D vector (X,Y,Z) was 1.0 ± 0.6 mm. The average and standard deviation of rotational angles were 0.5 ± 0.4, 0.6 ± 0.7 and 0.4 ± 0.5 degrees along yaw, roll and pitch at the halfway point and 0.4 ± 0.6, 0.6 ± 0.7, 0.3 ± 0.4 degrees after treatment. No evidence of radiation induced spinal cord toxicity has been observed.

Conclusion: Cone beam CT image guidance for single fraction spine radiosurgery is accurate and safe in patients with spine instrumentation in place.

205. Long–term (4–Year) Follow–up of rhBMP–2 for Instrumented Posterolateral Fusion
David Alexander, Stewart Bailey, Edward Abraham, Robert McBroom, James Mahood, Alain Jodoin, Charles Fisher, R. John Hurlbert

Introduction: We report long-term results from a prospective randomized controlled study evaluating clinical and radiographic outcomes in patients undergoing instrumented posterior lumbar fusions receiving either autograft or rhBMP-2 as their fusion substrate. The primary null hypothesis was that fusion rates would be no different between the two groups.

Methods: From 1999 to 2003, 97 patients undergoing either 1 or 2 level postero-lateral instrumented lumbar fusions were randomized across 8 institutions to either control (autograft) or treatment (rhBMP-2) groups. Patients were followed pre- and post-operatively with a variety of outcome measures including Oswestry disability index, SF-36, plain x-rays and thin slice CT scans. Fusion was assessed by two independent blinded radiologists. Statistical analyses were performed using parametric and non-parametric techniques where indicated for all primary and secondary comparisons.

Results: There were no differences in patient demographics amongst the two groups. Operative time, blood loss and hospital stay were similar. 93% of rhBMP-2 patients and 98% of control patients were available for 4-year follow-up. Both groups improved significantly compared to their pre-operative clinical status as measured by Oswestry and SF-36 instruments. This improvement persisted to 4 years, there was no statistical difference between the groups. At 4 years, 69% of autograft patients demonstrated unequivocal solid bony union compared to 94% of rhBMP-2 patients (p = 0.007).

Conclusion: Although clinical outcomes are similar, in patients undergoing 1-2 level posterolateral instrumented lumbar fusions rhBMP-2 provides statistically higher fusion rates. rhBMP-2 should be considered instead of autograft in surgeries involving lumbar instrumentation where the primary long-term goal is fusion.

206. Repeat Decompression Surgery for Recurrent Spinal Metastases
Ilya Laufer andrew Hanover, Eric Lis, Yoshiya Yamada, Mark H. Bilsky

Introduction: Re-operations for recurrent epidural spinal cord compression have been reported in the literature, but no consensus exists regarding the indications or efficacy of such surgery. We investigated our experience with re-operations for metastatic spine tumors in order to assess outcomes with regard to neurologic, functional and survival status, as well as complications.

Methods: A retrospective chart review was conducted of all patients who underwent spine surgery at the Memorial Sloan-Kettering Cancer Center between 1996 and 2007. Thirty-nine patients who underwent re-operation of the spine at the level previously treated with surgery were identified. Only patients whose re-operation was performed because of tumor recurrence leading to high-grade epidural spinal cord compression or recurrence with no further radiation options were included in the study. Patients who underwent re-operations exclusively for instrumentation failure were excluded. All patients underwent re-decompression via a posterolateral approach without removal of the spinal instrumentation.

Results: Patients underwent 1-4 re-operations at the same level. Median survival time of 12.4 months was noted after the first re-operation and median survival time of 9.1 months was noted after the last re-operation. At last follow-up 22 patients (65%) were ambulatory and the median time between loss-of-ambulation and death was 1 month. Functional status was maintained or improved by one ECOG grade in 97% of patients. A major surgical complication rate of 5% was noted.

Conclusion: Re-operation represents a viable option in patients with high-grade epidural spinal cord compression who have recurrent metastatic tumors at previously operated spinal levels. In carefully selected patients, re-operation can prolong ambulation and result in good functional and neurologic outcomes.

207. CT Scan Analysis of Pedicle Screw Placement: Measurement of Breach Is not Reliable
Amer F. Samdani, Randal Betz, John P. Gaughan, Stewart Bailey, Courtney Brown, Jahangir Asghar, Patrick Cahill, Linda P. D’Andrea, Maurice Bouriljon

Introduction: CT scan is widely used to assess the accuracy of pedicle screw placement. Recent experience with the measurement of pedicle screw breach by CT scan as an outcome measure in a multicenter clinical trial of PediGuard, a pedicle drilling instrument (SpineVision, Inc.) vs. manual pedicle drilling has led us to question the previously reported reliability. We sought to evaluate the inter-rater agreement of individual measurements of pedicle screw breach and its potential clinical significance.

Methods: To determine accuracy and agreement, we measured the breach of pedicle screws using 6 experienced spine surgeons to read post-op CT scans of 11 patients with degenerative disease who had titanium or stainless steel screws placed at T12 and below. Raters scored each screw as: in, out < 2 mm or out >= 2 mm. Multiple evaluations of 113 screws (44 titanium and 69 stainless steel) were used to calculate the chance-adjusted kappa statistic as an indicator of inter-rater agreement.

Results: Of 597 screw evaluations, 69 (11.6%) were found to have breach > - 2 mm, 165 (27.6%) were found to have breach < 2 mm and 363 (60.8%) were found to have no breach. The calculated kappa statistics were 0.115 (95%CI .054, .176) for titanium screws and 0.184 (95%CI .125, .243) for stainless steel screws, indicating poor agreement among raters.

Conclusion: Our results indicate that the evaluation of pedicle screw breach on CT by a single surgeon is highly variable and care should be taken in using individual CT evaluations of mm of breech as a basis for...
Degenerative Histological analysis revealed that
To appreciate the changes in
Containment plates are often
In spinal fusion techniques,
Only one patient (5%) in group O

<23x20>46 AANS/CNS Section on Disorders of the Spine and Peripheral Nerves

ORAL POSTER ABSTRACTS

Degenerative Spondylolisthesis with spinal stenosis is a common spinal disorder. The ultimate treatment may involve decompression followed by fusion and instrumentation. Minimally invasive techniques may help in limiting operative morbidity.

Methods: A comparison was made between 22 patients (Group O) who underwent open decompression, fusion and instrumentation and 17 patients (Group M) treated thru minimally invasive techniques. Pre-operative, operative and post-operative characteristics were reviewed.

Results: Only one patient (5%) in group O underwent unilateral instrumentation vs. 13 in group M (59%). Twelve patients (71%) in Group M required post-operative admission compared to 22 of Group O patients (100%). Between the 2 groups, there was a significant difference in inpatient hospital stay (O: 4.04 ± 1.43 days, M: 1.79 ± 1.57 days, p < 0.05), intraoperative estimated blood loss (O: 495 ± 273 ml, M: 121 ± 122 ml, p < 0.05) and intraoperative intravenous fluid use (O: 3515 ± 768 ml, M: 2582 ± 811 ml, p < 0.05). In Group O, 21 patients (95%) required post-operative in-patient physical therapy consultation, while only 7 (41%) in Group M did. There was no significant difference in operative time, intraoperative CSF leak, or pre- and post-operative outcome measures (VAS, ODI, patient satisfaction index).

Conclusion: Compared to open surgery, minimally invasive techniques for treating degenerative spondylolisthesis yield similar clinical results, while limiting intraoperative blood loss and intravenous fluid administration, use of physical therapy services and in-patient hospital stay. These may be especially important factors in the elderly, the population of patients months commonly affected by this disorder.

The Contribution of the Rib Cage to the Stability of the Thoracic Spine
Leonardo B. C. Brasiliense, Bruno C. R. Lazaro, Phillip M. Reyes, Nicholas Theodore, Neil R. Crawford

Introduction: To appreciate the changes in motion produced in the thoracic spine by different techniques and instrumentations, a thorough recognition of the role played by the rib cage in the physiological motion of this spine segment is mandatory. The authors present the results of an in vitro experiment to quantify the stability provided by the sternum and the rib cage in the thoracic spine.

Methods: Seven human cadaveric thoracic segments (T2-T5) with intact rib cages were studied. Before testing, the end levels were fixated in metal fixtures that allowed uniform loading of the vertebral body and ribs. Specimens were tested in the following sequence: 1) normal, 2) after a sternotomy, 3) after the sternum was removed, 4) after 50% of the ribs were removed, 5) after 75% of the ribs were removed and, 6) after disarticulating the ribs. Nonconstraining, nondestructive pure moments (7.5 Nm) were applied to induce flexion, extension, lateral bending and axial rotation while measuring three-dimensional motion optoelectronically.

Results: During flexion, except for the sternotomy, each step progressively increased the range of motion (ROM) compared to normal by 69%, 139%, 141%, 169% respectively (Figure 1. p < 0.03 RM-ANOVA/Holm-Sidak). During extension, ROM increased by 37%, 297%, 730%, 715% and 732%, respectively. The increase after the sternotomy did not reach significance (p = 0.67). However, every other step reached significance (p < 0.002). During lateral bending, the increase in ROM was 8%, 15%, 32%, 80% and 154%, respectively. Statistical significance was reached once 75% of the ribs were removed (p < 0.04). During axial rotation, ROM increased by 105%, 198%, 468%, 651% and 759%, respectively. Once the sternum was removed, significance was reached (p < 0.02).

Conclusion: In the region of true ribs, without the contribution of the sternum and rib cage, thoracic ROM increases by an average of 453%. This stabilizing potential is greater than previously predicted.

Failure Analysis of Absorbable Cervical Plates
Vikas V. Patel, Celeste Abjornson, Simon Turner, Howard B. Seim, Amy Lyons, Christian M. Puttlitz

Introduction: Containment plates are often placed anteriorly in ACFD procedures to provide stability and prevent interbody device/autograft migration. The main advantage of bioresorbable plates over typical metallic plates is that they will theoretically resorb by hydrolysis after fusion, thus mitigating stress shielding osteopenic effects associated with rigid instrumentation. Furthermore, their radiolucency eliminates imaging artifact. The purpose of this study was to determine the histological response elicited by a bioresorbable containment plate in a sheep model.

Methods: Six sheep underwent C2-C3 and C4-C5 discectomies. A polymeric plate (70/30 PDLLA) and four screws were placed over an intervertebral disc spacer at both levels. Fusions were performed using a PEEK cage with autograft bone. After 3 months, the animals were euthanized and functional spinal units were harvested for histological processing. X-rays and MRIs were also acquired post-sacrifice.

Results: Histological analysis revealed that tissue surrounding the plate and disc spacer consisted of vascularized fibrous tissue with islands of active woven bone. Inflammatory cells were rarely observed. Bone was relatively active in close proximity to the implants, with osseous activity decreasing with distance from the implants. At necropsy it was observed that 6 of 12 specimens had either a broken screw or cracked plate. These gross observations were confirmed within the histological sections. Fusion was successful at C2-C3 in three of the six sheep, none of the fusions were successful at C4-C5.

Conclusion: In this study we have shown that although the bioresorbable plates/screws did not illicit an iatrogenic tissue response, a high percentage of them failed mechanically. This phenomenon was difficult to observe radiographically, as the radiopaque markers were not able to convey these instrumentation failures. These findings suggest that resorbable implant materials with an acutely stiffer mechanical behavior are required for anterior cervical plating applications.

Facet Fate and Adjacent Level Disease in Lumbar Arthroplasty: Comparison between Anterior and Lateral TDR–12–Month Follow–up
Luiz Pimenta, Juliano Lhamby, Juliano Fratezi, Etevaldo Coutinho, Thomas Schaffa, Leonardo Oliveira

Introduction: In spinal fusion techniques, adjacent level disease is a recognized complication. The artificial disc prosthesis has been developed to avoid this problem based on motion preservation. However, spinal arthroplasty appears to have an increased rate of facet joint degeneration.

Methods: The X-rays and Axial MRI from 20 patients (10 Charité and 10 LTDR) were analyzed pre-op, post-op early and 12 months after surgery. The anterior and
posterior disc heights from operated and adjacent levels were measured and compared with pre-operative data (100% of height). Fujiwara’s criteria was used for grading the facet degeneration. Statistical differences within and between the two groups were compared using a paired t-test with a significance level of p<0.05.

Results: 12 months, the Charité showed an increase in disc height compared to pre-op of 271% (anterior height) and 194% (posterior height). LTDR operated levels increased by 144% (anterior height) and 140% (posterior height). The disc heights at levels adjacent to Charité diminished to 85% (anterior height) and 85% (posterior height). The change in levels adjacent to LTDR was 94% (anterior height) and 92% (posterior height). Charité group presented 30% of facet degeneration, while LTDR showed 10% 12 months after surgery.

Conclusion: The laterally placed LTDR resulted in less adjacent level loss of disc height than Charité artificial discs at 12-month follow-up. Retention of the ALL in laterally placed discs is thought to retain normal biomechanics at the operated and adjacent levels. Additionally, overdistraction of the disc space from an anterior approach may also contribute to adjacent level breakdown and facet fate. Lateral placement of a TDR device, with retention of the ALL, allows a relatively normal increase in disc height which may add less undue stress at adjacent levels and facet joints. However, longer-term follow-up is needed to demonstrate clinical relevance.

213. Assessment of Potential Predictors of Need for Mechanical Ventilation and the Occurrence of Extubation Failure in Patients with Traumatic Spinal Cord Injury
Julio C. Furlan, Deepa Kattail, Niall D. Ferguson, Michael G. Fehlings

Introduction: Respiratory dysfunction is a key complication after spinal cord injury (SCI). In this study, we sought to determine factors associated with the need for mechanical ventilation and the occurrence of subsequent extubation failure in patients with acute traumatic SCI at C4 to T12 level.

Methods: From 502 consecutive patients with acute spine trauma admitted from December 1995 to September 2007, we selected all cases at risk for mechanical ventilation and the occurrence of mechanical ventilation and for extubation failure. Extubation failure occurred in 7/53 patients including: 5 patients who experienced ventilator failure after the procedure, patients were re-warmed to 37°C at 1°C per 8 hours until normothermic. Patients with and without complications were separated and compared for: age, blood loss, anesthetic duration and pre-op Charlson Comorbidity Index (CCI) score and pre and post-op ASIA scores.

Results: Post-operative complications occurred in 7/53 patients including: myocardial infarction (2), arrhythmia (2), infection (4), pseudomemegoloe with operative repair (2) or DVT (1). Evaluation of cohort group normality by three separate tests yielded mixed results. Comparison of mean pre-op CCI scores between the cohort groups was found to be significant when assuming Gaussian distribution (p = 0.0096): without complications (n = 46, mean CCI score 2.848 ± 2.129 SD), with complications (n = 7, mean CCI score 5.571 ± 4.353 SD). Logistic regression of CCI and complications in the 53 patient sample yielded: p = 0.0242, O.R = 1.4172, range = 1.0464-1.9194. No other factors were found to be significant between the two groups.

Conclusion: Only pre-operative CCI score was found to be significant for predicting post-operative complications. Moderate hypothermia for elective surgery is safe and not associated with high rate of intra or post-operative complications.
215. Effect of Hyperglycemia on Progressive Paraparesis in a Rat Metastatic Spinal Tumor Model

Introduction: Hyperglycemia has been shown to potentiate spinal cord ischemic injury by quenching vasodilators and potentiating tissue acidosis and free-radical production. Steroid-induced hyperglycemia is common in management of metastatic epidural spinal cord compression (MESCC). We determined if experimentally-induced hyperglycemia accelerates neurological decline in MESCC-animal model.

Methods: Sixteen Fisher-344 rats underwent trans-abdominal approach for CRL-1666 breast adenocarcinoma cell line implantation within L6-vertebral body. After 72 hours recovery from implantation, animals received intraperitoneal (IP) injections every 12 hours of either 2g/kg Dextrose in 5cc 0.09% saline (hyperglycemia;n = 8) or 5cc 0.09% saline alone (normoglycemia;n = 8). Weight and hind-limb function was tested daily using Basso-Beattie-Bresnahan (BBB) scale (range:1-21). Animals were sacrificed at paralysis (BBB <7) and epidural tumor growth volume within the spinal canal measured. In order to determine degree of hyperglycemia induced, a surrogate group of 10 Fisher-344 rats underwent 2g/kg Dextrose (n = 5) or 0.09% saline (n = 5) IP injections every 12 hours and serum-glucose levels assessed 1, 3, 6, 9 and 12 hours after injections for 24 hours.

Results: Dextrose vs. Saline injections resulted in elevated mean serum-glucose 3 (259 vs.103ug/dl), 6 (219 vs.102ug/dl), 8 (169 vs.102ug/dl) and 10 hours (118 vs.99ug/dl) prior to subsequent injection. All rats had normal hind-limb function for 8 days after tumor implantation. Hyperglycemic vs. Normoglycemic rats demonstrated worsened median BBB-score by post-implantation day 9 (20 vs. 21, p = 0.023) through day 16 (8 vs.12, p = 0.047). Epidural tumor volume demonstrated near-linear growth rate across both groups, however, hyperglycemic rats developed paralysis earlier (median:15.5 vs.17.5 days, p = 0.0035), with less epidural tumor volume (2.750.38cc vs. 4.070.41cc, p <0.001) at time of paralysis.

Conclusion: In a rat model of MESCC, rats maintained in hyperglycemia experienced accelerated time-to-paralysis. Less epidural tumor volume was required to cause paralysis in hyperglycemic rats. These results suggest that hyperglycemia may contribute to decreased spinal cord tolerance to MESCC compression. Clinical studies evaluating effect of aggressive glucose control in patients with MESCC may be warranted.

216. The Development of a Constant Value to Predict Optimal Regional Spinal Curvature to Achieve Sagittal Balance
Chris J. Neal, Jamal McClendon, Frank L. Acosta, Tyler R. Koski, Stephen L. Ondra

Introduction: Optimal physiological function and mechanical efficiency requires the head to line up over the pelvis. We hypothesize that there is a constant age-dependent relationship between the spine and the pelvis. This “Spinal-Pelvic Constant” relates the cervical, thoracic and lumbar curvatures to the pelvis incidence. This can be used pre-operatively to understand how regional curves and their correction affect the sagittal alignment of the spine.

Methods: A retrospective review was performed of a database containing lateral long-cassette spinal radiographs in asymptomatic individuals. Films needed to include a single image that allowed visualization of the occipitocervical junction and the femoral heads. The first 10 studies that met this criteria were included. The sum of the regional spinal curves (cervical, thoracic and lumbar) measured from the occipitocervical junction to the lumbosacral junction was divided by the pelvic incidence. This value was termed the spinal-pelvic constant. The data was then compared to the literature.

Results: The average age in this study was 31.3 years (range 23-44). The average sum of the regional curves of the spine was -51.4 degrees (range -42 to -60). The average pelvic incidence was 58.8 degrees (range of 48-79). The spinal-pelvic constant was 1.136 range 0.73-1.3). The average sagittal balance was + 5 mm (range -43 to + 47). In the same age grouping, extrapolated data from recent literature showed a very similar spinal-pelvic constant of -1.125. Using this data, a mathematical relationship can be constructed where pelvic incidence equals the sum of the regional curves multiplied by the spinal-pelvic constant.

Conclusion: This pilot studies shows promise for developing a spinal-pelvic constant from normative values to help guide regional curvature correction in order to obtain sagittal balance. Further studies are warranted in order to validate this hypothesis.

217. Craniovertebral Fixation with Occipital Condyle Screws: Biomechanical Analysis of a Novel Technique
Juan S. Uribe, Edwin Ramos-Zapata, Nicholas B. Levine, A. Samy K. Youssef, Wesley Johnson, Fernando L. Vale

Introduction: The authors quantitatively compared the biomechanical stability of a new technique for occipitocervical fixation with an established method and the intact condition.

Methods: Six fresh frozen cadaveric human skulls with C1-C4 were tested intact and after destabilization and fixation as follows: 1) Occipital plate with C1 lateral mass screws and C2 pedicle screws and 2) Occipital condyle screws with C1 lateral mass screws and C2 pedicle screws. Specimens were loaded in a custom spine testing apparatus and subjected to the following tests all performed under 50 N unconstrained axial preload: flexion, extension, lateral bending and axial rotation at 1.5 Nm.(figure 1). The constructs were statistically compared with a one-way ANOVA as well as compared with the intact condition.

Results: There were no statistically significant biomechanical differences between the two tested constructs. The mean values indicated decreased range of motion and increased stiffness with the novel occipital condyle screw construct in comparison to the standard occipital plate and rod system.

Conclusion: Craniovertebral stabilization using occipital condyle screws as the sole cephalad fixation point is biomechanically equivalent to the standard occipital plate construct. This new technique can be considered an addition to the current craniovertebral fixation techniques.
Fifty-seven patients were randomized to receive lordotic allografts and 65 patients received parallel. Clinical outcomes were prospectively assessed using SF-36, Neck Disability Index (NDI) and VAS. Sagittal alignment was measured using the posterior tangent method.

**Results:** The mean post-operative cervical sagittal alignment was 18.6 degrees (range: 7.0 to 36.2) and 18.2 degrees (range: 7.0 to 37.3) in the lordotic and parallel graft patient groups, respectively. The mean segmental sagittal alignment was 5.9 (range: -4.2 to 19.25) and 6.5 (range: 3.0 to 19.4) degrees in the lordotic and parallel graft patient groups, respectively. There were no statistically significant differences in SF-36 PCS scores (44.9 vs. 45.3), NDI scores (11.1 vs. 11.5), VAS scores (2.8 vs. 2.8) in the lordotic and parallel graft patient groups. Cervical segmental alignment that did not change or increase towards lordosis was associated with a statistically significant (P < 0.037) improvement in NDI and SF-36 PCS scores.

**Conclusion:** The use of lordotically-shaped allografts does not increase cervical/segmental sagittal alignment or improve clinical outcomes. Maintaining a consistent segmental sagittal alignment or increasing segmental lordosis was related to improved clinical outcomes.


**Introduction:** The most common signs and symptoms of cervical myelopathy are typically found in the upper extremities and include hand numbness, hand clumsiness and distal upper extremity weakness: gait dysfunction and proximal lower extremity weakness are common lower extremity complaints. Cervical myelopathy presenting without signs or symptoms in the upper extremities is rare and the incidence and character of such presentations is not well known.

**Methods:** In a retrospective chart review of consecutive patients surgically treated for CSM, disc herniation or OPLL, patients without signs or symptoms in the upper extremities were identified and their presenting characteristics analyzed.

**Results:** Of 328 patients treated, 5 (1.5%) presented without signs or symptoms in the upper extremities. The patients were all male and the mean age was 53 (40-68). All patients complained of a sense of heaviness in the legs and gait dysfunction while 4 of 5 (80%) had objective lower extremity weakness. Three (60%) had discernable mid-thoracic pin level while the other two had loss of sensation only in the legs and genitalia. Four of five (80%) had hyperreflexia and three (60%) had a Babinski sign. Imaging demonstrated cord compression from either spondylosis or soft disc at C6/7 in two patients, C5/6 in two and C4/5 and C5/6 in one. No patient complained of urinary dysfunction however, two (40%) reported erectile dysfunction. All patients demonstrated neurological improvement after decompressive surgery.**

**Conclusion:** Cervical myelopathy from spondylosis or disc herniation may rarely present without signs or symptoms in the upper extremities. Based upon observations of a small number of such patients, the clinical picture is indistinguishable from thoracic myelopathy and surgical decompression results in neurologic improvement. Awareness of this atypical pattern of presentation may aid in the clinical assessment of a subset of patients with cervical cord compression.

**220. Multimodality Treatment of Iatrogenic Vertebral Artery Injury during Cervical or Craniovertebral Surgery**

**Introduction:** Iatrogenic injury to the vertebral artery (VA) during cervical or craniovertebral surgery is uncommon. We present a series of 13 patients with iatrogenic vertebral artery injuries during anterior cervical, posterior cervical or craniovertebral surgery. Treatment strategies included intra-operative tamponade, direct vessel repair or endovascular treatment. Endovascular treatment consisted of parent vessel coil occlusion, parent vessel stenting or pseudoaneurysm coiling. Neurologic outcome was good in all but one patient at last follow-up.

**Methods:** Surgical databases, morbidity and mortality reports and surgeon memory were retrospectively reviewed to capture all iatrogenic vertebral artery injuries that occurred at our institution from January 1997 to March 2008. Thirteen cases were identified. Six cases occurred during C1/2 instrumentation, 2 during far lateral approaches to the craniovertebral junction, 2 during anterior cervical corpectomy, 2 during anterior cervical disectomy with fusion and plating and one during odontoid screw placement. Patient age ranged from 3 to 74 years (mean 45.3 years).

**Results:** Vertebral artery injury occurred in 1.4% (6/430) posterior C1/2 fusion cases, 0.7% (2/284) of far lateral skull base approached, 0.06% (2/3444) of anterior cervical disectomies with fusion and plating, 0.5% (2/385) of anterior cervical corpectomies and 1.2% (1/84) odontoid screw placements. There were no documented cases of vertebral artery injury during non-fusion cases involving C1/2 (laminectomy, laminoplasty, chIari decompression, etc.) with the exception of the 2 far lateral cases. There were also no cases of vertebral artery injury during posterior cervical fusion from C3 to 6 (460 cases).

**Conclusion:** In the event of iatrogenic VA injury control of bleeding followed by primary repair is preferred when possible. If primary repair is not possible, control of bleeding followed by immediate post-operative endovascular consultation and angiography is recommended. Endovascular treatment may consist of vessel sacrifice, or treatment of the injured vessel via coiling or stenting. Serial angiography is recommended as pseudoaneurysm formation or enlargement may occur. Neurologic outcomes were stable or improved in 92% of patients (12/13).

**221. Tubular Microsurgery for Lumbar Discectomies and Laminectomies in Obese Patients: Operative Results and Outcome**

Andre Tomasin, Karishma Parikh, Jeremy Steinberger, Jared Knopman, Harry Gebhard, John A. Boockvar, Roger Hartl

**Introduction:** Spinal surgery in obese patients is associated with increased complications, blood loss and operative times. The purpose of this study was to evaluate the potential benefits of minimally invasive spine surgery (MISS) in obese and non-obese patients by operative results and patient outcomes.

**Methods:** All patients underwent one-level lumbar microdiscectomy (LMD) or laminectomy (LAM) using tubular retractors between the years 2004 to 2007. Data was collected on patients’ demographics, comorbidities, smoking habits, operative results and outcomes and compared for obese (BMI > 30) and non-obese patients. Operative results included operative times, blood loss, length of stay (LOS) and perioperative complications. Clinical outcomes were assessed using pre- and post-operative Visual Analog Scale (VAS) and Macnab outcome criteria at most recent follow-up.

**Results:** 31% of patients were classified as obese. Obese patients tended to undergo surgery at a younger age. No significant differences were seen between obese vs. non-obese patients in terms of incision lengths, operative time, blood loss and complication rates. In obese patients, operative results compared favorably to reported historical results of patients undergoing open lumbar surgery. Overall, favorable outcomes were seen in 92% and 84% of obese and non-obese LMD patients, respectively and in 75% of LAM patients. Obesity, comorbidities and age did not have a significant impact on perioperative complications and clinical outcome at a mean follow-up of 15.9 months.
Conclusion: This is the first study comparing operative results from tubular microsurgery between obese and non-obese patients. Operative results and complication rates, including length of stay, blood loss and operative time in obese patients were less while performing MISS compared to open spine procedures seen in the literature. Comparison between obese and non-obese patients in operative results and complication rates for minimally invasive microdiscectomy and laminectomy procedures showed no significant difference. Obese patients improved post-operatively and had similar outcomes as non-obese patients.

222. Complications in 500 XLIF Surgeries
W.B. Rodgers, Curtis S. Cox, Edward J. Gerber

Introduction: The XLIF procedure allows for minimally invasive placement of a large anterior graft, disk height and alignment restoration and indirect decompression.
Methods: Our single-site consecutive series of 500 XLIF outcomes were reviewed, including surgical details, hospital stay, pain scores, changes in disk height/alignment and fusion. Surgical and post-operative complications were documented.
Results: Patients age range 22-88 years (average 61 years). Diagnoses included stenosis (46%), spondylolisthesis (16%), DDD (12%), HNP (11%), post-laminectomy instability (8%) and scoliosis (7%). 78% had one or more pre-existing comorbidities, including diabetes, CAD, COPD, smoking and chronic steroid use. 37% had prior lumbar surgery. 49% were obese or morbidly obese. 610 levels were treated: 80% single-level, 60% at L4-5. All but 5 included supplemental instrumentation. Hospital stay averaged 1.24 days. 33 complications were reported (6.0% complication rate): 1 wound hernia, 7 GI (6 ileus, 1 gastric volvulus), 2 renal (1 urinary retention, 1 peritoneal catheter occlusion), 5 respiratory (3 pneumonia, 1 pulmonary embolism, 1 re-intubation), 4 cardiac (3 atrial fibrillations, 1 MI at 6 wks post-op), 4 neural (3 quad weakness, 1 anterior tibialis weakness), 4 vertebral body fractures (1 endplate fracture, 1 osteophyte fracture requiring reoperation, 1 subsidence requiring reoperation, 1 compression fracture at an adjacent level requiring vertebroplasty), 1 iatrogenic HNP (requiring laminectomy at 4 wks) and 5 hardware failures (3 cage fractures on insertion, 1 fractured rod at 6 months, 1 fractured screw at 1 year). Reoperation rate was 1.2% (hernia repair, gastric volvulus repair, vertebroplasty, laminectomy, 2 posterior instrumentation (1 for osteophyte fracture and 1 for subsidence). Average VAS scores, radiographic measures and fusion scores were not different between the complications group and the total series.

Conclusion: XLIF is a safe, effective treatment for multiple thoracolumbar degenerative conditions. XLIF surgery can be performed in many conditions with a low complication rate.

223. Multistaged Reduction with Magerl External Fixator and 360 Fusion for High Grade Spondylolisthesis and Spondyloptosis
Vishal Kakar, Jabir Nagaria, Michael Grevitt, John Webb

Introduction: Management of high grade spondylolisthesis/spondyloptosis in adolescents remains controversial (1, 2, 4). The natural history suggests high incidence of LBP, radicular pain and progressive lumbar sacral kypho scoliosis. Single staged procedures increase the risks of L5 nerve root dysfunction. Gaines (3) procedure remains popular, but has known complications.
Methods: We present a prospective observational study of 9 patients (median age 16) undergoing staged correction. All presented with > meyering grade 3 slips and indications for surgery were to relieve intractable LBP, improve neurology and sagittal alignment. The procedure involved: 1. Gille procedure, L5 root decompression, insertion of Schanz pins into L4 pedicles and ilium and application of external fixator 2. Correction of kyphosis and translation by gradual adjustment of external fixator on ward (2 weeks) 3. Anterior interbody fusion, removal of fixator and instrumented fusion of L5 to sacrum. Outcome measurement included 10 point visual analogue scale (VAS), Oswestry disability index and Low back outcome scores.
Results: Median follow-up was 11 years. No patients developed neurological deficit and imaging confirmed solid fusion in 8/9, with significant reduction in translation and correction of lumbar sacral kyphosis. (Most recent follow-up, 72% correction of percentage slip (p = 0.001), 66% slip angle improvement (p = 0.0001), 47% sacral inclination improvement (p = 0.006)). There was 76% and 70% improvement respectively in leg and back 10 point VAS score and significant improvement in the other parameters. One developed persisting bad pain following spondylolisthesis at L4/5.
Conclusion: Multistaged reduction and fusion improves severe cosmetic deformity and restores sagittal balance unlike in situ fusion. Good clinical outcome is accompanied by radiological improvement, particularly the slip angle. Gradual reduction and restoration of lordosis by adjusting the external fixator guided by patient comfort and neurology is very safe. We recommend this technique because of low risk of neurological complications and avoiding fusion involving two motion segments.

Matthew F. Gornet, Brett A. Taylor, Timothy R. Kuklo, Russ P. Nockels, Todd Hopkins Lanman

Introduction: Instrumented spinal fusion using pedicle screws with metal rods is associated with stress shielding of the intervertebral space. The prevention of load sharing of the interbody space by metal rods would seem contrary to Wolfe’s principle. Surgeons using PEEK rods have discussed anecdotally an apparent difference in the quantity of intervertebral bone, compared to patients with rigid metallic instrumentation, seen on computed tomography (CT) scans. This study introduces a methodology for quantitative CT assessment of intervertebral bone volume (IBV) following anterior/posterior instrumented lumbosacral fusion.

Methods: This retrospective, monocentric study included 24 consecutive fusion patients with 3 and 12-month CT scans to assess mean IBV, expressed as a percentage of the total available space in three designated intervertebral zones at each treated level. Sagittal and coronal views were used to estimate available disc space volume using the on-screen measurement tool. IBV percentages estimated by an independent radiologist were used to calculate a weighted measure of total bone volume, expressed as a percentage of available space.

Results: A significant difference in IBV was observed in PEEK patients. At three months post-operative, mean IBV was 51.4% ± 11.9 (n = 17) in the PEEK group and 44.2% ± 7.8 (n = 28) in the Ti group (p = 0.019). At 12 months, the mean bone volume was 69.1% ± 11.2 in the PEEK group and 58.6% ± 13.7 in the Ti group (p = 0.011). A sub-analysis by vertebral levels revealed a significant difference favoring PEEK rods at L5-S1.

Conclusion: This study reveals new findings about the impact of device-related stress shielding after anterior/posterior fusion with a rod/screw system. Fusion patients treated with PEEK rods appear to be developing bone more quickly and in greater volume.

226. The Role of Cannabinoids in Chronic Neuropathic Pain Development Following Contusive Spinal Cord Injury

Sharad Rajpal, Clayton Sweeney, Tiffany A. Gerovac, Bradley Alcock, Shannon McChesney, Amy Patel, Jessica Tilghman, Gurwattan M Ranpur, Daniel K. Resnick

Introduction: The cannabinoid (CB) system has increasingly been shown to play a role in neuropathic pain (NP) development following spinal cord injury (SCI). The CB1 and CB2 receptor agonist WIN 55,212-2 (WIN) has been shown to alleviate mechanical and thermal hyperalgesia (TH) in NP conditions. Our study was two-fold in design: (Part A) to determine a possible dose response of WIN in ameliorating TH and (Part B) to evaluate WIN’s mechanism in ameliorating TH using a CB1 (AM251) and CB2 (AM630) receptor antagonist.

Methods: Sprague-Dawley rats underwent contusive SCI with subsequent testing for chronic TH development. Part A (groups 1-4): TH testing was completed before and after drug administration. Group (1) saline, (2) DMSO, (3) low-dose (0.2 mg/kg) WIN and (4) high-dose (2.0 mg/kg) WIN. Part B (groups 5-8): animals underwent TH testing, were injected with a selective CB antagonist and tested for TH, injected with WIN and then retested for TH. Group (5) AM251/WIN, (6) AM630/WIN, (7) sham AM251/WIN and (8) sham AM630/WIN.

Results: There was a statistically significant improvement (p < 0.05) in TH following high-dose WIN administration (group 4), from pre-AM251 to post-WIN administration (group 5) and from post-AM251 to post-WIN administration (group 5). Further subgroup analysis of all animal groups revealed statistically significant improvement in TH only for those animals demonstrating "pain behavior" a) treated with high-dose of WIN (group 4), b) from pre-AM251 to post-WIN administration and post-AM251 to post-WIN (group 5) and c) from pre- to post-AM630 administration (group 6).

Conclusion: Although the CB system appears to play an important role in chronic NP states following contusive SCI, CB1 and CB2 receptor subtypes appear to play different roles in the amelioration of TH. Selective inhibition of specific CB receptor subtypes may therefore allow for potentially beneficial effects on NP development following SCI.

227. The Majority of Initial Coronal Imbalance Following Fusion Surgery for AIS Improves within Six Months

Amer F. Samdani, Jahangir Ashgar, Daniel M. Sciuropa, Patrick Cahill, David Clements, Darryl Antonacci, Randal Betz, Harms Study Group

Introduction: A substantial percentage of patients with AIS who undergo spinal fusion procedures will exhibit coronal imbalance (> 2cm) on initial post-operative erect radiographs. Due to the flexibility of non-instrumented segments in this population, it is often assumed that initial coronal imbalance will improve over time. In this study, patients with initial coronal imbalance were followed to assess the natural history of the imbalance and to identify potential factors associated with failure to correct.

Methods: A retrospective analysis was conducted at a single institution on patients with AIS undergoing spinal fusion from 1998-2005. Patients with radiographic coronal imbalance on initial erect radiographs were identified and serial erect radiographs at 3, 6, 12 and 24 months were evaluated. Parameters collected included: Lenke curve type, lumbar modifier, fusion levels, stable vertebrae and length of construct, trunk shape analysis, SRS scores, self image scores and post-operative C7 plumb line to central sacral vertical line (CSVL) distance. Correlation of persistent coronal imbalance with such factors was assessed via logistic regression analysis.

Results: Of 296 patients reviewed for this cohort, 91 patients (30.7%) exhibited coronal imbalance with initial erect radiographs and these patients were included in the analysis. The number of patients with persistent coronal imbalance fell to 29 (9.7%), 15 (5%), 12 (4.5%) and 14 (4.7%), respectively. Logistic regression analysis revealed no factors associated with failure to return to balance.

Conclusion: In patients with AIS undergoing spinal fusion procedures, initial post-operative coronal imbalance (> 2cm) improves dramatically, but such improvement plateaus at 6 months, with 5% still persisting.

228. Difference in Fusion Rates for One vs. Two Screws in Elderly Odontoid Fractures

Andrew T. Dailey, Michael Finn, Meic H. Schmidt, David J. Hart, Ronald I. Apfelbaum

Introduction: Fractures of the odontoid process are the most common cervical spine fracture in patients over the age of 70. The incidence of non-union in this population has been estimated to be 20-fold greater that in patients under the age of 50 if surgical stabilization is not utilized. Surgery through both anterior and posterior
approaches has been advocated with good results reported. Direct fixation with an odontoid screw has been widely utilized and previous reports have indicated no difference in fusion rates if one or two screws are utilized. However, this has not been specifically studied in the elderly population.

**Methods:** A retrospective review of patients over the age of 70 who had direct fixation of an odontoid fracture in a single institution from 1991-2006 yielded 57 patients. Patients were followed with flexion-extension radiographs and fracture outcome was classified as bony union, fibrous union (no motion on dynamic radiographs but incomplete bone bridging) or non-union (motion on dynamic radiographs or loosening of screws). Patients with bony or fibrous union were classified as stable. In addition, other procedure related complications were extracted from the medical record.

**Results:** Of the 57 patients who had placement of an odontoid screw, 42 had follow-up of at least 3 months (range 3-62 months, mean 15). In patients with two screws, 26 had 3-month follow-up and 96% (25/26) had stable radiographs (19 solid bony union, 6 fibrous union and 1 non-union). Of the 16 patients with one screw followed to 3 months, only 56% (9/16, p < 0.05) achieved stable radiographs at final follow-up (5 solid, 4 fibrous and 7 non-union). Overall, stability was confirmed in 81% of patients.

**Conclusion:** Direct fixation of Type II odontoid fractures showed higher stability rates when 2 screws were placed in this challenging population. This is in contrast to series not focusing on elderly patients where no significant difference in fusion rate has been noted between one and two screws. Due to poorer bone quality in the elderly population, the second screw may provide additional stability and promote bone fusion.

229. *Association of Autoimmune Cytokines with Gait Abnormalities and Mechanical Sensitivity in Radiculopathy*


**Introduction:** Intervertebral disc herniation can cause radiculopathy by mechanical compression and biochemical irritation of nearby neural structures. [1] Animal models of radiculopathy describe demyelination, slowed nerve conduction and heightened pain sensitivity following application of autologous NP to the DRG. [2,3] This study had the objective of investigating how disc-herniation radiculopathy impacts on animal locomotion, a previously uninvestigated functional outcome. Further, while local inflammation occurs at the injury site, [4] the role of autoimmune reactivity against previously immune-sequestered NP requires investigation.

**Methods:** NP-treated animals (n = 16) received autologous tail NP placed onto the L5 DRG exposed by unilateral facetectomy and control animals (n = 16) underwent exposure only. At weekly time points, animals were evaluated for mechanical allodynia, thermal hyperalgesia and gait characteristics through digitized video analysis. Serum cytokine content was measured after animal sacrifice and immunohistochemistry tested DRG tissue for mediators of inflammation and immune activation.

**Results:** Sensory testing revealed mechanical allodynia in the affected limb of NP-treated rats compared with sham animals (p < 0.01) at all timepoints. Gait analysis revealed functional locomotive consequences of marked asymmetry (p = 0.048) and preference to bear weight on the contralateral limb (duty factor imbalance, p < 0.01) at early time points. Equivalent serum cytokine expression occurred in both groups, confirming the local inflammatory nature of this disease model. Immunohistochemistry of the sectioned DRGs revealed equivalent post-surgical inflammatory activation (IL-23, p = 0.47) but substantial early immune activation in the NP-treated group (IL-17, p = 0.01).

**Conclusion:** This model of radiculopathy provides evidence of altered gait in a model of non-compressive disc herniation. Systemic inflammation was absent, but mechanical allodynia, local inflammation and autoreactive immune activation were observed. Future work will involve therapeutic interventions to rescue animals from the phenotype of inflammatory radiculopathy.


**Introduction:** Due to the distinct orientation of the pedicles in the thoracic spine the insertion of pedicle screws is considered technically difficult and potentially hazardous for the neurovascular structures inside the spinal canal. Moreover, malpositioned pedicle screws disrupt the integrity of the trabecular and cortical bone, which may result in loss of adequate bone/screw purchase. Therefore, we sought to compare quantitatively the pull-out force of standard pedicle screws and screws malpositioned in different directions.

**Methods:** Forty human cadaveric thoracic vertebrae were studied (T6-T11). Before testing, the bone mineral density (BMD) was determined for each specimen and the vertebrae were separated into four groups: 1) standard pedicle screws without cortical breaches, 2) pedicle screws with medial cortical perforations, 3) pedicle screws with lateral cortical perforations, 4) airball screws (completely missed the vertebral body). Each specimen was potted with PMMA and held in a vise with the screw oriented in line with the axis of the servohydraulic test frame’ piston. Each screw was pulled at a rate of 10 mm/min in a straight axial pull-out until the bone/screw visibly failed.

**Results:** The mean ultimate pull-out strength was 839 ± 337 N in the standard pedicle screws group, 904 ± 354 N for the medial screws, 660 ± 331 N for the lateral screws and 554 ± 418 N for the airball screws. The difference between standard pedicle screws and airball screws (p < 0.009, repeated-measures one-way analysis of variance), medial screw and airball screws (p < 0.002) and between medial screws and lateral screws (p < 0.01) reached significance. The mean BMD of the specimens was found to be in the osteoporotic range (0.674 g/cm²) and no correlation was found between BMD and ultimate pull-out strength in any of the groups.

**Conclusion:** Airball screws provided only 66% of the pull-out force compared to well-positioned pedicle screws and medial cortical perforations did not decrease the pull-out force of the screws.

231. *Measurement of the Occipital Condyle - C1 and C1-C2 Joint Interval in Normal Adults*

Zohny Zohny, Brian T. Jankowitiz, Dean B. Kostov, Erin Sauber-Schatz, Anthony Fabio, David O. Okonkwo

**Introduction:** Pang recently described a new method to diagnosis AOD in the pediatric population (1,2). We applied this system of measurement to normal adults and expanded its application to include the C1-2 joint. Determination of a normal joint diameter may allow the diagnosis of abnormal or injured joints.

**Methods:** We first calculated sample size requirements with Samps in STATA using estimated values from pilot data. To achieve adequate power we needed 60 total patients. The condyle-C1 interval (CCI) was measured for each patient as described by Pang (1,2) in five males and females in their 20s, 30s, 40s, 50s, 60s and 70s. The methodology was repeated in each patient to assess the C1-2 joint diameter. The differences in mean joint diameters were
Mean O-C1 joint diameter was 1.05 ± 0.20 mm. The joints were highly symmetric with no significant difference between right and left. The 0-C1 joint was consistently, but non-significantly, wider in males when compared to females and in older patients when compared to younger patients (< 50 vs. > 50). The mean C1-2 joint diameter was 1.46 ± 0.41 mm. The joints were highly symmetric with no significant difference between right and left. The C1-2 joint was significantly larger in men than women, measuring 1.61 vs. 1.31 mm (p = 0.005). The C1-2 joint was consistently, but non-significantly, wider in older patients when compared to younger patients (< 50 vs. > 50).

Conclusion: The O-C1 and C1-2 joints are symmetric, with a non-significant trend towards slightly greater diameters in older patients and a significantly larger diameter in males at C1-2. Once validated by comparing inter-observer measurements, this methodology may allow the diagnosis of atlanto-axial injury, distraction or subluxation on reformatted CT scans.

232. Rebalancing of the Spine after Total Disc Replacement: Contributing Factors and Impact on Sagittal Alignment
Frank Phillips, Domagoj Coric, Mark J. Krinock, Harold Hess, James Yue, Nicholas Wharton, John Hipp
Introduction: Disc replacement affects both local and global spinal balance and alignment. In this study, the realignment of the cervical spine was evaluated at multiple pre- and post-operative time points to study the effect of arthroplasty on global spinal realignment.
Methods: Radiographic data was analyzed on 75 consecutive patients undergoing cervical arthroplasty (DISCOVER™ IDE trial). Two week, 3 month and 6 month radiographs were analyzed for asymmetry of shell angles (PSA), functional spinal unit (FSU) angles and overall C2-C6 angulation.
Results: The mean PSA was 0.4º ± 5.4º and 75% of all subjects had a PSA between 5º and +5º. Average index-level FSU angles increased from 4.0º ± 5.2º to +1.4º ± 5.8º from pre-operative to 6 months post-operative. This increase in index-level lordosis was not correlated to PSA (r² = 0.3892). Changes in adjacent level FSU angles were observed early post-operatively, as if these adjacent levels were compensating for an increased lordosis at the index-level by adopting a slightly more kyphotic angulation. This effect disappeared by 6 months. Specifically, the average lower adjacent level changed from 4.8º ± 5.3º pre- to 5.5º ± 4.9º at 2 weeks and resumed back to 4.1º ± 5.0º by 6 months. Similarly, the upper adjacent level started at +1.08º ± 5.02º pre-operatively, changed to 1.4º ± 4.8º and returned back to 0.0º ± 4.7º at 6 months. At 6 months the C2-C6 angulation had increased by 3.2º from pre-operatively. Interestingly, the C2-C6 angle increase immediately post-operatively (1.6º) was smaller than that observed at index-TDR level (6.6º).
Conclusion: The cervical spine appears to re-balance itself after TDR and in early post-operative phases tends to assume a global alignment that is similar to pre-operatively regardless of changes at index level. It is possible that a soft tissue “memory” may impact the spinal behavior immediately post-operatively. This effect disappeared by 6 months and may reflect the spine realigning itself over time.

233. Diagnostic Tractography Features of Intramedullary Tumors
Eve C. Tsai, Fahad A. Alkherayf, Abdulaziz S. Al-Ali, John Sinclair, Brien G. Benoit, Alain Berthiaume, Thanh Binh Nguyen
Introduction: The ability to identify the effect of an intramedullary tumor on the motor and sensory tracts of the spinal cord is limited with conventional magnetic resonance imaging (MRI) sequences. Tractography is a novel MRI technique that utilizes diffusion weighted images to delineate white matter tracts. We assessed tractography features in pathologically confirmed spinal cord tumors to determine if there were features that could improve diagnosis.
Methods: Clinical status and image files of patients that underwent MRI tractography from December 2006 to January 2008 were obtained from the tractography database. Imaging was performed on a 1.5T Siemens MR Imager and the protocol began with the acquisition of a sagittal T2-weighted fast imaging. Imaging was then correlated with pathological features. Neurons were incubated with varying concentrations of OP1 (40,100,200ng), controls received no treatment. Coverslips for 24 hours. Growth and sprouting was quantified using pixel intensity and significance determined using ANOVA.
Results: There was a significantly greater sprouting density following OP1 exposure at all concentrations compared to controls with neurons grown on laminin (signifying greater plasticity). OP1 promoted cell survival and growth into the highly inhibitory rim (highest proteoglycan concentration) in a concentration dependent manner. The findings were highly significant. Control neurites rarely extended to the rim of the spot, they rather became dystrophic.
Conclusion: The results demonstrate that OP1 is neuroprotective and promotes plasticity in a model that mimics the glial scar following spinal cord injury. OP1 appears able to promote regeneration through the proteoglycan penumbra but not past the greatest concentration of this inhibitory barrier. Perhaps its use combined with other agents that promotes crossing of this highly inhibitory region, such as chondroitinase and/or increased cAMP.

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were necessary to regenerate past this inhibitory barriers. Would promote functional recovery.

235. The Efficacy of Mesenchymal Stem Cells in Thoracic–Lumbar Spine Fusion Surgery for Trauma: A Retrospective Review of Operated Cases
Roland A. Torres, Robert Edward Lieberson, Sherreen Parvish

Introduction: Stem cells have the capacity to differentiate into specialized cell types. Alloarthrotic stem cells from donor bone marrow (mesenchymal tissue) do not stimulate an immunological response and have the capacity to form bone in laboratory models. The FDA has approved the use of human allograft mesenchymal stem cells in demineralized bone matrix (MSC-DBM) in spinal fusion. Several commercial preparations, including Trinity® and Osteocel®, both manufactured by Osiris Therapeutics, are available. This is the first study documenting the efficacy of the stem cell preparations in promoting spinal fusion in thoraco-lumbar trauma.

Methods: To evaluate the efficacy of Trinity® and Osteocel® we review the cases of all seventeen (17) patients who underwent anterior or anterior-posterior fusions of the thoraco-lumbar spine, using MSC-DBM in combination with allograft, at our institution over a one-year period with a minimum of six-months follow-up. Post-operative computed tomographic scans and plain radiographs in flexion and extension are analyzed using the fusion criteria outlined by Burkus, et al., Williams, et al., and Molinari, et al. Fusion rates are compared to published rates for similar fusions with autograft, allograft and bone morphogenetic protein products.

Results: Fifteen (15) of the seventeen (17) study patients developed solid fusions in six to eighteen months (88% fusion rate). Of sixty-eight (68) levels operated, fifty-nine (59) levels fused. The two (2) patients with non-unions had undergone four and five level fusions and had other risk factors. Published fusion rates using autograft, allograft, or BMP range from approximately 75% to approximately 95% depending on the type of fusion and the length of the period of observation.

Conclusion: Fusion rates using MSC-DBM are comparable to published fusion rates using autograft, allograft or BMP in our study population. This study retrospectively describes a small sample population. We plan a larger, prospective trial.

236. Enhanced Stabilization of C–1 Lateral Mass/C2 Pedicle Screw Fixation Construct via Crosslink: A Biomechanical Study
John F. Hamilton, Carl Lauritsen, Hamid Miralikalbar, Mary Bilancini

Introduction: Atlantoaxial stability may be required in various destabilizing conditions such as trauma, malignancy and inflammatory diseases. Various stabilization techniques have been described. Professor Harms in 2001 described a novel technique of posterior C1/C2 fusion utilizing screw fixation of the lateral mass of C1 and the C2 pedicle (CLM/C2). Addition of a cross-link may provide added stability and increase fusion rates. This study’s objective is the assessment of the rigidity of C1 lateral mass/C-2 pedicle screw fixation construct, with and without a cross-link, in an odontoidectomy instability model.

Methods: Seven cadaver specimens were tested in the following order: intact specimen, destabilized C1-C2, instrumented CLM/C2 without a cross-link, instrumented CLM/C2 + crosslink. Thawed specimens underwent a series of test modes: (1) flexion/extension and (2) lateral bending (±1.5 Nm) and (3) torsion at (±1.0 Nm). Range of motion (ROM) and stiffness were calculated for the last three cycles of each test. Descriptive statistics were utilized to generate the means, standard deviations and standard errors of all data. Analysis of variance was performed to measure statistical difference in ROM and stiffness between the constructs.

Results: CLM/C2 construct (alone) and CLM/C2 (construct + cross-links) exhibited statistically significantly increased stiffness (Nm/degree) in flexion/extension, lateral bending and torsion than the intact specimen and the destabilized C1-C2 specimen. The stiffness during torsion of the instrumented CLM/C2 + cross-links (2.757 ± 0.52) was significantly increased (P < .001) compared to instrumented CLM/C2 alone (1.96 ± 0.51). There was a trend towards decreased ROM in CLM/C2 constructs + cross-links when compared to instrumented CLM/C2 constructs alone in flexion/extension (0.32 ± 0.01 vs. 0.33 ± 0.02, respectively) and lateral bending (0.55 ± 0.2 vs. 0.59 ± 0.17, respectively).

Conclusion: Cross-links statistically and significantly increased the stiffness in the CLM/C2 construct in torsion when compared with instrumented CLM/C2 constructs alone. A trend was noted for increased stiffness in lateral bending with cross-links. Cross-links increase stability of the CLM/C2 construct, potentially increasing the fusion rate in vivo.

237. The Role of Magnetic Resonance Neurography in Management of Patients with Suspected Neurogenic Thoracic Outlet Syndrome
Matthew Tate, Benjamin Lee, Leslie Gillum, Nicholas M. Barbaro, John Engstrom, Philip R. Weinstein, Cynthia Chin

Introduction: Neurogenic thoracic outlet syndrome (nTOS) results from brachial plexus compression within the thoracic outlet with resultant neurologic symptoms (1). Diagnosis of nTOS involves a thorough neurological examination, imaging studies and electrophysiologic testing. However, definitive diagnosis of nTOS remains difficult due to equivocal imaging/electric studies and heterogeneity of clinical presentation (2). MR neurography (MRN) is a recent technique which has the ability to detect subtle abnormalities in neural tissue characteristics, size and course within the thoracic outlet. In this report, we provide a review of our experience in the use of MRN for diagnosis, management and subsequent treatment of patients with suspected nTOS.

Methods: We performed a retrospective analysis of 26 patients (14 males, 12 females, ages 20-76) referred to UCSF from 2002-2007 with suspected nTOS who received MRN as part of their diagnostic workup. Images were analyzed with attention to nerve signal intensity, size asymmetry and abnormal trajectory through the thoracic outlet. Studies were also screened for extra neural abnormalities such as cervical ribs, fibromuscular bands and aberrant scalene muscle anatomy, EMG, clinical and intra-operative observations were reviewed and correlated with MRN findings.

Results: 19/26 patients with suspected nTOS had abnormal MRN findings: 16 had abnormal signal intensity, 11 demonstrated an irregular nerve course, 6 had bony abnormalities and 1 had abnormal scalene anatomy. 12 patients had EMG studies: 8 positive, 4 negative. All patients with positive EMG findings had corresponding abnormalities on MRN. Three patients failed to respond to conservative management and underwent decompressive surgery. Each of these patients reports sustained clinical improvement at most recent follow-up.

Conclusion: Diagnosis of nTOS remains a challenging problem for physicians. The combination of MRN imaging in conjunction with conventional studies may improve diagnostic accuracy and selection of patients who could benefit from neurosurgical intervention.
238. Neurological Outcome after Surgical Management of Adult Tethered Cord Syndrome

**Introduction:** Although incidences of post-surgical outcomes are well-known, rate and development of neurological improvement after first-time tethered cord release is incompletely understood. We reviewed our institutional experience with surgical management of adult tethered cord syndrome to assess the time course of symptomatic improvement and to identify patient subgroups most likely to experience improvement of motor symptoms.

**Methods:** We retrospectively reviewed 29 consecutive cases of first-time adult tethered cord release. Clinical symptoms of pain, motor and urinary dysfunction were evaluated 1 month and 3 months post-operatively, then every 6 months. Rates of improvement in pain, motor, or urinary dysfunction over time were identified and presenting factors associated with motor symptom improvement were assessed via multivariate survival analysis (Cox model).

**Results:** Mean age was 38 ± 13 years. Etiology included three (10%) lipomyelomeningocele, three (10%) tight filum, four (14%) lumbosacral lipoma, three (10%) intradural tumor, two (7%) previous lumbosacral surgery, and 14 (48%) previous myelomeningocele repair. Mean length of symptoms pre-operatively was 5 ± 7 months. Presentation included diffuse pain/parasthesias in bilateral lower-extremity [13 (45%)] or perineal distribution [18 (62%)], lower-extremity weakness [17 (59%)], gait difficulties [17 (60%)], or bladder dysfunction [14 (48%)].

Laminectomy included 2.5 ± 0.7 levels and 9 (30%) received duraplasty. At 18 months post-operatively, 47% of patients had improved urinary symptoms, 69% had improved lower extremity weakness and gait and 79% had decreased painful dysesthesias. Median time-to-improvement was least for pain (1 month), then motor (2.3 months), then urinary symptoms (4.3 months). (p = 0.04). For patients demonstrating improvement, 96% improved within 6 months post-operatively. Only 4% improved beyond one year. In multivariate analysis, presenting with asymmetric lower extremity weakness (p = 0.0021, HR = 5.7) or lower-extremity hyper-reflexia (p = 0.037, HR = 4.1) was associated with motor improvement.

**Conclusion:** In our experience, motor, pain and urinary dysfunction improve in the majority of patients. The rate of symptomatic improvement was greatest for pain, followed by motor, then urinary improvement.

Patients who experienced improvement in any symptom had done so by 6 months post-operatively. Patients with asymmetric motor symptoms or lower-extremity hyper-reflexia at presentation were most likely to improve in motor symptoms. These findings may help guide patient education and surgical decision-making.

239. Immediate and Long-term Outcomes for Multilevel Anterior Cervical Fusions
Tyler Kenning, Doniel Drazin, Constantine Plakas, Mark Calayag, Edward Gifford, Karen Petronis, Darryl J. Dirisio

**Introduction:** Optimal management of multilevel cervical spine disease remains debated. Often, a posterior approach is utilized to avoid the perceived complications accompanying anterior cervical surgery. We present a large series of multilevel anterior cervical fusions (ACDF) to identify radiographic and clinical outcomes.

**Methods:** A retrospective chart review was conducted from patients who underwent multilevel ACDF at Albany Medical Center from 2004 to 2008. 288 charts met the inclusion criteria of at least one follow-up and available radiographs. Outcome variables included (1) pre- and post-operative modified Japanese Orthopedic Association (JOA) cervical spine myelopathy functional assessment scores, (2) lateral upright radiographs and when possible CT and flexion-extension studies, to assess fusion and (3) complications.

**Results:** A two-level fusion was performed in 66 patients, 3-level in 78, 4-level in 104 and >5-level in 40 patients. Patients underwent a combined anterior-posterior fusion. Vertebral corpectomies were performed in 69 patients. Mean pre-operative JOA score was 14.2 ± 1.9. Mean post-operative (range: 6 months to 3 years) JOA score was 16.8 ± 1.8. Overall fusion rates, separated into intervals of <3 months, 3-6 months, 6-months-1 year and >1 year, were 13%, 29%, 67% and 70%, respectively. The >1 year fusion rate varied with additional levels: 80% for 2-level, 65% for 3-level, 70% for 4-level and 73% for >5-level. The most common complications, which subsequently resolved, were dysphagia in 16% of patients, followed by dysphonia and airway issues, each of which occurred in 2%.

**Conclusion:** This study is one of the largest series on the outcomes of anterior approach to multilevel cervical disease, including long-term follow-up. Data support that this procedure is safe and effective. For the most severe cervical disease patients, requiring multilevel cervical reconstruction, functional outcomes were improved, with complications transient and treatable.

240. Multilevel ACDF with and Without BMP: A Comparison of Outcomes and Dysphagia Rates
Daniel C. Lu, Luis M. Tumialan, Dean Chou, Praveen V. Mummaneni

**Introduction:** The goal in this study was to compare patients undergoing multilevel ACDF using BMP to those undergoing multilevel ACDF with allograft spacers (without BMP).

**Methods:** We retrospectively reviewed 100 patients. 50 patients underwent a multilevel (2 or more) ACDF with titanium plate fixation and PEEK spacer filled with <1 mg of rhBMP-2. This group was compared to a control group of 50 profile-matched patients (age, gender and operative levels) who underwent ACDF with allograft spacer (without BMP) and titanium plating. Complications were recorded in both groups. Clinical outcomes were assessed using pre- and post-operative Nurick grades and Odom criteria. Radiographic outcomes were assessed using dynamic radiographs and CT scans.

**Results:** The mean follow-up period was 28 months for the ACDF with BMP cohort and 31 months for the ACDF without BMP cohort. No differences were found between the two cohorts in Nurick grades or Odom criteria. All patients in the multi-level ACDF with BMP group achieved solid radiographic fusion on dynamic radiographs and CT scans whereas 7% of the patients in the multi-level ACDF with allograft group presented with clinically symptomatic pseudoarthrosis and all underwent reoperation (p < 0.01). Five patients (10%) in the BMP series experienced clinically significant dysphagia compared to two patients (4%) in the ACDF with allograft-only group (p < 0.001). Two patients (4%) in the BMP group required re-operation for hematoma while no patients in the ACDF with allograft group had hematoma reoperations (p < 0.001).

**Conclusion:** A multi-level ACDF performed with rhBMP-2 leads to a higher fusion rate than multi-level ACDF using allograft. BMP is particularly effective for fusion in smokers or patients with multi-level fusion when compared to the control cohort. However, there is an increased risk of post-operative dysphagia and hematoma with the use of BMP compared to the allograft group.

Anirban Deep Banerjee, Sampath Somanna

Introduction: Management of ossification of the posterior longitudinal ligament (OPLL), most commonly cervical, has been characteristically marred by unpredictable outcome, there is a distinct paucity of literature in this regard with no comparative study until date between fluorotic and non-fluorotic populations. Skeletal fluorosis, an important etiological factor of OPLL, is a major public-health problem world-wide whose early diagnosis is difficult in view of non-specific clinicoradiological profile with paucity of a quantitative yet cost-effective screening method. The present study attempts to address these distinct but related issues.

Methods: All patients of symptomatic Cervical OPLL, operated in our institute from September 2005 until February 2007 were studied prospectively and from January 1988 until August 2005 were studied retrospectively, including pre-operative, post-operative and serial follow-up clinicoradiological evaluations. Quantitative computed tomography was used in the assessment of bone mineral density.

Results: Of the 142 patients studied (37 patients prospectively and 105 patients retrospectively), 72 patients were from fluorotic and 70 patients were from non-fluorotic zones, with a median follow-up of 60 months (range: 6-102 months). Statistically significant poor clinical prognostic markers in our study are: age > 45 years, duration of symptoms > 12 months, sphincter disturbances, Harsh’s Spine Function Score < 8. Statistically significant poor radiological prognostic markers in our study are: Segmental stenotic index < 0.4, Occupancy ratio > 40%, when occupancy ratio is less than 40%: greater ‘range of motion’ is associated with greater severity of myelopathy, Spinal cord cross-sectional area < 42 square millimeters, MRI T2-Weighted hypertense signal changes, Antero-posterior cord compression ratio < 30%. Increased Trabeculo-Cortical ratios were found in patients from fluorotic zones.

Conclusion: 1. Patients from endemic fluorotic zones tend to present at more advanced stages of myelopathy with a worse outcome. 2. Patients from fluorotic zones have statistically significant increased Trabeculo-Cortical ratios as compared to those from non-fluorotic zones as well as normal subjects from fluorotic zones.

242. Multinodular/Multifascicular (Plexiform) Schwannomas of Major Peripheral Nerves: An Underrecognized Part of the Spectrum of Schwannomas

Marie-Noelle Hebert-Blouin, Kimberly K. Amrami, Bernd W. Scheithauer, Robert J. Spinner

Introduction: In the past twenty years, the clinical outcomes of schwannomas have improved based on resection of these tumors at a fascicular level. However, a subgroup of patients still have disappointing surgical outcomes (neurological deficits or subtotal resection) suggesting that schwannomas are more complex entities than is currently appreciated. This report describes patients with major peripheral nerve schwannomas with variable involvement of multiple fascicles as part of the spectrum of schwannomas in whom the imaging features, surgical findings and outcomes differ from conventional schwannomas.

Methods: The data from a subgroup of patients with complex major peripheral nerve schwannomas, treated by a single surgeon at our institution between 1998 and 2008, were reviewed. The clinical findings, imaging studies, operative findings, pathology specimens and clinical results were systematically reviewed.

Results: Ten patients were identified as having schwannomas affecting major peripheral nerves that differed from conventional schwannomas either by their imaging characteristics and/or surgical findings. Careful MRI analysis revealed imaging features in all tumors consistent with the plexiform elements encountered at operation, distinguishing them from conventional schwannomas. As only part of the lesion was resected in most cases, the systematic review of the pathologic specimens did not reveal significant histological differences in most tumors compared to conventional schwannomas.

Conclusion: This paper identifies a new subgroup of patients with multinodular/multifascicular (plexiform) schwannomas affecting major peripheral nerves. Upon close examination, this subgroup of patients differs from those with conventional schwannomas with respect to their clinical presentation, imaging, operative findings and clinical outcomes. These features can easily go unrecognized pre- and intra-operatively and explain suboptimal surgical results. Knowledge of and experience with the imaging features of the spectrum of schwannoma pathologies will help to identify this pathology pre-operatively, alter treatment approaches and improve neurological function in this important subgroup of patients.

243. Does the Presence of Low Back Pain Influence the Outcome of Lumbar Decompression Surgery in Spinal Stenosis?

Francois Porchet, Frank Kleinstück, Dieter Grob, Viktor Bartanusz, Friederike Lattig, Deszö Jeszenszky, Anne F. Mannion

Introduction: Decompression surgery is a common treatment for lumbar spinal canal stenosis, with generally good outcome. However, concomitant low back pain (LBP) at presentation can make it difficult to decide whether decompression alone will suffice. This prospective study sought to examine how the relative severity of LBP influences the outcome of decompression surgery.

Methods: The SSE Spine Tango system was used to acquire the data from 221 patients. Inclusion criteria were lumbar degenerative spinal stenosis, first-time surgery, maximum 3 affected levels and decompression as the only procedure. Before and 12 months after surgery, patients completed the multidimensional Core Outcome Measures Index (COMI, includes 0-10 leg/buttock pain (LP) and LBP scales), at 12 months, global outcome was rated on a Likert-scale and dichotomised into “good” and “poor” groups.

Results: In the “good” outcome group, mean baseline LP was 2.3 (± 3.7) points higher than LBP, in the “poor” group, the corresponding value was 0.8 (± 3.4) (p = 0.01 between groups). There was a significant positive correlation between baseline LP minus LBP scores and improvement in the multidimensional COMI score after 12-months (p = 0.03). Significantly fewer patients with back pain as their “main problem” had a good outcome (62% good) compared with those who reported leg/buttock pain or sensory disturbances to be their main problem (78%) (p = 0.03). In multivariate regression analyses (controlling for age, gender, comorbidity), baseline LBP intensity was the most significant predictor of the 12-month COMI score and LP-LBP intensity, of the global outcome (each p < 0.05).

Conclusion: Overall, patients in whom leg pain predominated over back pain showed significantly better outcomes after decompression. This finding seems intuitive, but has rarely been quantified in the many predictor studies conducted to date (1). Consideration of relative LBP and LP scores may assist in clinical decision-making and in establishing realistic patient expectations.
244. Surgical Management of Lumbar Synovial Cysts-to Fuse or Not to Fuse: A 65 Patient Experience and Review of Literature
Sid Chandela, Daniel S. Yanni, Noel I. Perin, Eric H. Elowitz, John K. Houten
Introduction: Lumbar synovial cysts represent degeneration of facet joints. Although the etiology is not well understood, underlying spinal instability correlates with cyst formation and worsening symptoms. Failure of conservative therapy warrants surgical treatment. Surgical options are resection and decompression with fusion or resection and decompression alone. The optimal surgical management of lumbar synovial cysts remains unclear. We present a single institution experience of 65 surgically treated patients with lumbar synovial cysts.
Methods: Retrospective data from 65 consecutive patients from July 2001 to October 2008 were analyzed. Twenty-five men (38%) and 40 females (62%) of mean age of 60.3 were studied with mean follow-up of 3 years (range 0-7 years). All pre-operative and post-operative signs and symptoms, flexion/extension and magnetic resonance imaging (MRI) were reviewed. All 65 patients were surgically treated by one of three surgeons based on individualized assessments and treatment plans. Surgical outcomes were based on McNabb scores 1-4 (1=excellent, 2=good, 3=fair, 4=excellent).
Results: All patients underwent minimally invasive resection and decompression. Five out of 65 patients (7%) were supplemented with stabilization and fusion. Two patients were initially treated with decompression alone and later progressed in instability requiring fusion. Ninety percent had good to excellent outcomes. Two patients progressed in symptoms requiring fusion. Four patients presented with synovial cysts at multiple levels. Two patients presented with bilateral cysts. There were no recurrences at the same side or same level. One patient had subsequent recurrence on the contralateral side at same level requiring fusion.
Conclusion: Minimally invasive resection of synovial cysts is safe and effective with low rate of fusion. We recommend decompression only and reserve fusion for specific criteria of progressive mechanical back pain and evidence of instability.

245. Interspinous Implants for Degenerative Lumbar Spine Disease: Experience with DIAM and APERIUS Devices
Anthony P. Fabrizi, Marcelo Galarza, Raffaella Maina
Introduction: The insertion of posterior lumbar dynamic devices is common procedure for the treatment of degenerative spine disease and lumbar stenosis. Clinical and radiographic results were assessed to determine the clinical outcomes and fusion rate in 1575 consecutive selected patients.
Methods: From 2000 through 2008, 1315 consecutive patients underwent “Device for Intervertebral Assisted Motion (DIAM)” and 260 had APERIUS PercLID “Percutaneous stand-alone Lumbar Interspinous Decompression System”. The main surgical indications included: symptomatic degenerative disc disease with foraminal stenosis (1060 patients), black disk and facet syndrome (240 patients), foraminal stenosis with disc herniation (211 patients) and topping-off syndrome (64 patients).
Results: 100 patients underwent a single level implant and 475 had a multiple level implant. Mean operating time was 35 minutes for DIAM and 7 minutes for APERIUS. At the mean 12-month follow-up assessment, all patients had solid bone fusions across the interspace. There was no sign of heterotopic ossification in any patient. No patient experienced migration of the intervertebral distracting implant on follow-up imaging. Complications were detected in 20 patients (10 cases of infections, 10 fractures of the posterior spinous process). 40 patients were subsequently treated with posterior arthrodesis (n=30) or total disk replacement (n=10). Patients’ post-operative clinical status was rated according to the modified Macnab criteria: symptoms resolution or improvement was achieved in 1505 patients and unchanged or unsatisfactory results in 70 in a mean post-operative time of 56 months.
Conclusion: We present our experience in DIAM implant over a decade and with APERIUS in patients with degenerative lumbar spine. Both techniques are safe, simple and less technically demanding. These approaches appear to be an effective alternative in selected cases, although conventional posterior lumbar decompression and fusion still may be required.

246. Predictors for Success or Failure of Conservative Treatment in Thoracolumbar Burst Fractures
Nader Suhaill Dahdahle, Yousaf K. Karam, Chandan G. Reddy, Patrick W. Hitchon
Introduction: Conservative treatment in patients with traumatic burst fractures remains a valid option. Predictors for either success or failure of conservative management in these patients are poorly studied.
Methods: Patients admitted for the treatment of thoracolumbar burst fractures at our institution between January 2001 and April 2008 were followed prospectively. All of the patients underwent thoracolumbar X-rays and CT Scans to assess angulation and residual canal. MRI scans assessed the integrity of the posterior ligamentous complex. Patients treated conservatively on initial evaluation and then discharged were analyzed and stratified into two groups: successes and failures.
Results: Out of 165 patients with burst fractures 34 patients (20.6%) were treated conservatively. Patients had a minimum follow-up of six months. 14 (41.2%) failed conservative management and required a surgical intervention. In 71.4% failure was declared by 4-12 weeks. These patients underwent either a corpectomy (8 patients), decompression with posterior fixation (3 patients) or vertebroplasty/kyphoplasty (3 patients).
In patients who were successfully treated conservatively, 85% had an intact exam and no pain at discharge. All of the failures had either neurological deficit (50%), or persistent pain (50%) at discharge.
Conclusion: In burst fracture patients treated conservatively, the presence of persistent pain, a neurological deficit, angulation > 10 deg and a residual canal < 50%. 50% of failures had an angulation of > 10 deg as opposed to 10% in the successful group. Angulation > 10 deg and a canal < 50% were also more prevalent in the failure group.

247. Age as a Potential Determinant of Disability Following Traumatic Spinal Cord Injury: Analysis of the Third National Acute SCI Study (NASCIS-3) Dataset
Julio C. Furlan, Michael Bracken, Michael G. Fehlings
Introduction: Given the increasing incidence of spinal cord injury (SCI) in the elderly (65 years of age or older), we sought to examine whether age is a key determinant of functional recovery after acute traumatic SCI.
Methods: Functional recovery was assessed at 6 weeks, 6 months and 1 year following SCI using Functional Independence Measure (FIM). Data analysis was performed using Fisher’s exact test, Mann Whitney U test and multiple linear regression. All patients who were enrolled in the Third National Acute SCI Study (NASCIS-3) trial were included.
Results: There were 499 patients (423 males, 76 females, ages 14 to 92 years with
Wound infection following surgery for neuromuscular scoliosis is more common than in other forms of scoliosis. The purpose of this study was to 1) determine risk factors for infection following corrective surgery for neuromuscular scoliosis and 2) report the causative organisms and the results of treatment.

Methods: A computerized database identified 151 patients with neuromuscular scoliosis who underwent corrective surgery and had a minimum of two years follow-up. From this group, 8 wound infections were identified and 72 patients, matched by year and type of surgery, were selected as controls. Pre-operative, intra-operative and post-operative factors were analyzed for any association with wound infection utilizing stepwise logistic regression. In addition, causative organisms as well as the methods and results of treatment were recorded for each infection.

Results: The study population consisted of 36 males and 44 females with a mean age at surgery of 13.3 ± 2.9 years (range, 7 to 21 years) and a mean follow-up of 55 ± 41 months (range, 24 to 251 months). There were no significant differences between the infection and control groups for age, Cobb angle, number of levels fused, operative time, blood loss or transfusion requirement. There were 8 wound infections (5 early, 3 late) in 151 patients (prevalence of 5.3%). Only the presence of a ventriculo-peritoneal shunt pre-operatively correlated with an increased prevalence of wound infection (p < 0.01). Infection was associated with pseudoarthrosis (p < 0.01) and an increased length of hospitalization (p < 0.01). The most common causative organism was staphylococcus aureus and the majority (88%) of infections required surgical intervention.

Conclusion: The presence of a ventriculo-peritoneal shunt pre-operatively is a significant risk factor for wound infection following corrective surgery for neuromuscular scoliosis. Wound infection in this population is associated with pseudoarthrosis and a significantly increased length of hospitalization.

249. Do Expandable Cages Improve Segmental Stability Following a Lumbar Corpectomy? An In Vitro Biomechanical Study

Anton E. Dmitriev, Melvin D. Helgeson, Mario J. Cardoso, Frederick L. Stephens, Ronald A. Lehman, Patrick B. Cooper, Michael K. Rosner

Introduction: Segmental instability following lumbar corpectomy remains a clinical concern. Therefore, we compared the biomechanical potential of two new expandable cages that offer the advantage of adjusting the implant height to fit the defect size, to a standard titanium mesh cage.

Methods: Lumbar male calf spines (n = 24) were obtained and randomized in three groups (n = 8/group): 1) Titanium mesh cage, 2) Expandable titanium cage, 3) Expandable PEEK cage. Following intact spine testing under axial rotation (AR), flexion/extension (FE) and lateral bending (LB) (±6Nm all planes), an L3 corpectomy was performed and an appropriate implant placed in the defect. Reconstructed spines were tested with the following additional instrumentation: L2-4 anterior plate, L2-4 pedicle screws + crosslink, L1-5 pedicle screws + 2 crosslinks. Full ROM (degrees) was measured across the L2-4 levels.

Results: No differences were observed between the three implants augmented with an anterior plate. However, FE ROM was significantly higher for the mesh constructs augmented with posterior fixation spanning either L2-4 or L1-5 compared to both expandable cages. Similar statistical differences were recorded in AR between Groups 1 and 3, while high ‘within group’ standard deviation precluded significance between Groups 1 and 2. Additional statistical analysis indicated that anterior plate fixation was weaker than L1-L5 pedicle screw augmentation for Group 1 in LB and Groups 2, 3 in LB and FE.

Conclusion: Expandable cages offer improved segmental stability over a standard mesh cage when augmented with posterior pedicle screws. These differences are diminished when using anterior only fixation. Furthermore, mesh cages augmented with the anterior plates offer decreased segmental stability than circumferential constructs.

250. Biomechanical Importance of the Anterior Longitudinal Ligament in a Corpectomy Model

Melvin D. Helgeson, Anton E. Dmitriev, Mario J. Cardoso, Frederick L. Stephens, Ronald A. Lehman, Patrick B. Cooper, Michael K. Rosner

Introduction: Surgical reconstruction options for lumbar corpectomies are problematic due to significant segmental instability. Our study evaluated the importance of the anterior longitudinal ligament (ALL) to determine its role in stabilizing lumbar segments using various instrumentation techniques following a corpectomy.

Methods: Twenty-four (24) bovine lumbar spines were tested intact under axial rotation (AR), flexion/extension (FE) and lateral bending (LB). An ALL sparing corpectomy was performed at L3 and specimens were randomized as follows (n = 8/group): Group 1: titanium mesh cage, Group 2: expandable titanium cage, Group 3: expandable PEEK cage. Instrumented specimens were tested with the following additional instrumentation: anterior plate, posterior pedicles screw fixation from L1 to L5 and posterior pedicle screw fixation from L2 to L4. Subsequently, the ALL was excised at the corpectomy site and the testing sequence repeated for all testing modalities.

Results: In Group 1 with posterior constructs, there was a significant increase in FE without the ALL. With an intact ALL in Group 1, the anterior construct had significantly more FE and LB than both posterior constructs. When using an expandable cage, there was no significant difference when comparing the same constructs before and after excision of the ALL. Regardless of the status of the ALL in Group 3, the posterior constructs significantly decreased FE compared to the anterior plate, with similar trends observed in group 2.

Conclusion: When using a titanium mesh, anterior cage with posterior pedicle screw instrumentation, the anterior longitudinal ligament offers significant biomechanical stability in FE. Conversely, there was no significant advantage in maintaining the ALL with the use of an expandable cage implant. Finally, circumferential instrumentation techniques consistently performed better than anterior stand-alone constructs.
Lamina screws have been reported to be a biomechanically sound alternative to gain fixation in the upper thoracic spine. However, concerns have been raised that midline catastrophic lamina screw failure may result in a spinal canal breach. Therefore, the following study evaluates both anatomically and biomechanically the midline failure of lamina screws within the proximal thoracic spine.

Methods: Nineteen fresh-frozen T1-T2 vertebrae were DEXA scanned for bone mineral density (BMD). Caliper measurements of lamina thickness, pedicle width and lamina-lateral mass width for bicortical purchase were obtained. Ten specimens had lamina screws inserted entirely within the lamina (unicortical). Nine specimens had lamina screws inserted breaching the cortex behind the 1st and 2nd rib necks (bicortical). Insertional torque (IT) was recorded while placing all implants and reported in “lbs-in.” Tensile loading to failure was performed midline to the vertebral plane. Pull-out loading was applied at a rate of 0.25mm/sec using a MTS 858 MiniBionix II System. Maximum pullout strength (POS) was recorded in Newtons. All specimens were evaluated with video fluoroscopy during testing and visually inspected to ascertain spinal canal breach.

Results: Neither the unicortical nor bicortical lamina screws violated the spinal canal during catastrophic midline failure. The ventral lamina cortex remained intact for both lamina screw techniques. All of the unicortical lamina screws resulted in dorsal avulsion of the spinous process and lamina. All nine bicortical lamina screws separated the dorsal lamina from the ventral, but were able to maintain lateral mass purchase. Peak IT for both lamina screw techniques was significantly greater than pedicle screws (p<0.05). However, unicortical lamina screw POS (462 ± 93 N) was significantly lower than forces recorded for the pedicle screws (659 ± 238 N) (p = 0.021). Bicortical lamina screw POS (595 ± 156N) was not significantly different from pedicle screw POS (629 ± 219 N) (p = 0.66). BMD showed a stronger correlation with pedicle screw POS (r = 0.71) than unicortical (r = 0.67) or bicortical (r = 0.47) lamina screw POS. The mean laminar thickness was measured at 7.3 ± 3.7mm and the mean lamina-lateral mass width was 37.7 ± 3.7mm.

Conclusion: Our results suggest that catastrophic midline failure of lamina screws does not result in spinal canal breach. Bicortical lamina screws have a biomechanical advantage over unicortical lamina screws as compared to pedicle screws.
Chordomas are rare and intra vertebral disc. Turbidity results show the minimally invasive survival. Included pain (Visual analog scale), quality months (7 to 65 months). Outcome metrics median dose 35 Gy (24.0-40 Gy) delivered tumor volume 128.0 cm3 (12.0-457.3 cm3), was 60 years (24-85 years). Tumor location primary adjuvant (17), only treatment (1) lesions in 28 treatments, with CK/SRS patients with chordoma were treated for 24 ratio support high dose irradiation hypofractionation and low predicted a/ß.

**Conclusion:** Chordomas are rare and intractable. We present a series of patients with chordomas, prospectively treated with CyberKnife® (Accuray, Sunnyvale, California) Stereotactic Radiosurgery (CK/SRS). We suggest that the safety, efficacy and quality of life profile of CyberKnife treatment and a low predicted a/ß ratio support high dose treatments in a hypofractionation regimen.

**Methods:** In an IRB approved study, 18 patients with chordoma were treated for 24 lesions in 28 treatments, with CK/SRS primary adjuvant (17), only treatment (1) or after previous irradiation (6). Median age was 60 years (24-85 years). Tumor location was mobile spine (44%), clival (39%), sacral (17%). Male/female ratio 1:1. Mean tumor volume 128.0 cm3 (12.0-457.3 cm3), median dose 35 Gy (24.0-40 Gy) delivered in five sessions. Median follow-up was 46 months (7 to 65 months). Outcome metrics included pain (Visual analog scale), quality of life (SF36), neurological exam and survival.

**Results:** There were three grade 2 complications in patients previously irradiated: infection (2), decreased vision (1). Neurological exam was maintained throughout, quality of life showed a trend to improvement, site specific pain was durably and statistically improved (p<0.05). At 65 months follow-up, there was recurrence in 7, disseminated disease in 4, reduction in tumor volume in 2 and stable disease in 9, local control rate was 59.1%, overall survival 74.3% and disease-specific survival was 88.9%. There was no recurrence for tumors receiving 37.5 Gy to the margin. Radiation sensitivity plots predicted an a/ß 2.45 Gy.

**Conclusion:** The safety, quality of life and efficacy profile of high dose hypofractionation and low predicted a/ß ratio support high dose irradiation hypofractionation for treatment of chordoma. We recommend 40 Gy in 5 sessions to the clinical treatment volume (CTV), including gross tumor volume (GTV) and margin at risk (1cm margin).

**301. Improvement in Segmental Lumbar Lordosis after Minimally Invasive Transforaminal Lumbar Interbody Fusion (TLIF)**

Jaypal Reddy Sangala, Frank LaMarca, Paul Park

**Introduction:** Minimally invasive transforaminal interbody fusion (TLIF) is an increasingly popular procedure for the treatment of degenerative spine disease. Its role in improving segmental lordosis and overall sagittal balance, however, has not been adequately addressed.

**Methods:** After institutional review board approval, we retrospectively reviewed 38 patients who underwent minimally invasive TLIF at L4-5, L5-S1, or L4-S1. Pre and post-operative radiographs were evaluated. Segmental lumbar lordosis from L4 to S1 was measured using segmental posterior tangent methods and the four-line Cobb angle technique. Pre-operative radiographs were compared to post-operative radiographs at 6 months. Surgical technique involved use of non-expandable tubular retractors with percutaneous pedicle screw placement. Interbody cage placement was performed after sequential disk space distraction.

**Results:** There were 22 females and 16 males. The age range was 18-76 years. The mean increase in lumbar lordosis measured between L4 and S1 was 7 degrees.

**Conclusion:** Improvement in segmental lumbar lordosis after TLIF appears to improve lumbar lordosis. The technique of sequential distraction of the disk space with use of a bullet nose self-expanding interbody cage is important. Further studies measuring global sagittal balance are needed.

**302. Injectable Chitosan for Sustained Drug Delivery to Treat Painful Radiculopathy**

Mohammed F. Shamji, Priscilla Hwang, Robert W. Bullock, Samuel B. Adams, Dana L. Nettles, Allan H. Friedman, William J. Richardson, Lori A. Setton

**Introduction:** Intervertebral disc herniation may cause painful radiculopathy by both mechanical compression and biochemical irritation of nearby neural structures. [1] Tumor necrosis factor alpha (TNFa) is a proinflammatory cytokine implicated in this pathology and while effective symptomatic treatment is achieved by systemic anti-TNF therapy, [2] patients are exposed to substantial immunosuppression and associated side effects. [3] There exists a need for a drug delivery vehicle that sustains release of locally-active therapeutics.

**Methods:** Chitosan is a biocompatible amionic polysaccharide that undergoes thermally-initiated gelation in cosolutions with glycerophosphate (GP). [4] This injectable vehicle entraps and slowly releases therapeutics upon local injection. Gelation time and temperature of chitosan/GP thermogels were evaluated by optical density readings (350 nm), as was the effect of bovine serum albumin (BSA) entrapment on the kinetics of this process. We investigated the in vitro release of BSA and various anti-TNF agents: curcumin (368 Da), sTNFRII (17 kDa) and anti-TNF antibody (150 kDa). In vitro activity of the released drugs was evaluated using an established bioassay.

**Results:** Turbidity results show the chitosan/GP thermogel achieves gelation at 37°C after 5-10 minutes, independent of protein loading from 0 to 3.75 mg per gel. Sustained BSA release occurred with 50% release at 7 days. All three anti-TNF therapeutics exhibited sustained release, with over 10% of both sTNFRII (Figure 1) and anti-TNF antibody remaining in the gels after 7 days. Each compound exhibited expected activity antagonizing TNF cytotoxicity in murine fibrosarcoma cells (Figure 2).

**Conclusion:** This study demonstrates that thermogelling chitosan/GP entrap and sustains the release of a broad range of anti-TNF agents. Such delivery of disease-modifying therapy could establish a drug depot to treat local inflammation implicated in radiculopathy. The breadth of molecular sizes demonstrates the system’s versatility and the slow and sustained release could protect the body against toxicities of systemic delivery.

**303. Fusing Four or More Levels? A Nationwide Perspective on the Treatment of Diffuse Cervical Spondylisis**

Mohammed F. Shamji, Chad Cook, Sean Tackett, Ricardo Pietrobon, Christopher Brown, Robert E. Isaacs

**Introduction:** Surgery for diffuse cervical spondylisis can vary based on disease pathoanatomy, surgeon experience and patient characteristics. More frequently, anterior decompression is performed over fewer levels in healthier patients, with posterior surgery offered to older, more comorbid patients under the belief that this approach is less complicated. Nevertheless, the choice between procedures remains ambiguous, particularly in the context of diffuse, multilevel disease. [1] This study challenged the perceived safety of posterior cervical spine fusion by comparing complications and resource utilization of each approach.

**Methods:** Data was collected from the...
Nationally In-patient Sample (2003-2005) database for 8548 patients who underwent multilevel cervical fusion for degenerative disease. Subjects were grouped by surgical approach (anterior vs. posterior) and multivariate regression evaluated group effects on selected post-operative complications, length of stay and discharge disposition (0.05 level of significance).

**Results:** While patient demographics were substantially different based on surgical approach, including age, Deyo comorbidity index and pre-operative neurological status, the results of this work suggest that posterior multilevel cervical fusion may still be more frequently complicated. This approach yielded a higher incidence of respiratory complications (2-fold), infections (7-fold), symptomatic hematomas (2-fold) and transfusions (5-fold) compared to the anterior approach. Further, those undergoing posterior surgery had a longer length of stay, a 50% higher inflation-adjusted cost and a substantially greater need for assisted living at discharge. Not surprisingly, however, this study confirms that patients fused posteriorly had a lower incidence of symptomatic post-operative dysphagia.

**Conclusion:** This work provides large-scale insight into the safety and cost of multilevel cervical spine fusion, compared between patients undergoing anterior and posterior surgery. While the lack of information about disease pathoanatomy may limit the conclusions from this work, the results suggest that immediate morbidity and resource utilization from anterior approaches is lesser when controlling for observed covariates.


**Introduction:** For the treatment of lumbar disc herniation, it remains unknown whether “aggressive” disc removal with curettage vs. “limited” removal of disc fragment alone affects recurrent disc herniation or long-term back/leg pain. We set out to determine whether a limited discectomy (LD) vs. aggressive discectomy (AD) results in better long-term outcome or lower rate of recurrent disc herniation and assess the healthcare costs associated with recurrent disc herniation.

**Methods:** Part 1: A systematic Medline search was performed to identify all studies published between 1980-2007 reporting outcomes after aggressive or limited discectomy for herniated lumbar disc. The incidence of long-term recurrent back or leg pain and recurrent disc herniation was assessed from each study. Part 2: We reviewed the charts and billing/accounting records of 156 consecutive patients undergoing “limited” single-level lumbar discectomy at our institution to identify the incidence and healthcare cost of symptomatic same-level recurrent disc herniation.

**Results:** Part 1: Fifty-four studies (60 discectomy cohorts) met inclusion criteria, reporting the outcomes of 13,359 patients after lumbar discectomy (LD:6,135 patients, AD: 7,224 patients). The cumulative incidence of recurrent back/leg pain was 2.5-fold less after AD (11.5%, range 7-16%) compared to AD (29%, range 19-37%), p < 0.0001. LD (7%, range 2-18%) was associated with 2-fold increase in the incidence of recurrent disc herniation vs. AD (3.5%, range 0.9-5.5%), p < 0.0001. Part 2: Twelve-months after surgery, 17 (10.9%) patients developed radiographically proven symptomatic same-level recurrent lumbar disc herniation. Eleven (7%) required revision surgery while 6 (3.9%) responded to conservative therapy alone. For 156 primary lumbar discotomies performed at our institution, the total cost associated with the management of recurrent disc herniation was $452,083 ($289,797 per 100 primary discotomies).

**Conclusion:** Review of the literature suggests that LD vs. AD is associated with marked decrease in incidence of long-term recurrent low-back pain despite increase in recurrent disc herniation. In our experience, there was substantial health care cost associated with recurrent disc herniation. Given reported outcomes to date, the combination of limited discectomy with annular closure may be warranted.

**305. Factors Associated with Recurrent Disc Herniation and Disc Height Loss after Primary Lumbar Discectomy: A Prospective Cohort Study**
Matthew McGirt, Timothy F. Witham, Sandro Eustacchio, Peter Varga, Milorad Velendecic, N. Eskinja, Martin Trummer, Miro Gorenske, Darko Ledic, Eugene Carragee

**Introduction:** The true incidence of same-level recurrent disc herniation following lumbar discectomy is unclear. Retrospective studies have reported widely varying incidences between 3%-18%. Prospective controlled studies examining incidence of re-herniation are lacking. We performed a prospective cohort study to assess incidence and factors associated with same-level recurrent disc-herniation.

**Methods:** 108 patients undergoing first-time lumbar discectomy for refractory radiculopathy were enrolled. Lumbar CT, MRI, back (BP-VAS) and leg (LP-VAS) pain scores and health-related quality of life measures (Medical-Outcomes-Short-Form-36 (SF-36) and Oswestry-Disability-Index (ODI)) were assessed pre-operatively, 6 weeks, 3, 6, 12 and 24 months after surgery. Patients were also assessed at the time of clinically significant recurrent sciatica. Pre-operative disc volume, volume of disc removed and size of annular defect seen at operation were compared with post-operative disc height loss and recurrent disc-herniation using regression analysis.

**Results:** One-hundred patients (41 ± 10 years-old) were available for one-year follow-up (93%) and 58 for two-year follow-up (54%). Mean follow-up: 19months. Operative level: L5-S1 (n = 46), L4-5 (n = 52) and L3-4 (n = 2). Improvement in all outcome measures was observed 6-weeks post-operatively (p < 0.05) and maintained through 12 months. Eleven (11%) patients experience recurrent disc-herniation requiring revision discectomy at median 11months post-operatively, Figure 3A. 18% loss of disc height was observed 3 months post-operatively, progressing to 26% height loss by 2years. Subjects with larger annular defects (p = 0.04) and those with smaller disk volume removed (p = 0.06) were associated with increased risk of recurrent disc-herniation.

Conversely, subjects in whom greater disk volumes were removed (p = 0.02) were associated with greater pain and symptom progression throughout 12-months. Disc height loss did not correlate with ODIorBP-VAS at any time point. However, patients requiring revision discectomy (mean 12 months post-operatively) demonstrated worsened 2-year ODI (33 vs.18, p < 0.05), LP-VAS (4.9 vs. 2.0, p < 0.05) and SF-36PCS scores (37.8 vs. 48.9, p < 0.05).

**Conclusion:** Same-level recurrent disc-herniation occurred in 11% of cases and was associated with worsened two-year outcome. Greater volumes of disc removal during discectomy was associated with accelerated disc height loss. Larger annular defects and less disc removal increased the risk of re-herniation. In the setting of larger annular defects, aggressive disc removal may be warranted.

**306. Surgical Management of Pediatric Tethered Cord Syndrome with and without Duraplasty: Neurological Outcome and Incidence of Retethering after 115 Consecutive Cases**

**Introduction:** The neurological outcomes
and retethering rates after first-time tethered cord release in the pediatric population are not completely understood. Furthermore, large pediatric series are sparse in the existing literature. To clarify the incidence, time-course and factors associated with neurological improvement and retethering, we reviewed our 10-year experience with pediatric tethered cord release.

**Methods:** We retrospectively reviewed 115 consecutive pediatric first-time cord untetherings. Incidences of post-operative motor, pain and urinary improvement and symptomatic retethering were evaluated via Kaplan-Meier. We assessed factors associated with neurological improvement and retethering.

**Results:** Mean age was 5.8 ± 4.9 years. Patient etiology included 21 (18%) lipomyelomeningocele, 26 (23%) fatty filum, 19 (17%) lumbosacral lipoma, 6 (5%) intra-dural tumor, 5 (4%) split cord malformation, 2 (2%) previous lipomyelomeningocele repair and 36 (31%) previous myelomeningocele repair. By 18 months post-operatively, 74% of patients improved urinary symptoms, 75% improved lower-extremity weakness and gait and 92% decreased painful dysesthesias. Patients with asymmetric lower-extremity weakness (p = 0.045, HR = 1.9) or perineal sensory dysfunction (p = 0.013, HR = 4.7) were more likely to experience improvement in motor and pain (p = 0.049, HR = 3.03). Thirty (26%) patients experienced retethering (median = 3 months post-operatively). Patients with fatty filum were least likely to experience retethering (p = 0.039, HR = 0.122). Duraplasty was not associated with retethering.

**Conclusion:** Cord untethering is associated with improvement in motor, sensory and urinary dysfunction in the vast majority of patients by 6 months post-operatively. Pain resolution occurred first, followed by urinary or motor improvement. Patients presenting with perineal sensory dysfunction or with asymmetric lower-extremity weakness had a greater likelihood of improvement and patients with fatty filum were least likely to re-tether. We found no difference in rates of retethering with duraplasty. Untethering for symptomatic tethered cord in the pediatric population is safe and effective. Prospective trials are needed to further evaluate outcome after retethering, however, this retrospective study will be useful in evaluating patient populations and managing post-operative expectations.

**307. Factors Associated with Long-term Neurological Outcome and Tumor Progression after Resection of Intramedullary Spinal Cord Tumors: Analysis of 101 Consecutive Cases**


**Introduction:** With introduction of electrophysiological spinal cord monitoring, radical resection of intramedullary spinal cord tumors (IMSCCT) can be achieved. However, factors associated with tumor respectability, tumor recurrence and long-term neurological outcome are poorly understood.

**Methods:** We retrospectively reviewed 103 consecutive cases of IMSCCT resection in adults and children at one institution. Neurological function and MRIs were evaluated pre-operatively, at discharge, 1 month after surgery and every 6 months thereafter. Factors associated with gross-total resection (GTR), progression-free survival (PFS) and long-term neurological improvement were assessed via multivariate regression-analysis.

**Results:** Mean age was 40 ± 18 years (pediatric: n = 17 [15%]). Pathology included ependymoma (n = 31), hemangioblastoma (n = 15), pilocytic astrocytoma (n = 16) and infiltrating astrocytoma (n = 21). GTR was achieved in 59 (58%) cases. Independent of histopathology, presence of intraoperatively identifiable tumor plane (OR: 25.1, p = 0.001) and decreasing tumor size (OR: 1.2, p = 0.05) was associated with increased odds of GTR. Thirty-four (34%) patients experienced acute neurological decline after surgery (greater likelihood with increasing age, OR:1.04, p = 0.02), 14 (41%) of which returned to baseline within one-month. Fifty-five (55%) patients maintained long-term neurological improvement by last follow-up (mean: 19 months). Motor, sensory and bladder dysfunction improved in a similar time course. PFS was months dependent on histopathology (p = 0.01). GTR vs. STR was associated with marked improvement in PFS for hemangioblastoma and ependymoma but was not associated with PFS for low-grade or high-grade astrocytoma. Presence of an intraoperatively identifiable tumor plane (OR:1.92, p = 0.05) and lack of tumor progression (OR:2.37, p = 0.057) independently predicted long-term improvement in neurologic deficits.

**Conclusion:** GTR can be achieved in the vast majority of IMSCCTs when intra-operative plane is identified, independent of pathology. GTR should be safely attempted for all cases of ependymoma or hemangioblastoma, but may not affect infiltrating astrocytoma PFS. Incidence of acute perioperative neurological decline increases with age, but will improve to baseline in nearly half of these patients within one-month. Long-term improvement in motor, sensory and bladder dysfunction may be achieved in the majority of patients, however, patients with identifiable surgical planes are most likely to experience long-term sustained neurological improvement.

**308. Scoliosis Progression after First-time Pediatric Spinal Cord Untethering: Risk Factors and Time Course for Progression and Fusion**

Matthew McGirt, Vivek Mehta, Giannina L. Garcés-Ambrossi, Edward Grant Sutter, Edward Sanghoon Ahn, Jon D. Weingart, Benjamin S. Carson, George I. Jallo

**Introduction:** Tethered cord syndrome (TCS) is frequently associated with scoliosis in the pediatric population. Following spinal cord untethering, many patients continue to experience progression of spinal deformity. However, incidence, time course and risk factors for scoliosis progression following tethered cord release remain unclear. We set out to determine factors associated with scoliosis progression and whether tethered cord release alone would halt curve progression in pediatric TCS.

**Methods:** We retrospectively reviewed 27 consecutive pediatric cases of spinal cord untethering associated with scoliosis. The incidence and factors associated with scoliosis progression (≥ 10° increased Cobb angle) after untethering was evaluated via Kaplan-Meier method.

**Results:** Mean age was 8.9 years old. All patients underwent cord untethering for lower extremity weakness, back and leg pain, or bowel and bladder changes. Mean ± SD Cobb angle at presentation was 47 ± 15°. Etiology of tethering included post-myelomeningocele repair in 14 (52%) patients, fatty filum in 4 (15%), lipomeningocele in 3 (11%), occult spina bifida in 3 (11%) and diastematomyelia in 2 (7%) patients. Mean ± SD follow-up was 6 ± 2 years. Thirteen (48%) patients experienced scoliosis progression occurring a median of 2.4 years post-operatively and 8 (29%) required subsequent fusion for progression. At time of untethering, scoliosis < 40° was associated with a 32% incidence of progression, while scoliosis > 40° was associated with an 88% incidence of progression, p < 0.01. Riser grade 0-2 patients were also more likely to experience scoliosis progression vs. Riser grade 3-5, p = 0.05. While nearly all Riser grade 0-2 patients with curves > 40° progressed (86%), 54% of Riser grade 0-2 patients with curves < 40° progressed and
Tethered cord syndrome

Mean age was 9.5 years-old (5

PLIF was performed in 76(63%)

post-operative outcomes were evaluated.

Introduction: Tethered cord syndrome (TCS) is frequently associated with scoliosis in the pediatric population. Conventional practice suggests waiting several months after untethering for scoliosis correction, however, many patients will continue to experience progression of their spinal deformity. Only a few cases of concurrent untethering and deformity correction have been reported to date. We report our series of scoliosis and/or kyphosis correction done concurrently with tethered cord release.

Methods: We retrospectively reviewed 15 consecutive pediatric cases of concurrent spinal cord untethering and fusion for scoliosis and/or kyphosis at the Johns Hopkins Hospital. The pre-operative presentation, peri-operative morbidity and post-operative outcomes were evaluated.

Results: Mean age was 9.5 years-old (5 male, 10 female). All patients underwent spinal cord untethering for lower extremity weakness or bowel and bladder changes. Mean ± SD Cobb angle at presentation was 64 ± 32°. Etiology of tethering included four patients with occult spina bifida, 5- lipomyelomeningocele, 3 status-post myelomeningocele repair and 2-tight filum. Ten (66%) patients presented with scoliosis only, 3 (20%) with kypho-scoliosis and 2 (13%) with kyphosis. Eight (53%) patients underwent both anterior and posterior fusion. Average fusion length was 9.4 ± 6 levels. Average post-operative curve was 38 ± 22° resulting in an average correction of 26 degrees. Average blood loss was 1100 cc [range: 400-3500cc]. Average length of hospitalization was 10 days [range:4-34 days]. Only one (7%) patient experienced a persistant peri-operative neurological deficit. 7 (87.5%) experienced improvement in their neurological TCS symptoms. By a mean ± SD follow-up of 5 ± 3 years, only 1 (7%) patient required subsequent fusion.

Conclusion: In our experience with pediatric spinal deformity associated with tethered cord syndrome of multiple etiologies, concurrent fusion and spinal cord untethering can be safely and effectively performed in a single staged procedure with acceptable blood loss, neurological injury and peri-operative morbidity. Concurrent fusion and untethering may be a safe surgical option even with complex tethered-cord etiologies.

310. Trans-laminar vs. Pedicle Screw Fixation of C2: Comparison of Surgical Morbidity and Accuracy of 313 Consecutive Screws


Introduction: C2-trans-laminar (TL) screws rigidly capture C2-posterior elements, avoid risk of vertebral artery injury and are less technically demanding than C2-pedicle (PD) screws. However, C2-TL screw breach places the spinal cord at risk and the durability of C2-TL screws remains unknown. It is unclear if TL vs. PD screw C2-fixture is associated with less operative morbidity, greater accuracy of screw placement or equivalent durability.

Methods: We retrospectively reviewed 167 consecutive cases of posterior cervical C2 fusion with either PD or TL screws. Peri-operative morbidity, breach of C2 lamina or pedicle on post-operative CT and operative revision rates were compared between PD vs. TL constructs in axial (C1-2 or C1-C3) and sub-axial (C2 and caudal) fusions.

Results: 152 C2-TL and 161 C2-PD screws were placed in 167 patients. Thirty-one (19%) cases of axial cervical fusion were performed (mean age:63.8±20.6 years) with either C2-TL[16(52%)] or C2-PD[15(48%)] screws. 136 (81%) cases of sub-axial cervical fusion were performed (mean age:57.9±14.7 years) with either C2-TL[66(49%)] or C2-PD[70(51%)] screws. For axial and sub-axial cervical fusions, baseline patient characteristics and all measures of peri-operative morbidity were similar between C2-TLvs.C2-PD. Eleven (7%) PD screws breached the pedicle (0 requiring acute revision) vs. 2 (1.3%) TL screws breached the C2 lamina (1 requiring acute revision), p = 0.018. By one-year post-operatively, pseudoarthrosis or screw pullout requiring re-operation was required in 4 (6.1%) patients with C2-TL screws vs.0 (0%) PD, p < 0.05 for subaxial constructs. No cases of C2-TL or C2-PD axial fusion had re-operation or screw pullout or pseudoarthrosis.

Conclusion: In our experience, radiographic breach of C2 pedicle screws occurred more frequently than C2 laminar screw breach. However, this was no associated morbidity increase. By 12 months post-operatively, C2-translaminar screws were associated with higher incidence of operative revision when used in sub-axial constructs but not axial cervical constructs. The one-year durability of C2-TL screws may be inferior to C2-PD screws for sub-axial fusions, but equally effective for axial cervical fusions.

311. An Institutional Experience with Trans-foraminal vs. Posterior Lumbar Interbody Fusion: Comparison of Surgical Morbidity and One-year Outcomes

Matthew McGirt, Vivek Mehta, Gianna L. Garces-Ambrossi, Scott Parker, Daniel M. Scibba, Ali Bydon, Jean-Paul Wolinsky, Ziya L. Gokaslan, Timothy F. Witham

Introduction: Posterior lumbar interbody fusion (PLIF) and trans-foraminal lumbar interbody fusion (TLIF) are accepted approaches for spinal fusion for spondylolysisis and degenerative disk disease. The unilateral approach of TLIF may minimize risk of iatrogenic durotomy and nerve root injury however, definitive evidence supporting either approach is lacking. We set out to determine whether TLIF vs. PLIF was associated with reduced operative complications and improved outcomes.

Methods: We retrospectively reviewed 119 consecutive cases of PLIF or TLIF performed for degenerative disc disease or spondylolisthesis at one institution. The incidence of operative and peri-operative complications and one-year resolution of back or leg pain were compared between surgical approaches.

Results: PLIF was performed in 76(63%) patients and TLIF in 43(37%). Mean age was 48.4±13.16 years-old and presented with mechanical back pain (92%), radicular pain (80%) and radicular motor weakness (8%). BMP was more frequently used with TLIF (35% vs. 11%). Otherwise, there were no differences in demographics, clinical presentation, spinal disease etiology, or operative variables between cohorts. Incidence of iatrogenic nerve root injury (7.8% vs. 2%) and durotomy (17% vs. 9%) were greater with PLIF vs. TLIF. All cases of nerve root injury were transient and returned to baseline by 3 months post-operatively. Length of hospitalization, estimated operative blood loss and all other measures of peri-operative morbidity were similar. By a mean follow-up of 1year, incidence and rate of improvement in back or leg pain was similar.

Conclusion: In our experience, TLIF was associated with decreased incidence of durotomy and iatrogenic nerve root injury compared to PLIF for patients with degenerative disc disease or spondylolisthesis. Both approaches were
Gross total resection of 180 patients underwent LM and 393 adults (37.8±11.3 years, 59 ± 19 years-old) with intramedullary tumors (11% vs. 11%).

Introduction: Gross total resection of intradural spinal cord tumors can be achieved in the majority of cases with preservation of long-term neurological function. However, post-operative progressive spinal deformity complicates outcome in a subset of patients after surgery. We set out to determine whether the use of laminoplasty (LP) vs. laminectomy (LM) has reduced the incidence of subsequent spinal deformity following intradural tumor resection at our institution.

Methods: We retrospectively reviewed the records of 238 consecutive patients undergoing resection of intradural tumor at a single institution. The incidence of subsequent progressive kyphosis or scoliosis, peri-operative morbidity and neurological outcome were compared between laminoplasty and laminectomy cohorts.

Results: 180 patients underwent LM and 58 underwent LP. Patients were 46 ± 19 years-old with median modified McCormick Score (MMS) of 2. Tumors were intramedullary in 102 (43%) and extramedullary in 136 (57%).

Conclusion: In our experience, laminoplasty for the resection of intradural spinal tumor was not associated with a decreased incidence of short-term progressive spinal deformity or improved neurological function. However, laminoplasty was associated with a three-fold reduction in incisional CSF leak. Longer-term follow-up is warranted to definitively assess the long-term effect of laminoplasty.

313. Biomechanical Comparison of Translaminar vs. Pedicle Screws at T1 and T2 in Long Subaxial Cervical Constructs
Matthew McGirt, Edward Grant Sutter, Risheng Xu, Daniel M. Sciubba, Timothy F. Witham, Jean-Paul Wolinsky, Ziya L. Gokaslan, Ali Bydon

Introduction: Thoracic pedicle screws have become gold standard for posterior spinal fixation and are frequently utilized in long sub-axial cervical constructs crossing cervico-thoracic-junctions. Recently, thoracic trans-laminar (TL) screws have been reported as an option for posterior fixation of the upper thoracic spine with less technical demand. In an in vitro biomechanical study, we compared the immediate and post-cyclical loading rigidity of thoracic TL vs. PD screw fixation in long sub-axial cervical constructs.

Methods: Ten fresh frozen nonosteoporotic human cadaveric spines underwent C4-6-lateral mass screw and T1-2-TL(n=5) vs. PD (n=5)screw fixation. Spines were then potted in polymethylmethacrylate bone cement and loaded in testing setup converting linear actuator displacement of a materials testing machine to 4Nm uniaxial pure moment bending. Angular displacement about axis of bending was measured using passive retroreflective markers and infrared motion capture cameras. The extent of angular displacement between C4 and T2 in flexion-extension and lateral bending was assessed un-instrumented, immediately post-instrumentation and following 40,000 cycles(1Hz) 4Nm flexion-extension and 40,000cycles(1 Hz) 4 Nm lateral bending.

Results: Compared to pre-instrumented spines, PDscrew constructs significantly reduced mean angular displacement during flexion-extension (0.58° vs. 0.19°, p<0.05) and lateral bending (37° vs. 17°, p<0.05). TLscrew constructs also reduced mean angular displacement during flexion-extension (76° vs. 28°, p<0.05) and lateral bending (40° vs. 25°, p<0.05). An increase in C4-T2 angular displacement occurred in instrumented spines after cyclic loading in both TL and PDscrew groups. With flexion-extension, mean angular displacement was greater within TL vs. PD screw constructs immediately after instrumentation (0.28° vs. 0.19°, p<0.05) and after cyclic loading (0.39° vs. 0.26°, p<0.05).

Conclusion: C4-T2 posterior fusion constructs utilizing thoracic TL vs. PD screws demonstrated inferior rigidity. While a partial loss of rigidity occurred after cyclical stress in both constructs, long cervical constructs utilizing thoracic laminar screws may provide less rigidity during the biological fusion period.
patients undergoing revision decompression, 15 (47%) experienced headache improvement and 26 (62%) experienced improvement in brainstem symptoms. **Conclusion:** In our experience, month-old adult patients with headache or brainstem symptoms improve after suboccipital decompression and < 10% require revision surgery. While the majority of patients improve after revision decompression, response rate is less than primary revision. Frontal headache, apnea and vertigo were symptoms more refractory to hindbrain decompression. Lack of duraplasty and CSF leak may be associated with increased treatment failure.

315. **Suboccipital Decompression for Chiari I Malformation: Outcome Comparison of Duraplasty with Expanded Polytetrafluoroethylene Dural Substitute vs. Pericranial Autograft**

Matthew McGirt, Frank Attenello, Giannina L. Garces-Ambrosi, Kaisorn L. Chaichana, Benjamin S. Carson, Edward Sanghoon Ahn, George I. Jallo

**Introduction:** Treatment failure for Chiari decompression is frequently associated with scarring, intradural adhesions and recurrent loss of hindbrain space. While autograft has been our standard for hindbrain duraplasty, we investigated whether introducing anti-adhesive synthetic Gore PRECLUDE® MVP® Dura Substitute (ePTFE graft) was associated with improved patient outcomes.

**Methods:** We retrospectively reviewed records of patients undergoing first-time suboccipital decompression/duraplasty for Chiari I malformation utilizing ePTFE graft or pericranial autograft. MRI at last follow-up was assessed for: 1) recurrent loss of dorsal hindbrain CSF space/CSF flow (cine-MR) at duraplasty site 2) pseudomeningocele, or 3) syringomyelia improvement. Symptom recurrence warranting revision surgery was compared between cohorts.

**Results:** Sixty-seven patients (age: 11 ± 5 years) underwent duraplasty with pericranial autograft (n = 40) or ePTFE graft (n = 27). Peri-operative morbidity did not differ between cohorts, Table 1. No patients receiving ePTFE graft experienced incisional CSF leak, surgical site infection, or symptomatic pseudomeningocele. At median eight months post-operatively, all (100%) patients with ePTFE graft maintained physiological CSF flow/decompressed hindbrain CSF space on cine-MRI vs. 32 (79%) patients receiving pericranial autograft (p < 0.05). Radiographic syrinx improvement occurred in 80% of patients with ePTFE graft and 52% of patients with pericranial autograft (median time to improvement: 5 vs. 12 months respectively, p < 0.05). At median 16 months post-operatively, 4 (10%) patients with pericranial autograft required revision decompression vs. 0 (0%) patients with ePTFE graft (p = 0.090).

**Conclusion:** Duraplasty utilizing ePTFE graft was associated with improved maintenance of hindbrain space, accelerated syringomyelia improvement and a trend towards decreased treatment failure vs. pericranial autograft. Future studies of long-term outcome are warranted to confirm observed effects. Synthetic ePTFE graft is a safe alternative for duraplasty in the setting of Chiari malformation.

316. **Pre-operative Radiographic Factors and Surgeon Experience Are Associated with Cortical Breach of C2 Pedicle Screws**

Daniel M. Scibbbu, Hassan Alosh, Clarke Nelson, Scott Parker, Ziya L. Gokaslan, Timothy F. Witham, Ali Bydon, Jean-Paul Wolinsky

**Introduction:** Stabilization of the cervical spine can be challenging when instrumentation involves the axis. Pre-operative assessment of computed tomography (CT) scans may indicate which patients are at increased risk for cortical breach during screw placement. In this study we attempt to identify radiographic variables associated with likelihood of intraoperative breach. In addition, we attempt to correlate surgeon experience with breach rate.

**Methods:** A retrospective review of all patients undergoing C2 pedicle screw fixation at a single institution over the last 6 years was conducted. Radiographic cortical breaches were defined on post-operative CT scans as visualization of the screw beyond the cortical edge. Radiographic measurements were determined from pre-operative CT scans and were then correlated with breaches via a student’s t-test. The association of breach rate with surgeon experience was evaluated using univariate linear regression.

**Results:** 93 patients underwent C2 pedicle screw fixation at a single institution over the last 6 years. Radiographic cortical breach during screw placement occurred in 21 (23%) patients. Cortical breach was significantly smaller in patients with breach than in patients without breach for measurements on CT scans ranging from 12 to 75 months. The following variables were associated with likelihood of cortical breach: (a) pedicle diameter of less than 6mm was associated with cortical breach (37% vs. 21%). Surgeons with a trend towards decreased treatment failure rate had performed fewer C2 pedicle screws (p=0.010, respectively. Specifically, a cortical breach was associated with size of pedicle and may be associated with size of pedicle and surgeon experience. Excessive pre-operative evaluation of CT scans and consideration of technical demands of procedure may help avoid complications with such internal fixation.

317. **Posterior Atlantoaxial Fixation Using C1-C2 Transarticular Screw and C1 Lateral Mass-C2 Pedicle Screw: A Comparison of Clinical Results in 55 Patients**

Sun-Ho Lee, Yeun-Mook Park, Whan Eoh

**Introduction:** This study compared the surgical results of the atlantoaxial fixation using a transarticular screw with those of polyaxial screw-rod system in the management of 55 patients with symptomatic atlantoaxial instability.

**Methods:** During a 6-year period, posterior C1-2 fixation was performed in 63 patients. Of these, 55 patients were followed-up for more than 12 months and were included in this study. C1-C2 transarticular screw fixation was carried out on 28 patients (group 1) and C1 lateral mass C2 pedicle screw fixation was performed on 27 patients (group 2). In 53 patients, permanent C1-C2 fixation was used to achieve atlantoaxial arthrodesis. In two patients with an odontoid fracture, the C1 lateral mass C2 pedicle screw fixation was applied as temporary fixation for a period of 4 to 6 months without using bone grafts or their substitutes. The clinical and radiological results were evaluated in the early post-operative period and at 3, 6 and 12 months after surgery, respectively. The long-term post-operative stability and bone fusion were also examined. The follow-up ranged from 12 to 75 months.

**Results:** In both groups, 93% and 96% of the patients were free of neck pain. The solid fusion rates of these patients were 82% and 96% at 12 months, respectively. Three cases showed fibrous union in group 1. Four cases had hardware failure due to a screw malposition (one in group 1) and pseudoarthrosis (2 in group 1 and one in group 2). One patient in group 1 had CSF leakage that healed with a lumbar drain secondarily. One patient in group 2 had occipital neuralgia related to surgery. Two vertebral artery injuries occurred while screwing in group 1 and another two injuries were encountered in group 2 during the muscle dissection.

**Conclusion:** The surgical results were excellent in both groups but slightly better in group 2.
Among several surgical strategies, cervical anterior discectomy with placement of a stand-alone cage (CADC) is a known and effective procedure. Intraoperative radiographic control is mandatory. To improve care for our patients we evaluated several steps within our usual care. One of them was the need for performing post-operative X-rays. In our spinal unit, plain radiographs (lateral, anterior-posterior) were taken in all patients that underwent a CADC the day after surgery, six weeks post-operatively and from then, at every outpatient clinic visit.

Methods: Retrospectively, the radiographic examinations and charts were reviewed of the patients who underwent a CADC in 2007. Apart from the normal baseline characteristics including the involved level and characteristics of the used cage, for each cluster of radiographs the following items were evaluated: the complaints of the patients (Odoms criteria), abnormalities at the radiographs (subsidence, infection, extrusion of the cage, wrong level, etc) and influence of the radiographic examination at medical or surgical treatment. The same was also done for a prospective cohort of patients who visited our outpatient clinic or were operated on in 2008.

Results: Although some X-rays disclosed an abnormality (subsidence), the X-Ray never altered or influenced the management of a patient.

Conclusion: It is recommended that standard plain radiographs are not made post-operatively in patients who underwent a CADC. Only for educational reasons or (in some countries) for medicolegal aspects, post-operative radiographs are mandatory.

319. Neurologic Recovery Following Thoracic, Thoracolumbar and Lumbar Spinal Cord Injuries

Introduction: Variations in spine anatomy should affect recovery from a traumatic spinal cord injury. Upper thoracic spinal cord injuries with limited blood supply due to a watershed region may explain why injuries there are more often complete. However, relatively less of the thoracolumbar spinal cord consists of ascending and descending cord tracts and trauma there might preferentially injure lower motor neurons, which have better prognosis for recovery.

Methods: Over a 10-year period between January 1995 and 2005, 1746 consecutive spinal injured patients were seen, evaluated and treated through a Level 1 trauma referral center. A retrospective analysis of the effect of anatomic location on neurological recovery was performed on 150 patients meeting the criteria of T4 to S5 injury, excluding gunshot wounds. One-year follow-up data was available on 95 of these patients.

Results: 89.3% of lumbar patients recovered one ASIA level or more, vs. 22-23% for thoracic or thoracolumbar patients. Only 9.4% of ASIA A patients recovered, while 95.2% of ASIA D did, ASIA B patients had 62.5% recovery, while ASIA C had 76.9% recovery. When the two effects were considered jointly in a multivariate analysis, ASIA A and thoracic/thoracolumbar patients had only a 4.1% rate of recovery, vs. 92% for lumbar and incomplete patients (ASIA B-D) and 72% -75% for the rest the patients. All of these relationships were significant to p < 0.001 (chi-square test). There was no link to age or gender and race and etiology were secondary to region and severity of injury.

Conclusion: Predicting patient outcomes is an important public health concern. Ongoing clinical and translational trials are only beginning to appreciate of the complexity of spinal cord regeneration. Combining all regions of the spine in spinal cord injury trials may be misleading as different regions recover at different rates.

320. Minimally Invasive Direct Repair of Lumbar Spondylolysis Using Pedicle Screw and Hook Construct
Daniel M. Scuibba, Joseph C. Noggle, Anthony Gregory, Amer F. Samdani, David Greg Anderson, Randal Betz, Jahangir Ashgar

Introduction: Lumbar spondylolisthesis occurs in approximately 6% of the population and presents with localized mechanical back pain, often in young athletes. Surgical treatment may involve decompression, lumbar inter-segmental fusion, or direct repair of pars defects. Although such open procedures may effectively resolve symptoms, minimal access approaches may additionally decrease collateral damage to soft tissues, allowing young active patients to resume athletic activities sooner. In this study, we review our experience repairing bilateral lumbar spondylolyses with screw and hook constructs placed via minimal access.

Methods: Five consecutive pediatric patients with bilateral L5 spondylolisthesis were treated. Bilateral incisions (2.5cm) were made over L5. Exposure was maintained with bilateral expandable tubular retractor systems. Pedicle screws were placed in the L5 pedicles and attached to hooks under the L5 laminae. A direct repair was performed at the pars defect. Clinical characteristics, operative variables and post-operative outcomes were collected.

Results: Five patients underwent surgery, four patients were male (80%) and one female (20%). Mean age was 15.8 years (range 15-17 years). Average estimated blood loss and duration of surgery were 37 cc (range: 15-75 cc) and 1.94 hours (range: 1-3 hrs), respectively. Post-operative hospital stays ranged from 1-3 days (mean: 1.8 d). The only complication occurred in one patient who experienced minor superficial wound breakdown. All patients have experienced resolution of symptoms at this preliminary stage, which has been over an 8-month follow-up period.

Conclusion: Lumbar spondylolisthesis can be adequately and safely treated via minimal access surgical repair of the pars interarticularis using pedicle screws and rod-hook constructs. This approach may decrease collateral soft tissue damage common to open dissections and may be ideal for young, active surgical candidates.
A major cause of death in patients with spinal metastases from prostate cancer is metastatic spinal disease. The study included 44 patients, of whom 23 patient records were available for analysis. Surgical treatment of lumbar fractures with transpedicular instrumentation may lead to the loss of correction and instrumentation failure because of deficient anterior column support. The aim of the present study is to report in a prospective series of five patients with a follow-up superior to one year, a novel technique that associates balloon kyphoplasty to augmented short transpedicular stabilization with fenestrated screws. The term Balloon Assisted Screw Augmentation (BASA) has been utilized. Five consecutive patients with an average age of 53 years, who sustained single lumbar A3-type burst fracture between January and September 2007 were included in this prospective study. On admission, three patients had neurologic lesion. Gardner kyphosis angle, anterior and posterior body height ratio, and canal encroachment were calculated before and after surgery. VAS and ODI were measured. Principal surgical steps are: 1. Neural structures decompression at the fracture level. 2. Cannulation of lumbar pedicles. 3. Bilateral balloon cavity creation and balloon deflation. 4. Fenestrated screws positioning in the balloon-created space through the same transpedicular approach. 5. PMMA cement delivery through fenestrated screws 6. Upper and lower level conventional transpedicular screwing.

Conclusion: Patients with NF1 and MPNST have a worse survival than patients without NF1 and improved survival is associated with low grade vs. high grade MPNST. Although the role of amputation remains controversial, our data suggest that early amputation may result in improved survival.

323. Balloon Assisted Screw Augmentation (BASA): A Novel Technique that Combines Balloon Kyphoplasty and Transpedicular Stabilization with Fenestrated Screws – Preliminary Clinical Study in Lumbar Fractures
Duccio Boscherini

Introduction: Surgical treatment of lumbar fractures with transpedicular instrumentation may lead to the loss of correction and instrumentation failure because of deficient anterior column support. The aim of the present study is to report in a prospective series of five patients with a follow-up superior to one year, a novel technique that associates balloon kyphoplasty to augmented short transpedicular stabilization with fenestrated screws. The term Balloon Assisted Screw Augmentation (BASA) has been utilized.

Methods: Five consecutive patients with an average age of 53 years, who sustained single lumbar A3-type burst fracture between January and September 2007 were included in this prospective study. On admission, three patients had neurologic lesion. Gardner kyphosis angle, anterior and posterior body height ratio, and canal encroachment were calculated before and after surgery. VAS and ODI were measured. Principal surgical steps are: 1. Neural structures decompression at the fracture level. 2. Cannulation of lumbar pedicles. 3. Bilateral balloon cavity creation and balloon deflation. 4. Fenestrated screws positioning in the balloon-created space through the same transpedicular approach. 5. PMMA cement delivery through fenestrated screws. 6. Upper and lower level conventional transpedicular screwing.

Results: All patients were followed for at least 12 months after index surgery. The three patients with incomplete neurologic lesions improved by at least one American Spine Injury Association grade, whereas no neurologic deterioration was observed in any case. Overall sagittal alignment was improved from an average pre-operative 16° to 1° kyphosis at final follow-up observation. The anterior vertebral height ratio improved from 0.5 before surgery to 0.9 after surgery, posterior vertebral body height was improved from 0.85 to 1. There was no instrumentation failure or measurable loss of sagittal curve and vertebral height correction at one year.

Conclusion: This preliminary report suggest that BASA can achieve a three-column reconstruction through a posterior approach. This technique provides short fixation in the lumbar spine with anterior support, biomechanical stability, height restoration, cement extravasation control with satisfactory clinical outcome.

324. Surgical Treatment of Prostate Cancer Metastases to the Spine
Brian Jeremy Williams, Benjamin Davis Fox, Daniel M. Scuibba, Dima Suki, Shi Ming Tu, Deborah Kuban, Ziya L. Gokaslan, Laurence D. Rhines, Ganesh Rao

Introduction: Metastatic spinal disease is a common consequence of prostate cancer. There have been few critical analyses of the surgical management of this disease. We report the results of a series of patients treated surgically for metastatic prostate cancer to the spine.

Methods: A retrospective review was performed of patients treated surgically for prostate cancer metastases to the spine from 1993 to 2005 at the M.D. Anderson Cancer Center.

Results: The study included 44 patients. The median age at surgery was 68 years (range 51-85). The median Gleason sum was 8 (2-10). The median number of extraspinal metastases at time of surgery was 5 (1-10). Twelve patients (27%) presented with acute (<1 week) neurologic deterioration. The month of common pre-operative Frankel grade was D (26 patients, 59%). Pre-operatively, 32 patients (73%) were walking and 33 (75%) continent. Frankel scores on discharge were significantly improved compared to pre-operative scores (p = 0.001). On discharge, 36/42 (82%) patients were walking and 37 (84%) continent. The median pre-operative ASIA motor score was 92 (50-100) and the median post-operative ASIA motor score was 97 (60-100). The median post-operative steroid dose was significantly lower than the pre-operative dose (16 mg vs. 0 mg, p = 0.001). The median post-operative opioid dose was significantly lower than the pre-operative dose (21.5mg vs. 12mg, p < 0.001). Complications occurred in 16 procedures (34%) with 9 (19%) major complications and there were two deaths (4%). The median overall survival was 5.4 months (95% CI 0.8-10.1). Significant multivariate predictors of survival included Gleason sum <8 (p = 0.002), <5 extraspinal metastases (p = 0.001), the absence of lymph node metastases at surgery (p = 0.04) and the degree (≥25%) of spinal canal compromise (p = 0.001).

Conclusion: We present a large series of patients with spinal metastases from prostate cancer and show that surgery can maintain neurologic function and minimize steroid and opioid use. We identify important predictors of survival that may guide treatment for a select group of patients.
Adequate decompression of rigid fusion is often difficult. Ultrasonic surgical aspirators (05S hand pieces (M&M Co., Ltd., Tokyo, Japan) to do laminotomy. After a tumor who underwent laminoplastic laminotomy and hemilaminotomy. We used a SONOPET UST-2001® ultrasonic bone curette with HB-05S hand pieces (M&M Co., Ltd., Tokyo, Japan) to do laminotomy. After a tumor

Introduction: Adequate decompression of the thoracic spinal cord often requires a complete vertebrectomy. Such procedures can be done from an anterior/transthoracic, posterior, or a combined approach. In this study, we sought to compare the clinical outcomes of patients undergoing anterior, posterior and combined thoracic vertebrectomies to determine efficacy and operative morbidity of such approaches.

Methods: A retrospective review of all patients undergoing thoracic vertebrectomy at a single institution over the last 6 years was conducted. Characteristics of patients and operative procedures were documented. Neurological status, perioperative variables and complications were assessed and associations with approach were analyzed.

Results: 105 patients (age: 54 ± 14 years) underwent vertebrectomy via anterior approach (23 [21.9%]), posterior approach [56 (53.3%)], or combined anterior-posterior approach [26 (24.8%)]. Underlying etiologies included tumor in 79 (75.2%), degenerative in 22 (21.0%) and trauma in 4 (3.8%) cases. The anterior approach cohort had a better pre-operative Nurick score (p = 0.005), otherwise, there were no differences in patient characteristics. Anterior approaches were associated with less blood loss than posterior (1100 ± 2000 mL vs. 2600 ± 2000 mL, p = 0.017) or combined approaches (1100 ± 2000 mL vs. 3200 ± 3000 mL, p = 0.022) but was associated with a similar length of stay (12 ± 9 days vs. 15 ± 7, p = 0.189). The anterior approach was associated with lower incidence of wound infection (4% vs. 18%, p = 0.049) and deep vein thrombosis (0% vs. 11%, p = 0.013). Duration of chest tube use was greater when combined vs. anterior alone procedures were done (9 ± 6 days vs. 5 ± 2 days, p = 0.011). Post-operatively, both groups improved neurologically, although function in posterior alone patients improved to a lesser extent.

Conclusion: Decisions regarding approach to thoracic vertebrectomy may be complex. In our experience, approach is likely influenced by pre-operative neurological status. Although patients may improve following decompression, such improvement is directly related to pre-operative neurological status. Complications occur more commonly in the posterior group, but this does not significantly alter length of stay or disposition.

Incidence of Flexible Cervical Kyphosis in Patients with Cervical Myelopathy
Michael P. Steinmetz, David Gwinn

Introduction: Addressing cervical deformity at the time of decompressive surgery for cervical myelopathy is essential to achieving good outcomes. Although poorly defined, flexible cervical kyphosis, unlike rigid kyphosis, is said to allow for posterior only surgical approaches. The purpose of this study is to establish the incidence and characteristics of flexible cervical kyphosis in the surgical myelopathy population.

Methods: Ninety-three charts of patients undergoing surgery for cervical myelopathy were reviewed. Pre-operative radiographs were analyzed with standard digital imaging software using two separate measures of cervical alignment. The incidence of flexible cervical kyphosis was calculated using each method and patient characteristics were statistically compared based on alignment group (flexible kyphosis, rigid kyphosis or lordosis).

Results: The incidence of flexible cervical kyphosis was statistically different (p < 0.05) utilizing the effective lordosis method (15.1%, 95% CI: 9.2 to 23.7) compared to the posterior tangent method (5.4%, 95% CI: 5.4 to 23.2). Dynamic spondylolisthesis, intersegmental kyphosis and/or posterior osteophytes were present in all patients who had lordotic angle measurements but loss of effective lordosis on neutral lateral radiographs in a single patient characteristic, including average age (56.7 years) and gender (57% female) were statistically different from patients with lordosis or rigid kyphosis.

Conclusion: This study establishes the incidence of flexible cervical kyphosis in patients with cervical myelopathy. No single patient characteristic studied was unique in regards to cervical alignment within this population. Radiographic methods which consider only the rostral and caudal subaxial vertebral angles may underestimate the true incidence of flexible cervical kyphosis as they do not consider intersegmental deformity.

Primary Clinical and Radiological Results Using a Hybrid Dynamic System for Spinal Fusion
Ely Ashkenazi, Ory Keynan, Michael Millgram, Nahshon Rand, Yizhar Floman

Introduction: Rigid fusion is often associated with adjacent segment disease. Dynamic devices have been recently developed to reduce this drawback. The aim of these systems is to reduce pressure on the level adjacent to the fusion and protect it from aggravated forces caused by the proximity to a fused level. Cable technology of the rod is designed to provide enough axial compressive stiffness to restore disc height and reduce loading across the intervertebral disc, CableRod flexibility under flexion/extension is designed to preserve motion of the functional unit while stabilizing the joint.

Methods: Between 2006 and 2008, 13 patients (6 females and 7 males) underwent surgery using the hybrid FlexPLUS system. Age ranged between 32 and 72 (mean 51). All patients underwent decompression and fusion with an adjacent level stabilization using a hybrid rod. Follow-up ranged between 6 and 24 (mean 13.5) months. All patients were evaluated by pre-operative and post-operative X-rays, CT scans, VAS and ODI.

Results: VAS score legs/back: pre-operative 8.2/9.3, post-operative 4.2/3.6. ODI: pre-operative 0.81 (severe disability), post-operative 0.36 (minimal disability). X-rays revealed no hardware failure or screw loosening. CT scans at 6 and 12 months post-operative and dynamic X-rays revealed solid fusion at the fused level and motion of 2 to 8 degrees (mean 3.4) at the adjacent (dynamic) level. None of the patients have shown deterioration at the adjacent level.

Conclusion: The results of our short experience shows that dynamic stabilization is an effective and safe procedure to treat lumbar degenerative disease, while preserving adjacent level from early degeneration. Our results after hybrid dynamic stabilization are very encouraging, however, our findings need to be confirmed by a prospective long-term study.

330. Safe and Minimally Invasive Laminoplastic Laminotomy Using an Ultrasonic Bone Curette for Spinal Surgery
Kiyoshi Ito, Shigetoshi Ishizaka, Tetsuo Sasaki, Takahiro Miyahara, Tetsuyoshi Horiuchi, Keiichi Sakai, Kazuhiro Hongo

Introduction: Ultrasonic surgical aspirators have been used mainly for removing brain tumors. Because of their longitudinal and torsional tip, they are used for cutting the bone structures in spinal surgery installing a scalpel-type tip. The purpose of this report is to describe effectiveness and surgical pitfalls of an ultrasonic bone curette in laminoplastic laminotomy and hemilaminotomy.

Methods: The authors present 12 patients who underwent laminoplastic laminotomy and hemilaminotomy. We used a SONOPET UST-2001® ultrasonic bone curette with HB-05S hand pieces (M&M Co., Ltd., Tokyo, Japan) to do laminotomy. After a tumor
was removed, titanium plates were used for the laminoplasty laminotomy and hemilaminotomy. We examined the surgical procedure for preventing dural tear using this device. The technical advantage of an ultrasonic bone curette and procedure-related complication were examined.

**Results:** There were no major procedure-related complications such as cord injury. Wound infection and subcutaneous fluid collection caused by cerebrospinal fluid leakage did not occur for reconstruction of posterior bony structure. In one patient with calcified dura mater associated with a tumor, dural tear occurred. The width of the tip was narrow enough for resected laminae to be fused post-operatively and spinal instability, postlaminateky kyphosis and postlaminate scar did not occur in all cases. All patients with at least 6-month follow-up had a tendency of fusion of the resected laminae on the computed tomographic scan.

**Conclusion:** The scalpel-type ultrasonic bone curette is useful for cutting bone and effective for reconstruction of the laminae. Laminotomy with an ultrasonic bone curette is safe and minimally invasive. To prevent dural tear, we recommend drilling laminae to make the bone thin as the first step, followed by cutting the remaining laminae using a bone curette especially in cases with calcified or tense dura mater.

### 331. Telemedicine: Advancing Care for Spinal Surgery

Penny Susan Seibert, Caitlin Otto, Missy Coblentz, Nichole Whitener, Christian G. Zimmerman

**Introduction:** Telemedicine technologies offer an innovative approach to enhance health care in hospitals, professional offices and homes. Many applications exist including increased specialist support for rural practitioners, optimized patient and medical staff education/training, improved access to patient records and greater capabilities for patient monitoring. Healthcare delivery to rural locations is often limited by lack of efficient communication technology, isolated location and limited access to healthcare specialists. An American College of Emergency Physicians (2004) study found that 57% of rural hospitals reported a shortage of specialists. Even when rural hospitals have acute care surgeons available, these physicians are often reticent to perform surgeries in subspecialty areas such as neurosurgery. Also, better outcomes may be achieved when specialists assess and perform the procedures in cases such as a potential spinal instability and evacuation of an intracranial mass. Though rural areas are monthst severely impacted, metropolitan areas also are experiencing increasing neurosurgical demands that will grow exponentially as the U.S.’s aging population rises. Telemedicine may help relieve the paucity of neurosurgeons in both rural and urban areas.

**Methods:** We compiled information gleaned from three broad domains to advance evidence based guidelines: 1) existing literature, 2) applications from our telemedicine program of research and 3) sources delineating available technology.

**Results:** We report an overview of the benefits, opportunities and challenges when evaluating the potential for spinal surgery telemedicine applications. We also provide information regarding developing telemedicine applications across multiple domains, including reimbursement for telemedicine, credentialing and licensing, liability for physicians and gaining physician and medical staff support.

**Conclusion:** Telemedicine is a way to enhance rather than replace healthcare. Research is needed to demonstrate evidence based telemedicine practice, efficacies and pathways for acceptance. Neurosurgeons have the skills and expertise needed to effectively contribute to telemedicine development.

### 332. Immune Cytokine Stimulation of Pathological Human Intervertebral Disc Cells Creates an Inflammatory Phenotype

Mohammed F. Shamji, Antonia Helbling, J. Chen, Liufang Jing, Robert E. Isaacs, Christopher Brown, William J. Richardson, Lori A. Setton

**Introduction:** Pathological intervertebral disc tissue (IVD) exhibits infiltrating macrophages and lymphocytes, [1,2] with higher proinflammatory cytokine expression than in autopsy controls. [3,4] Expression and spontaneous production of IL-6, IL-12 and IFNg, further suggests Th1 pathway immune activation. [5,6,7] The contribution of the Th17 pathway to IVD pathology remains uninvestigated and this study evaluated expression of IL-17, IL-23 and other inflammatory mediators in degenerative and herniated IVD tissues to explore this question.

**Methods:** Surgical IVD tissues were procured from patients with degenerative disc disease (n = 25) or herniation (n = 12). Immunohistochemistry was performed for cell markers (CD68 macrophage, CD4 lymphocyte) and various inflammatory mediators (IL-4, IL-6, IL-12, IL-17, IL-23, IFNg). Cellularity and antigen positivity were evaluated to consensus by two graders viewing 9 fields per sample for each target. Repeated-measures ANOVA tested differences in cytokine immunoreactivity between groups. Repeated-measures chi-square test evaluated differences in cellularity.

**Results:** Greater expression of IL-4, IL-6, IL-12 and IFNg was observed in herniated compared to degenerative disc tissue (p < 0.05). The fraction of positive fields was low for these cytokines. Conversely, Th17-related cytokines, IL-17 and IL-23,
were frequently present, although expression frequency did not differ between groups. Macrophage surface antigens were prevalent in both groups, more so among herniated samples (p < 0.05) and lymphocyte surface antigens were scarce. Tissue cellularity was higher herniated tissue (chi-square test, p < 0.05).

**Conclusion:** The higher prevalence of IFNγ-positivity, macrophage presence and cellularity in herniation samples suggests a role for Th1 lymphocyte activation with monocyte recruitment. The very high pathological tissue expression of IL-17 and IL-23 is novel and suggests involvement of alternative inflammatory pathways. In other tissues, IL-17 upregulates inflammatory mediators including PGE2 and NOx and further work will determine the biological responses of IVD cells to IL-17 stimulation.

**334. Biomechanical Evaluation of A New AxiaLIF Technique for Two Level Lumbar Fusion**
Chunhui Wu

**Introduction:** Single level axial lumbar interbody fusion (AxiaLIF) using a transsacral rod through a paracoccygeal approach has been developed with promising early clinical results and biomechanical stability. Recently, the transsacral rod has been extended to perform two-level fusion at both L4-5 and L5-S1 levels (AxiaLIF 2L). Although limited clinical trials suggest that this is a safe and feasible procedure, no biomechanical studies have been conducted on multi-level fusion using the AxiaLIF technique. In this study, the biomechanics of L4-S1 motion segments instrumented with the AxiaLIF 2L transsacral rod was evaluated. Six human cadaveric lumbosacral spine segments from L4 to S1 were used (age range 46-74 years).

**Methods:** Unconstrained and nondestructive pure moments in axial torsion lateral bending and flexion extension were applied to each specimen following intact, standalone AxiaLIF 2L and AxiaLIF 2L with two posterior fixation options: facet screws and pedicle screws with rods. Range of motion was calculated from raw data collected with an optical motion tracking system.

**Results:** The two level transsacral rod was successfully inserted in all specimens. At L4-L5 level in axial torsion (AT) and flexion-extension (FE), none of the three surgical treatments were statistically significant (all P > 0.05) although facet screws and pedicle screws tended to have higher stability. In lateral bending (LB), the two posterior fixation techniques had significantly higher construct stability (P < 0.05) than the standalone rod. No significant difference was found between facet screws and pedicle screws (P = 0.821) in all directions. At L5-S1 level in AT and LB, none of the surgical treatments were found to be statistically significant (all P > 0.05). In FE, standalone two-level transsacral rod had significantly higher range of motion (ROM) compared with the posterior fixation techniques (P < 0.05).

**Conclusion:** In conclusion, two-level transsacral rod fixation through a paracoccygeal approach offers the advantage of maintaining strong ligamentotaxis forces as a result of an intact annulus. Although the data didn’t show that supplementary posterior fixation, e.g. facet screws and pedicle screws, offered statistically greater stability, they appear to achieve a higher construct stability to aid in a successful fusion. Further clinical studies are essential to evaluate the practical success of this technique.

**335. The Use of X-STOP in the Management of Radiculopathy from Degenerative Lumbar Scoliosis**
Marlon S. Mathews, Grant Sorkin, Jennifer Roger, Eric P. Roger, Marygrace Hagan

**Introduction:** The Use of X-STOP in the Management of Radiculopathy from Degenerative Lumbar Scoliosis.

**Methods:** Between April 2007 and June 2008 five patients aged 72, 78, 77, 65 and 91 years (Cases #1, 2, 3, 4 and 5) underwent placement of an X-STOP device for radiculopathy from degenerative lumbar scoliosis with foraminal stenosis. Two of the five cases (#2, 5) had canal stenosis on imaging. Four patients presented with L4 radiculopathy (#1, 2, 4, 5) and bilateral or unilateral radicular involvement in one case (#3). Four cases had lateral listhesis on imaging (#1, 2, 4, 5) while one also had retrolisthesis (#2). All patients complained of back pain and Claudication. One case (#2) had undergone previous surgery (L3-4 and L4-5 foraminotomy, L4-5 disc extraction). Prior to implantation of X-STOP, four cases (#1, 3, 4, 5) underwent selective nerve blocks at the L4 level with transient relief of leg pain, confirming etiologic level of radiculopathy.

**Results:** Four cases (#1, 3, 4, 5) underwent X-STOP placement at L4-5 interspinous level and one at L3-4 (#2). After intervention, the patients reported 90%, 25%, 75%, 80% and 100% improvement in leg pain respectively at a median follow-up of 6.8 months (range = 1mo-13mo) with discontinuation of narcotic pain medicines. There were no immediate or delayed procedure related complications.

**Conclusion:** X-STOP may be a useful adjunct in the management of patients with focal radiculopathy from degenerative lumbar scoliosis. Our results suggest that the procedure may be safe and effective for relief of leg pain in appropriately selected patients. Further study is necessary to determine long-term benefit and complication rates.

**336. Minimally Invasive Laminotomy in the Treatment of Acquired Lumbar Spinal Stenosis: A 105-Patient Prospective Study**
Mario Ganau, Fulvio Adorni, Enrico Piovano, Enrico De Micheli

**Introduction:** To evaluate the effectiveness of laminotomy in the treatment of acquired lumbar spinal stenosis, a prospective study on 105 patients with no previous lumbar spine surgery has been conducted.

**Methods:** On admission, each patient underwent clinical evaluation using the Beaufort Scoring System (BSS) and VAS scale, radiography, CT and/or MRI studies of the lumbar spine were performed in all cases pre-operatively and 12 months following surgery. Outcome was evaluated in two stages: at discharge using the BSS and VAS scales and at long-term follow-up time (12 months minimum) using a four-grade scale (grade I-excellent, II-good, III-fair, IV-poor).

**Results:** Fifty-eight percent of patients were operated at a single spinal level and 42% at multiple levels, for a total of 154 stenotic levels treated. Laminotomy was performed unilaterally in 88% of patients and bilaterally in 19% of them. At discharge, clinical improvement assessed by BSS and VAS scales was significant in all patients, at long-term follow-up time, 71% of patients were in excellent, 22.9% in good, 4.8% in fair and 1.9% in poor conditions. Following surgery the lumbar spinal canal diameters (anteroposterior, transpeduncular, interapophyseal) were significantly larger than the pre-operative measurements and no cases of vertebral instability were found. The presence of comorbidities (i.e. rheumatoid arthritis, scoliosis and osteoporosis), the female gender, an age older than 65 years and a low pre-operative BSS score significantly reduce the chance to obtain a long-term excellent clinical outcome.

**Conclusion:** The results of our study indicate that laminotomy, a more tailored and less invasive technique than wide laminectomy, is a valid surgical option in the treatment of acquired spinal stenosis. Laminotomy should be recommended particularly in patients with fragility of the spine, where it is important for surgeons to preserve spinal stability.
Julio C. Furlan, Michael Bracken, Michael G. Feihling

Introduction: Experimental studies indicated a potential detrimental effect of administration of ethanol on tissue sparing and locomotor recovery in animal SCI models. Given this, we examined whether BAC is a key determinant of survival, neurological and functional recovery after acute traumatic SCI.

Methods: All patients who were enrolled in the third National Acute SCI Study (NASCIS-3) were included. The study population was divided into: “no-alcohol”, “legal” (BAC greater than 0 but equal/lower than 0.08%) and “illegal” (BAC greater than 0.08%). Outcome measures included survival, NASCIS motor and sensory scores, NASCIS pain scores and Functional Independence Measure (FIM) at baseline and at 6 weeks, 6 months and 1 year post-SCI. Analyses were adjusted for major potential confounders: age, gender, ethnicity, trial protocol, Glasgow coma score, cause, level and extent of SCI.

Results: There were 499 patients (423 males, 76 females, ages 14 to 92 years, mean of 35.7) who received 24-hour methylprednisolone, 48-hour methylprednisolone or 48-hour tirilazad mesylate. The mean BAC was 0.054 ± 0.006% (range: 0 to 1%). The survival at 1 year (94.4%) was not associated with the BAC (log-rank test: p = 0.374). BAC was not significantly correlated with motor recovery (p > 0.166), sensory recovery (p > 0.323), change in pain score (p > 0.312) and functional recovery (p > 0.133) at 6 weeks, 6 months and 1 year post-SCI.

Conclusion: Despite pre-clinical animal work suggesting a potential deleterious effect of alcohol on neurological outcomes post-SCI, BAC at time of injury did not have a detrimental effect on the patients’ mortality, impairment or disability within the first year post-SCI.

338. Cadaveric Allograft Infused with Autogenous Bone Marrow for Anterior Cervical Discectomy and Fusion
Daniel L. Master, David J. Hart

Introduction: Cadaveric allograft infused with autogenous bone marrow may be the ideal graft material for patients undergoing multi-level ACDF to avoid the donor site morbidity associated with autologous graft harvest. The purpose of this study was to evaluate the efficacy of this graft material for both single and multi-level ACDF.

Methods: Patients who underwent single or multi-level ACDF with bone marrow-infused cadaveric allograft and dynamic anterior plating were retrospectively reviewed. Patients with less than twelve months of follow-up, rheumatoid arthritis, bone marrow abnormalities or a history of tobacco use were excluded. Outcome measures included fusion rate, time to fusion, visual analog scores (VAS), change in sagittal alignment and percent graft collapse.

Results: The study population consisted of 55 patients (28 females, 27 males) with a total of 108 fusion levels (see Table 1 for diagnoses). Mean age at surgery was 56 ± 12 years (range, 34 to 83). At last follow-up (range 12 to 38 months), there was a 94% fusion rate with a mean time to fusion of 4.70 (4.05, 5.35) months. The mean difference between pre-operative and latest follow-up VAS scores for neck pain was 4.83 (4.61, 5.05) points and for arm pain was 4.90 (3.95, 5.85) points (see Table 2 and Figures 1 and 2). Mean difference in cervical sagittal alignment from pre-operative to latest follow-up radiographs was 1.39 (1.28, 1.49) degrees representing a 6.23 (5.83, 6.63) percent overall lordotic correction. Finally, mean graft collapse was 8.06 (6.26, 9.86) percent.

Conclusion: Bone marrow infused cadaveric allograft yields clinical and radiographic results comparable to autologous iliac crest bone grafting for both single and multi-level ACDF. However, this new technique avoids the morbidity associated with autogenous bone grafting and the cost associated with BMP while still providing osteoinductive substrate for fusion.

339. Significant Reduction in Infection Rates in Minimally Invasive Lumbar Fusions, Decompressions and Discectomies using Minimally Invasive Techniques
J. Frederick Harrington, Patrice French

Introduction: Minimally invasive procedures promise less pain and shorter hospital stays compared to traditional surgery. An additional benefit may be a lower infection rate, with smaller incisions and less dead space post-operatively.

Methods: Infection rates from 101 minimally invasive lumbar one and two level fusions, 78 one to 3 level laminectomies and 98 lumbar discectomies from a single surgeon’s practice using the Atavi system were compared to contemporaneous infection rates for the same procedures performed by other surgeons at the same institutions.

Results: For fusion, the infection rate was 1% for minimally invasive fusions and 5.8% for open fusions. For laminectomies, the infection rate was 0% for minimally invasive techniques and 2.1% for open. For minimally invasive techniques, there was a 1% infection rate for minimally invasive and 1.6% for open.

Conclusion: CONCLUSIONS: Minimally invasive procedures confer a lower rate of infection. The differences are particularly significant in fusion procedures.

340. Is There a Resident Learning Curve for Minimal Access TLIF? 
Chris J. Neal, Michael K. Rosner

Introduction: Minimal access TLIF has gained popularity as a method to obtain an interbody fusion from a posterior only approach while minimizing injury to adjacent tissue. While many studies have reported successful outcomes, questions remain regarding the potential learning curve to successfully complete this procedure. The goal of this study was to determine if there is a significant learning curve based on a single resident’s experience to performing a minimal access TLIF.

Methods: We performed a retrospective review of all minimal access TLIF’s performed by a single neurosurgical resident surgeon from July 2006 to January 2008. Minimally invasive TLIF’s were performed using a tubular retractor inserted via a muscle-dilating exposure to limit approach-related morbidity. Accuracy of screw placement and operative times were assessed.

Results: A total of 28 minimal access TLIF cases were performed by a single resident/attending team. Sixty-five screws were placed from a resident perspective (L2-1, L3-2, L4-18, L5-27, S1-17). Post-operative CT’s were reviewed to determine screw placement accuracy. An accuracy of 62/65 (95.4%) was noted on post-op imaging. Two screws (case 17 at L5 and case 9 at S1) were lateral and no revision was needed. One screw (case 24 at L4) was 1mm medial without symptoms or need for revision. In evaluating operative times, 2 deformity cases (Grade IV spondylolisthesis) were excluded. The average operating time per level for the remaining 26 cases was 113.25 minutes. The average time per level for the first 13 cases was 121.2 minutes. This decreased to 105.3 minutes for the second group of 13 cases (p = 0.25).

Conclusion: In summary, minimal access TLIF can be safely performed in a training environment without a significant complication rate from the expected learning curve.
341. **Learning Curve for Placement of Thoracic Pedicle Screws in the Deformed Spine**  
Amer F. Samdani, Ashish Ranade, Menacham Yondorf  
**Introduction:** Placement of thoracic pedicle screws, particularly in the deformed spine, poses unique challenges and surgeons experience a learning curve. We sought to determine the in vivo accuracy as determined by computed tomography (CT) of placement of thoracic pedicle screws in the deformed spine by a single surgeon over time.  
**Methods:** After obtaining IRB approval, we retrospectively selected the first 30 consecutive patients who had undergone a posterior spinal fusion for adolescent idiopathic scoliosis (AIS) by a single surgeon. The average patient age was 14 years and the average pre-operative thoracic Cobb angle 62.6 degrees. These patients were divided into three groups: A) Patients 1-10 (the first 10 patients operated on by a single surgeon), B) patient numbers 11-20 and C) patient numbers 21-30. Post-operative CT scans were evaluated by two spine surgeons and a consensus read established.  
**Results:** A total of 553 thoracic pedicle screws were studied (Group A = 181, B = 189, C = 183) with 64 graded as out (medial = 35, lateral = 29), for an overall breach rate of 11.6%. When the breach rates were stratified by the surgeon’s evolving experience, there was a temporal decrease in the breach rate (Group A = 15.5%, B = 10.6%, C = 8.7%, P < 0.05). This decreased breach rate was reflected by fewer medial breaches over time (medial breach rate Group A = 9.4%, B = 5.8%, C = 3.8%, P < 0.05). Similar trends were observed for the concave periapical screws (A = 21.2%, B = 16.2%, C = 10.5%), although statistical significance was not attained. One patient from Group A (the first 10 patients) returned to the operating room on post-operative day 2 for removal of an asymptomatic left T7 thoracic pedicle screw abutting the aorta.  
**Conclusion:** The overall accuracy of placement of thoracic pedicle screws in the deformed spine was 88.4%, with no neurologic or visceral complications. As surgeon experience increases, there is an overall decreased breach rate, which is mainly reflected in fewer medial breaches.

342. **Treatment Options for Infantile Idiopathic Scoliosis: Single Institution Experience with 32 Patients**  
Amer F. Samdani, Jason R. Smith, Joshua M. Palys, Ashish Ranade, Jahangir Asghar, Patrick Cahill, Randal Betz  
**Introduction:** There is a paucity of data on treatment results for patients with idiopathic infantile scoliosis (IIS). We sought to retrospectively review our experience in treating these patients, particularly as newer technologies, such as vertical expandable prosthetic titanium rib (VEPTR), emerge.  
**Methods:** This is a retrospective study evaluating the treatment methods used to manage 32 consecutive patients with IIS at a single institution. Patients were screened to ensure there were no confounding congenital anomalies or comorbidities that might contribute to the spinal deformity. The average age at time of initial treatment was 25 months. Treatment modalities included bracing, serial body casting and VEPTR. Pre-treatment, post-treatment and most recent Cobb angles were compared to assess the overall curve correction and patient charts were reviewed for complications.  
**Results:** Seventeen patients were treated with a brace, 9 of whom demonstrated curve progression and went on to other forms of treatment. Of the 8 that did respond to bracing, there was an overall improvement of 54.1%. The 11 casted patients, with a mean pre-operative Cobb angle of 42.9°, demonstrated an average correction of 54% and only a few skin irritations were reported. The 9 patients treated with VEPTR devices demonstrated an average pre-operative Cobb angle of 76.8° and an average correction of 33.9%. Three patients (33%) experienced minor complications.  
**Conclusion:** Our results suggest that casting has utility for appropriately selected patients, i.e. those with smaller, flexible curves. Bracing had little utility, with high levels of progression and the need for secondary treatments. VEPTR appears to be a viable alternative for curves of large magnitude.

343. **In Vivo, Comparative, Single-Cycle Biomechanical Properties of Chopped Carbon Fiber PEEK Rods in Lumbar Fusions**  
Harlan J. Bruner, Yabo Guan, Frank Pintar, Narayan Voganandan, Dennis J. Maiman  
**Introduction:** The senior author has performed 110 minimally invasive lumbar interbody fusions at one or two spinal levels using the Atavi system allograft bone and BMP-2. Eight patients have developed delayed new unilateral radicular symptoms despite uncomplicated surgery. Patients with persistent symptoms have been offered a minimally invasive foraminotomy.  
**Methods:** One-hundred-and-one minimally invasive lumbar interbody fusions at one or two spinal levels using the Atavi system allograft bone and BMP-2. Some patients have developed delayed new unilateral radicular symptoms despite uncomplicated surgery. All patients underwent CT and MRI in the post op period. Patients with persistent symptoms have been offered a minimally invasive foraminotomy.  
**Results:** All eight patients undergoing minimally invasive reoperation had at least 80% relief in leg pain one month after surgery. Intraoperative findings were loose foraminal facet fragments in 3, 2 foraminal stenoses, two foraminal disc fragments and one medial pedicle screw. Only 3 of 4 bone fragments were radiologically detected.
pre-operatively, only one of 2 foraminal stenoses were detected and neither disc herniations were detected pre-operatively. Surgeries averaged 52 minutes and blood loss averaged 10 cc.

**Conclusion:** Patients with post op radicular pain in a single lower extremity after uncomplicated minimally invasive interbody fusions will demonstrate root compression despite frequently negative radiological reports. Minimally invasive foraminotomy can salvage outcome with minimal risk to the patient.

### 346. Intradiscal Electrothermal Therapy in the Treatment of Chronic Low Back Pain: Experience with 93 Patients

Shao-Ching Chao, Chiung-Chyi Shen, Hsi-Kai Tsou, Hsi-en Te Chen

**Introduction:** Low back pain (LBP) has become a main cause of absenteeism and disability in industrialized societies. Chronic LBP is an important health issue in modern countries. Discogenic LBP is one of the causes that result in chronic low back pain. The management of chronic discogenic LBP has been limited to either conservative treatment or operative treatment. Intradiscal electrothermal therapy (IDET) is now being performed as an alternative treatment.

**Methods:** Ninety-three consecutive patients undergoing IDET at 134 disc levels from October 2004 to January 2007 were retrospectively evaluated. Sixty-four patients were reated at the Department of Neurosurgery of Taichung Veterans General Hospital in Taiwan and twenty-nine patients were reated at the Department of Orthopedic Surgery of China Medical University Hospital in Taiwan. All patients, as determined by clinical features, physical examination and image studies had discogenic disease with chronic LBP and failed to improve with conservative treatment for at least 6 months. Follow-up period was from one week to three years post-operatively. All patients were followed up at least 1 year, except 2 patients underwent successive lumbar surgery and 2 patients were lost to follow-up.

**Results:** There were 50 male and 43 female patients, whose mean age was 46.07 years (range 21-65 years). The results were classified as symptom free (100% improvement), better (~50% improvement), slightly better (<50% improvement), unchanged and aggravated. 89 patients were followed up in the first week, 77 patients (86.5%) improved (4 were symptom free, 45 better and 28 slightly better). The improvement rate gradually decreased to 80.9% in one year and 73.9% in three years.

**Conclusion:** In conclusion, IDET offers a safe, minimally invasive therapy option for carefully selected patients with chronic discogenic LBP who have not responded to conservative treatment. Although IDET appears to provide intermediate-term relief of pain, further studies with long-term follow-up are necessary.

### 347. Cross-Link Technique in C1-Lateral Mass/C2-Translaminar Screw Fixation in Patients with Loss of C1 Ring Integrity: An Innovative Technique

Grant Sorkin, Marlon Mathews, Jennifer Roger, Eric P. Roger

**Introduction:** The use of cross-linking devices for additional stability in posterior spinal instrumentation is well documented. However, cross-linking of C1-lateral mass/C2-translaminar screws is difficult due to the obliquity of the rods. C1-C2 cross-linking would be especially desirable in patients with open C1-ring fractures. The authors report on the efficacy and short-term outcomes of cross-linking atlantoaxial stabilization in two patients with C1-rings fractures.

**Methods:** Between March 2007 and September 2008 two patients aged 71 and 83 years underwent placement of C1-lateral mass/C2-translaminar screws with a cross-link device to compensate for loss of C1-ring integrity. Vertex Max instrumentation (Medtronic, Memphis, TN) was utilized. One patient was myelopathic at presentation. Both had type II odontoid and C1-Jefferson fractures. Both cases presented with non-union after attempted external immobilization, were unstable on flexion-extension films and presented with severe midline cervical tenderness.

**Results:** The technique involves the standard cervical cross-link, with use of side-connectors on each rod. The cross-link is attached to a side connector on each end, rather than the rod itself. Intraoperatively, there was obvious increased stability with the addition of the cross-link. Both patients had excellent radiographical outcomes and reported significant improvement in functionality, decreased cervical tenderness and significant improvement of myelopathic findings at a median follow-up of 12 months.

**Conclusion:** Addition of a cross-link to C1 lateral mass and C2 trans-laminar screw constructs may improve stability in patients with C1 ring compromise (Jefferson fracture).

### 348. Maintenance of Kyphosis Correction in Thoracic and Lumbar Burst Fractures Treated with Short Segment Pedicle Screw and Plate Fixation Utilizing Intermediate Screws at the Fractured Level

John P. Eickman, Charles L. Branch

**Introduction:** Treatment of thoracic and lumbar burst fractures remains controversial. The initial experiences with short segment pedicle screw fixation were characterized by relatively high rates of implant failure. Recent studies have observed recurrent kyphosis post-operatively with short segment pedicle screw constructs. We sought to examine initial sagittal deformity correction and post-operative maintenance that correction in the treatment of thoracic and lumbar burst fractures with contemporary short segment pedicle screw and plate constructs.

**Methods:** We reviewed all patients with thoracic or lumbar burst fractures treated with short-segment titanium pedicle screw and plate fixation (DynaLock Classic or CD Horizon Engage, Medtronic Sofamor Danek) over an eight-year period. Fixation consisted of segmental constructs that included bilateral pedicle screws at the fractured level as well as screws one level superior and inferior. Fracture subtype was classified according to the Magerl/AO system. Compression and wedge fractures were excluded. Sagittal plane deformity was measured by Cobb angle from pre-operative CT reconstructions and post-operative radiographs.

**Results:** Twenty patients with an average age of 42.9 years (range 20-72 years) were treated with a mean follow-up period of 10.0 months (range 3.1-39.8 months). Mean initial operative correction in Cobb angle for all fractures was 9.5°. Post-operative loss of kyphosis correction was 4.5° and 5.1° for type A3.1 and A3.2 fractures respectively. However, correction loss for type A3.3 fractures was 10.4°. No hardware failures or new post-operative neurologic deficits were observed.

**Conclusion:** Short segment pedicle screw and plate fixation can be successfully used to treat type A3.1 and A3.2 burst fractures with tolerable post-operative correction losses superior to several published series. However this construct was unable to adequately achieve deformity correction with the more severe type A3.3 fractures for which we recommend either longer segmental posterior instrumentation or an anterior approach.

### 349. Prevalence of Concurrent Lumbar and Cervical Arthrosis: An Anatomic Study of Cadaveric Specimens

Daniel L. Master, Jason D. Eubanks, Nicholas U. Ahn

**Introduction:** Lumbar and cervical arthrosis are common radiographic findings which have both been linked to pain. However, the prevalence of and temporal relationship between combined lumbar and cervical arthrosis has not been defined. The purpose of this study was to determine the prevalence of combined lumbar and cervical arthrosis in a large population sample and examine its association with age, sex and race.

**Methods:** The lumbar and cervical...
segments from 234 cadaveric spines were examined by a single investigator for evidence of endplate and facet arthrosis. Arthrosis at each endplate and facet was graded on a continuum from 0 to IV. Race, age at death and sex of each specimen was recorded. Stepwise multiple linear regression was used to analyze any association between race, age, sex, lumbar arthrosis and cervical arthrosis. Factors with p-values < 0.05 remained in the analysis. T-tests for matched samples were used to analyze any difference between the mean lumbar and cervical arthrosis severity among patients within the same decades of life.

Results: Concurrent lumbar and cervical arthrosis was present in 80% of the study population. Stepwise multiple linear regression revealed significant (p < 0.01) associations between lumbar arthrosis and cervical arthrosis and between age and cervical arthrosis. Race and sex did not correlate with lumbar or cervical arthrosis. In addition, patients in age groups 20-29, 30-39, 40-49, 50-59, 60-69, 70-79 and 80-89 demonstrated more severe (p < 0.01) lumbar arthrosis in comparison to cervical arthrosis.

Conclusion: Concurrent lumbar and cervical arthrosis is a common condition. Lumbar arthrosis and advancing age are associated with cervical arthrosis independent of race and sex. Lumbar arthrosis precedes cervical arthrosis. These findings suggest an underlying systemic component for spinal osteoarthritis.

Daniel L. Master, Jason D. Eubanks, Nicholas U. Ahn

Introduction: Cervical endplate and facet arthrosis are common radiographic findings which have both been linked to pain. However, the prevalence of and temporal relationship between cervical endplate and facet arthrosis has not been well defined. The purpose of this study was to determine the prevalence of and relationship between cervical endplate and facet arthrosis in a large population sample.

Methods: The cervical vertebrae from 234 cadaveric spines were examined by a single investigator for evidence of endplate and facet arthrosis. Arthrosis at each endplate and facet was graded on a continuum from 0 to IV. Race, age at death and sex of each specimen was also recorded. Stepwise multiple linear regression was used to analyze any association between race, age, sex, endplate arthrosis and facet arthrosis. Factors with p-values < 0.05 remained in the analysis. T-tests for matched samples were used to analyze any difference between mean endplate and facet arthrosis severity scores among patients within the same decades of life.

Results: Concurrent cervical endplate and facet arthrosis was present in 77% of the study population. Stepwise multiple linear regression revealed significant (p < 0.01) associations between endplate and facet arthrosis and between age and facet arthrosis. Race and sex did not correlate with facet arthrosis. In addition, patients in age groups 30-39, 40-49, 50-59, 60-69, 70-79 and 80-89 demonstrated more severe (p < 0.01) endplate arthrosis in comparison to facet arthrosis.

Conclusion: Concurrent cervical endplate and facet arthrosis is a common condition. Cervical endplate arthrosis and advancing age are associated with cervical facet arthrosis independent of race and sex. Cervical endplate arthrosis precedes facet arthrosis.

351. Accuracy of Thoracic Pedicle Screw Placement in Adolescent Idiopathic Scoliosis: How Much of a Difference Does Surgeon Experience Make?
Amer F. Samdani, Jahangir Asghar, Ashish Ranade, Daniel M. Scibbba, Patrick Cahill, Darryl Antonacci, David Clements, Randal Betz

Introduction: The in vivo accuracy as determined by computed tomography (CT) of placement of thoracic pedicle screws in the deformed spine as a function of surgeon experience is unknown. We sought to determine the effect of surgeon experience on the accuracy of thoracic pedicle screw placement in adolescent idiopathic scoliosis (AIS).

Methods: Fifteen consecutive AIS patients treated with a posterior spinal fusion and a post-operative CT were selected stratified by attending surgeon experience (N = 45): (A) < 20 cases of all pedicle screw constructs for AIS, (B) 20-50 cases and (C) > 50 cases. A total of 856 thoracic pedicle screws were studied. Post-operative CT scans were evaluated by two spine surgeons and a consensus read established as follows: 1) Intraoperative placement or < = 2 mm breach, 2) Out: > 2 mm breach, either medial or lateral.

Results: 104/856 screws demonstrated a > 2 mm breach for an overall rate of 12.1% (medial = 55, lateral = 49, P = 0.67). When the breach rates were stratified by surgeon experience, there was a trend toward decreased rate of breach for the most experienced surgeons, although this did not attain statistical significance (A: 12.7%, B: 12.9%, C: 10.8%, P = 0.58). However, the most experienced group (C) had a markedly decreased rate of medial breaches (3.5% vs. 7.4% and 8.4% for Groups A and B, respectively, P < 0.01). The breach rate for the concave periapical screws was not statistically different from the overall breach rate (13.0% vs. 12.1%, P = 0.93).

Conclusion: The overall accuracy of placement of pedicle screws in the deformed spine was 87.9% with no neurologic, vascular or visceral complications. Meticulous technique allows spine surgeons with a range of surgical experience to accurately place thoracic pedicle screws in the deformed spine. The most experienced surgeons demonstrated the lowest rate of medial breaches.

352. Vertebroplasty and Kyphoplasty for the Treatment of Vertebral Compression Fractures: An Evidence Based Review of the Literature
Matthew McGirt, Scott Parker, Jean-Paul Wolinsky, Timothy F. Witham, Ali Bydon, Ziya L. Gokaslan

Introduction: Vertebroplasty (VP) and kyphoplasty (KP) are routinely utilized to treat vertebral body compression fractures (VCFs) resulting from osteoporosis or vertebral body tumors to provide rapid pain relief. It remains debated whether VP/KP results in superior outcomes vs. medical management alone in patients experiencing VCFs. We set out to determine level of evidence supporting VP/KP for treatment of VCFs via a systemic literature review.

Methods: We reviewed all papers published between 1980-2008 reporting outcomes after VP/KP for osteoporotic or tumor-associated VCFs and rated the level of evidence and grades of recommendation (per NASS guidelines) supporting the use of VP/KP for the treatment of VCFs.

Results: Seventy-four VP studies for osteoporotic VCF (1 level I, 3 level II, 70 level IV), 35 KP studies for osteoporotic VCF (2 level II, 33 level IV) and 18 VP/KP for tumor VCFs (all level IV) were reviewed. There is good evidence (level I) VP results in superior pain control within the first two weeks of intervention compared to optimal medical management for osteoporotic VCFs. There is fair evidence (level II-III) VP results in less analgesia use, less disability and greater improvement in general health compared to optimal medical management within the first three months after intervention. There is fair evidence (level II-III) by two years after intervention, VP provides a similar degree of pain control and physical function as optimal medical management. There is fair evidence (level II-III) KP results in greater improvement in daily activity, physical function and pain relief compared to optimal medical management for osteoporotic VCFs by 6 months after intervention. There is poor quality evidence VP/KP results in greater pain relief for tumor-associated VCFs.

Conclusion: While evidence suggests physical disability, general health and pain relief is better with VP/KP than with medical management within the first three
months randomized trials with 2-year follow-up are needed for confirmation. Furthermore, the reported incidence of symptomatic procedure-related morbidity for both VP/KP is very low.

353. Bilateral VEPTR to the Pelvis: A Novel Treatment for Scoliosis in the Growing Spine
Amer F. Samdani, Ashish Ranade, Henry J. Dolch, Reed Williams, Tricia St. Hilaire, Patrick Cahill, Randal Betz

Introduction: Few options exist for the treatment of severe early onset scoliosis. Goals of treatment include stabilizing curve progression while allowing for normal spine, chest and lung growth. The Vertical Expandable Prosthetic Titanium Rib (VEPTR) is a novel device designed to control the spine deformity while allowing for lung and spine growth. In this paper, we report our experience with bilateral VEPTR from ribs to pelvis for children with severe early onset scoliosis.

Methods: We identified 11 children who had been treated with bilateral VEPTR from ribs to pelvis. The following data were retrospectively reviewed: clinical diagnosis, age at surgery, number of lengthenings and complications. In addition, pre- and post-operative x-rays were reviewed to measure maximum Cobb angle (both thoracic and lumbar), thoracic height, total spine height as measured from T1-S1, thoracic kyphosis (T2-T12) and lumbar lordosis (L1-S1).

Results: Average age at surgery was 5 years + 11 months with a pre-operative thoracic Cobb angle of 81.7°. This corrected to 50.6° immediately post-operatively and this correction was maintained, with curves averaging 54° at month 1 visit. Similarly, the kyphosis (T2-T12) measured 43° pre-operatively, 23° on first erect film and 32° at month 1 visit. The patients underwent a total of 27 lengthenings (average 2.5/patient) and overall spine length increased from 23.1 cm pre-operatively to 27.3 cm at final follow-up. Four of the eleven patients (36.4%) experienced a complication.

Conclusion: The VEPTR offers a viable treatment option for children with severe early onset scoliosis. It achieves and maintains spine deformity correction while allowing for continued spine and chest wall growth. Complication rates are similar to those reported for other growing systems.

354. Surgical Trunk Rotation Correction in Patients with Moderate Thoracic AIS (< 75°): An All Pedicle Screw Construct with Derotation Is Better than Thoracoplasty
Amer F. Samdani, Jahangir Asghar, Daniel M. Scuibba, David Clements, Patrick Cahill, Darryl Antonacci, Randal Betz, Harms Study Group

Introduction: Thoracoplasty with spinal fusion has been used to treat thoracic rotational deformity associated with AIS. More recently, the use of pedicle screw fixation and the subsequent development of techniques for axial derotation have allowed for correction of the chest wall deformity. To date, no studies have compared the residual rib prominence and percent correction in patients with thoracoplasty (TP) vs. all pedicle screw and direct vertebral body derotation (VBR).

Methods: Our AIS database was reviewed for patients with structural thoracic curves treated with PSF and thoracoplasty with a hybrid hook and screw construct or direct vertebral body derotation with an all pedicle screw construct. Patients had to have a thoracic Cobb angle of < 75° and pre-operative and post-operative scoliometer readings done at two years. 122 patients were included; 103 patients in the TP group and 89 patients in the VBR group. The scoliometer readings were compared between the groups for pre-op thoracic curve magnitude, flexibility, or scoliometer reading.

Results: The mean pre-operative scoliometer reading was similar between the two groups (TP 19.8, VBR 19.1, p = 0.41), as was the mean post-operative scoliometer reading (TP 7.25, VBR 6.15, p = 0.29). However, the percent correction showed a trend toward statistical significant difference with 61.4% correction in TP group and a 67.8% in the VBR group (P = 0.14). Moreover, when comparing the subgroup (VBR: n = 27, TP: n = 19) of patients with a curve magnitude < 75° and thoracic curve flexibility of > 50%, the percent correction of the rib prominence showed a significant difference, with 67.2% correction in the TP group and 80% in the VBR group (P = 0.047).

Conclusion: At two years, for all curves the percent corrections between the VBR and TP groups in correcting rib prominence are statistically similar. However, those whose thoracic curves had flexibility > 50%, the percent correction of the rib prominence was statistically greater in the vertebral body derotation group.

355. Clinical Efficacy of Purely Cortical Lateral Mass Screws for Posterior Cervical Fixation
Naresh P. Patel, Barry D. Birch, Eric W. Nottmeier

Introduction: Lateral mass fixation has been used to address cervical spine instability for a variety of pathologies including degenerative disease, tumor, infection and trauma. Current instrumentation designs employ cancellous polyaxial lateral mass screws connected to titanium rods. Screw backout and failure has been reported as a complication of lateral mass fixation, especially in elderly, osteoporotic individuals. The lateral mass in the cervical spine is predominantly cortical bone in older individuals with little cancellous bone available for screw purchase. We describe the use of a purely cortical screw rod system for posterior cervical fixation in this population.

Methods: Using a purely cortical screw-rod system (Oasys, Stryker Spine), 232 cortical lateral mass screws were implanted in 28 patients over a 4-year period of time. Ages ranged from 60 to 84 years old. Pathology included degenerative disease, trauma and infection. Patients were followed for at least one year with interval cervical plain x-rays and/or CT scans with sagittal reconstructions at 2 weeks, 3 months and one-year post-operatively.

Results: All radiographs and CT scans were reviewed by board-certified radiologists. There were no screw backouts or loosening, and no evidence of other hardware related complications. One patient developed a superficial wound infection that did not require hardware removal. Another patient developed a new unilateral painless CS palsy which was confirmed by CT scan to be unrelated to screw placement. There were no adverse reactions to the hardware and no other significant complications.

Conclusion: The cortical nature of the lateral mass makes cortical screw fixation a natural choice for posterior cervical stabilization. Excellent screw purchase was achieved initially and subsequent one-year follow-up shows durable results. The use purely cortical lateral mass screws for older individuals appears to be a viable alternative to traditional cancellous screws.
356. Association Between Cervical Vertebra Dynamic Factors and Unilateral or Asymmetrical Symptoms in Upper Limbs in Patients with Cervical Disk Disease

Toshitaka Seki, Rokuya Tanikawa, Toshihide Sugimura, Naoto Izumi, Takahiro Maeda, Tetsuro Sameshima, Toshiyuki Tsuboi, Masayori Masuya, Masaaki Hashimoto

Introduction: In order to determine the onset mechanisms responsible for unilateral or asymmetrical neurological symptoms in upper limbs in cervical disk diseases, we performed 3-Dimension Computed Tomography (3D-CT) in the neutral and retroflexed positions. We then examined the association between cervical vertebrae dynamic factors with the onset of the neurological symptoms.

Methods: We selected 12 patients with unilateral or asymmetrical neurological symptoms in their upper limbs from 37 patients who underwent anterior decompression and fusion or posterior decompression to treat cervical disk diseases between January 2007 and September 2008. Subjects comprised 11 males and 1 female between the ages of 28 to 70 (average 51.3). These represented five cases of mono-segmental fusion and 7 cases of bi-segmental fusion. Surgery was performed for 2 cases at C4-5 level, 10 cases at C5-6 level and 7 cases at C6-7 level. Aquilion 16 TXS-10A/GB (Toshiba Medical Systems) was used for the 3D-CT imaging. CT was performed at a 0.5 mm slice thickness for the neutral and retroflexed positions, after which we performed volume rendering. The level of disease in intervertebrae was assessed from clinical symptoms and MRI results. The inclination between vertebral bodies was measured and compared (unilateral spondylolisthesis) by drawing a line perpendicular to the line which connected the transverse processes of each vertebral body on the 3D-CT frontal view. We also examined instabilities such as misalignment or gaps of facet joints in the neutral and retroflexed positions.

Results: Of a total of 38 facet joints, instabilities or unilateral spondylolisthesis of unilateral facet joints were observed in 13 (34.2%) in the retroflexed position. Of these, 1 was located at the C4-5 level, 7 were at the C5-6 level and 4 at the C6-7 level.

Conclusion: 1. We investigated mechanisms involved in the onset of unilateral or asymmetrical neurological symptoms in upper limbs in those with cervical disk diseases using 3D-CT in the neutral and retroflexed positions. 2. We conclude that instabilities or unilateral spondylolisthesis in unilateral facet joints in the retroflexed position can influence the onset of neurological symptoms.

357. Sagittal Profile of Pediatric Patients with Spinal Cord Injury: A Radiographic Analysis

Amer F. Samdani, Reginald S. Fayssoux, Jahangir Asghar, MJ Mulcahey, James J. McCarthy, Randall Betz

Introduction: Historically, pediatric SCI patients with spinal deformity requiring surgery have been fused in a sagittal plane alignment similar to that of ambulatory able-bodied individuals. In our experience, doing so has the potential to compromise patients’ ability to perform activities of daily living, such as feeding, grooming, perineal care and self-catheterization. We sought to radiographically profile the seated sagittal plane alignment of pediatric SCI patients in an effort to guide operative planning in spinal deformity surgery.

Methods: Our pediatric SCI database was reviewed for patients with coronal curvatures of < 20° and with adequate seated lateral radiographs taken > 1 year post-injury. Exclusion criteria included previous thoracolumbar fusion. Thirty-two subjects (21 males, 11 females) met the above criteria. The average age at injury was 6.8 years (range, birth to 17.9 years). The average age at radiographic examination was 11 years (range, 3.7 to 20 years). Sixteen subjects (50%) sustained cervical level injury and 16 (50%) sustained thoracic level injury. The radiographic sagittal alignment was assessed with sagittal Cobb angle measurements of the thoracic (T2-T12) and lumbar spine (L1-S1) and the thoracolumbar junction (T10-L2). Results were compared with previously published data by Bernhardt & Bridwell (1989) and Mac-Thiong et al (2005).

Results: The thoracic sagittal alignment was similar between all groups, but the thoracolumbar junction was significantly more kyphotic by 14° and the lumbar lordosis significantly decreased by an average of 43° (P < 0.05) (table).

Conclusion: In pediatric SCI patients, the normally neutral thoracolumbar junction was found to be more kyphotic by 14° and the lumbar lordosis significantly decreased by an average of 43°. Thus, the levels of surgery were C5 (18 cases), C6 (11), C3 (4), C4 (3). Clinical results (Odom Criteria): 17, excellent, 10, good. There were no graft collapses or extrusions. Four patients experienced graft subsidence which was not clinically significant. Union of all levels was recognized on dynamic radiography. Graft incorporation with bone evident throughout the disc space was only evident after a minimum of 16 months.

358. Ambulatory Outcome Following Decompressive Surgery for Different Histological Types of Metastatic Tumors Causing Epidural Spinal Cord Compression

Kaisorn L. Chaichana, Daniel M. Scuibba, Jean-Paul Wolinsky, Ziya L. Gokaslan

Introduction: Metastatic epidural spinal cord compression (MESCC) is a relatively common and debilitating complication of metastatic disease that often results in neurological deficits. Recent studies have supported decompressive surgery over radiation therapy for patients who present with MESCC. These studies, however, have grouped all patients with different histological types of metastatic disease into the same study population. The differential
outcomes for patients with different histological types of metastatic disease therefore remain unknown.

Methods: An institutional database of patients undergoing decompressive surgery for MESCC at an academic tertiary-care institution between 1996 and 2006 was retrospectively reviewed. Patients with primary lung, breast, prostate, kidney, melanoma and gastrointestinal cancers were identified. Fisher exact analysis was used to compare pre-, peri- and post-operative variables for patients with these different types of primary cancers.

Results: Twenty-seven patients with primary lung cancer, 26 with breast, 20 with prostate, 21 with kidney, 7 with melanoma and 13 with gastrointestinal cancers were identified and categorized. All of these patients were followed for a mean ± SD of 10.8 ± 3.8 months following surgery. Patients with primary lung and prostate cancers were typically older than patients with other types of primary cancers. Patients with prostate cancers had the shortest duration of symptoms and more commonly presented with motor deficits, while patients with breast cancers more commonly had cervical spine involvement and compression fractures. For all histological types, greater than 90% of patients retained the ability to ambulate following surgery. However, patients with primary lung cancer had the highest incidence of patients who regained ambulation following decompressive surgery.

Conclusion: The present study identifies differences in presenting symptoms, operative course, peri-operative complications and long-term ambulatory outcomes for patients with lung, breast, prostate, kidney, melanoma and GI cancers. This understanding may allow for better risk stratification for patients with MESCC.

360. Single-Stage Circumferential Thoracic Decompression and Stabilization via the Transpedicular/Posterolateral Approach

Robert M. Galler

Introduction: Circumferential decompression and fusion of the thoracic spine often represents a difficult problem in spine surgery. This is mainly because of the complex anatomy and exposure when the anterior approach is required. This case series describes the technique and experience of a single surgeon in the performance of single stage circumferential decompression and fusion of the thoracic spine.

Methods: This is a retrospective study of 21 patients with varied pathology treated operatively using a novel circumferential decompression and instrumented fusion technique with an expandable cage and pedicle screw fixation. Fifteen patients had thoracic tumors of various pathologies. These patients presented with neurological compromise and were treated operatively without the need for a separate approach. A complete or near complete vertebodyectomy was performed, often with the placement of an expandable cage with pedicle screw instrumented fixation.

Results: Eighteen patients had improvement or preservation of neurological function after surgery. One patient had a delayed neurological deficit associated with a post-operative hematoma after anti-coagulation which required re-operation. Two patients had persistence of a complete neurological deficit that occurred pre-operatively. There was one peri-operative mortality secondary to multiorgan failure in a patient with advanced multiple myeloma.

Conclusion: Circumferential decompression and fusion using the posterolateral approach is feasible and safe for the treatment of varied thoracic pathologies. This technique is reproducible and has a learning curve that is reasonable. The posterior approach is familiar to most thoracic surgeons and allows for an aggressive decompression and stabilization without the need for thoracic surgeon.

361. Exophytic Ependymoma of the Thoracic Spinal Cord: Case Report and Review of the Literature

Ludwig David Orozco, Robert L. Tiel

Introduction: Spinal cord ependymomas are the most common spinal cord tumor in adults. Ependymomas are intramedullary tumors with predilection for the cervical cord. A case of a combined intradural extramedullary and intramedullary ependymoma at a thoracic spinal cord is presented. We describe its clinical, radiographic and pathologic features and the surgical approach employed.

Methods: A 61-year-old man presented with one-year history of progressive thoracic back pain, weakness and numbness of his lower extremities. Examination revealed a MRC grade 4/5 weakness in the right lower extremity and grade 2/5 weakness in the left lower extremity. He exhibited a T5 sensory level. MRI showed an intradural enhancing lesion that extended from T3 to T11 and had both intramedullary and extramedullary components. The patient underwent T3-T10 laminectomy for resection of the lesion. Dissection was carried out with gross total resection of the extramedullary component and subtotal resection of the intramedullary component.

Results: Post-operatively, the patient’s strength deteriorated to MRC grade 2/5 in the right lower extremity and grade 0/5 in the left lower extremity. Post-operative MRI showed the residual intramedullary tumor, cord edema and an epidural fluid collection. At six-weeks follow-up the patient’s strength had improved to 4/5 in the right lower extremity and 1/5 in the left lower extremity, with partial sensory deficits from T5 down. MRI at this point showed residual intramedullary tumor from T4 to T11 with resolving edema and epidural fluid collection.

Conclusion: Our case exemplifies the fact that spinal cord ependymomas can present with an exophytic-extramedullary growth. Gross total resection is possible with initial resection of the extramedullary component followed by resection of the intramedullary component.

362. Minimally Invasive Treatment of Thoracolumbar Spine Fractures

Terrence D. Julien, Cara Sedney, James Mills, Brenton R. Coger

Introduction: Thoracolumbar spinal injuries are common, especially in blunt trauma such as motor vehicle accidents and falls. These injuries often necessitate operative interventions to restore stability to the spinal column. While more traditional methods of spinal fusion are successful for these injuries, newer minimally invasive techniques have been developed and show promise in the setting of traumatic injury.

Methods: All surgical cases from the senior author over a period of 15 months were reviewed. Cases of minimally invasive fusions done for thoracolumbar trauma were identified. Laminctomies and kyphoplasty/vertebroplasty were omitted. These cases were assessed for operative time, length of hospital stay and estimated blood loss. The exact procedure and number of levels fused were also recorded.

Results: Of the 210 cases done over a one-year period by the senior author, 12 of these were minimally invasive fusions for thoracolumbar spinal trauma. The average number of levels fused was 5. Average estimated blood loss was 250 ml. Average operative time was 4 hours. Average hospital stay was 8.3 days.

Conclusion: Minimally invasive spinal fusion techniques are promising and growing in popularity. Minimally invasive techniques in general have been shown to reduce length of stay, post-operative pain and blood loss. There may be a particular utility for minimally invasive techniques in spinal trauma for these same reasons. A direct comparison of minimally invasive techniques with more traditional methods of spinal fusion for trauma is warranted to assess these topics.
363. Ten-Year Follow-up after PLIF with Titanium Cages and Pedicle Screw Fixation in a Case of 5th Lumbar Burst Fracture  
Kosuke Kuribayashi  
**Introduction:** Burst fracture of the fifth lumbar vertebra is very rare. In the past, it was a stable injury that caused minimal neurological deficits, so it should be managed conservatively. Even if surgery had been done, there was little improvement in neurological status and most patients lost lordosis between L4 and the sacrum. I present a burst fracture of a fifth lumbar vertebra case ten years postoperatively with the TFC and pedicle screw fixation.  
**Methods:** A 20-year-old nursing school student was involved in a car accident. She sustained a burst fracture of the fifth lumbar vertebra and fractures of the second through fourth right transverse process. The initial neurological examination showed anesthesia of both lower extremities, the loss of all motor functions of the left lower extremity and the disorder of bladder function. She underwent an open reduction and stabilization of her spine using the TFC and pedicle screw fixation from L4 to S1. She was allowed to ambulate in a hard cast two months after the surgery, because both the vertebral body and the endplate were destroyed completely.  
**Results:** Although her deficits of muscle strength remained a grade 4 in ankle dorsiflexion and grade 0 in long toe extendors, she can walk completely and become a nurse. In addition, she became a mother. This instrumentation can maintain the vertebral height and then restore lumbar lordosis. Bone union was achieved.  
**Conclusion:** The combination of the compensation of the defect of the vertebral body with the TFC and posterolateral fusion with pedicle screw fixation makes not only the strict fusion but also maintaining the vertebral height and restoring lumbar lordosis at the same approach. In this case, the key to success was using TFC and requiring bed rest for 2 months postoperatively.  

366. Contralateral Approach for Minimally Invasive Surgical Resection of Lumbar Synovial Cysts  
Ilya Laufer, Karishma Parikh, Roger Hartl  
**Introduction:** We report our experience with the minimally invasive resection of lumbar facet joint cysts via an approach using tubular retractors from the contralateral side. This muscle splitting approach allows optimal visualization of the cyst without extensive removal of the fact joint, thus minimizing the risk of inducing iatrogenic instability. It furthermore allows complete dissection of the cyst from surrounding tissues since we are able to start with normal anatomical planes.  
**Methods:** Twelve consecutive patients were treated using this approach. A retrospective chart and imaging review was conducted in order to determine operative and clinical measures. Subsequently, patients were contacted in order to obtain long-term clinical follow-up.  
**Results:** Eight patients had an excellent and four had a good outcome, with median follow-up of 20 months. The mean operative time was 114 minutes and in all cases the blood loss was less than 40 cc. No post-operative instability was noted.  
**Conclusion:** A contralateral approach using a tubular retractor system provides excellent visualization of the facet cyst allowing safe cyst resection and nerve root decompression without compromising the stability of the joint. Larger case series with prospective follow-up may elucidate whether this approach may prevent joint instability that may result from the ipsilateral facet dissection.  

367. Iatrogenic Spinal Arachnoid Cyst as a Complication of Lumbar Spine Surgery: Report of Two Cases  
Eric W. Nottmeier, Naresh P. Patel, Robert E. Wharen  
**Introduction:** The authors describe two cases of iatrogenic spinal arachnoid cyst formation occurring after lumbar spine surgeries that were complicated by a dural tear.  
**Methods:** The charts of two patients with iatrogenic spinal arachnoid cyst formation as a complication of lumbar spine surgery were retrospectively reviewed.  
**Results:** Case 1: This 79-year-old female underwent extention of her L5-S1 fusion to the L3 level secondary to symptomatic adjacent segment stenosis. Intraoperatively, a small dural tear occurred in the axilla of the right L3 nerve root with a minimal amount of cerebrospinal fluid leakage. The leak was primarily repaired. Two weeks after surgery the patient complained of progressive right lower extremity pain. Magnetic resonance (MR) imaging revealed no extradural compression, but it did show intradural compression of the cauda equina possibly related to arachnoid cyst formation anterior and posterior to the nerve rootlets. Computed tomographic (CT) myelography revealed that the arachnoid cyst extended to her lower thoracic spine. The patient underwent intradural exploration at the L4 level with fenestration of her cyst. At 3-month follow-up, the patient’s leg pain improved and MR imaging revealed no evidence of the arachnoid cyst. Case 2: This 67-year-old female presented with chief complaint of positional headache with nausea/vomiting 2 weeks post L4-5 lumbar laminectomy, which was complicated by a dural tear. MRI revealed pseudomeningocele with intradural compression of the cauda equina by an arachnoid cyst. She underwent intradural exploration with fenestration of the arachnoid cyst and repair of the pseudomeningocele. Post-operatively her symptoms abated and MR imaging revealed good intradural decompression of her cauda equina.  
**Conclusion:** Iatrogenic spinal arachnoid cysts are rare. Only two case reports exist in the literature describing this entity and both are associated with spinal injections 1, 2. This phenomenon has not previously been reported as a complication of lumbar surgery.  

368. Tricks of C1 Lateral Mass Exposure  
Masahiko Akiyama, Shigehiro Nakahara, Hiroyasu Nagashima, Howard J. Ginsberg, Satoshi Tateshima, Satoshi Tani  
**Introduction:** Recently C1 lateral mass screw placement has been widely used for posterior fusion on treatment of craniovertebral junction and upper cervical lesions. However, it is often difficult to exposure of the C1 lateral masses mainly due to bleeding from the vertebral venous plexus. Here we present our method, coagulating the vertebral venous plexus to minimize bleeding during exposure of the C1 lateral mass.  
**Methods:** With the patient in prone position, midline skin incision was made and the occipital bone, C1 and C2 were exposed. Setting a bipolar coagulator at about 50% higher output of regular use, the layer between muscles and the vertebral venous plexus was easily dissected with bipolar forces (bipolar cutting method) and the lateral edges of C2 lateral masses were exposed. The vertebral venous plexus between C1 and C2 was thoroughly coagulated with bipolar forces from midline and then, the dural sac and the C2 nerve roots were exposed. As the C1 lateral mass is located on the shoulder of the C2 nerve root, coagulation and dissection were performed toward this direction. The operating field for the placement of C1 lateral screws is usually wide enough without cutting C2 nerve roots, which can avoid anesthesia of C2 region.  
**Results:** The estimated blood loss (EBL) of four cases without coagulating the vertebral venous plexus was 700 - 4500 ml (mean 1975 ml), three out of four cases required blood transfusion. Whereas, EBL of six cases with this procedure was 200-520 ml (mean 332 ml), no patients required blood transfusion.  
**Conclusion:** Coagulating the vertebral venous plexus is a safe and useful method to expose C1 lateral masses for placement of C1 lateral mass screws.
369. Anular Repair is Effectied by Quantity but not Configuration of Devices: A Laboratory Simulation

Ashley Bartlett, Larry Wales, Rodney Houfburg, Steven L. Griffith

Introduction: Defects remaining in anulus fibrosus (AF) after discectomy can be a pathway for reherniation. Repairing anular defects could mitigate reherniation and improve patient outcome. In these experiments, artificial AF with a pressuressure chamber was used to examine various configurations of repair.

Methods: Layered silicone and polyester mesh (1.25 in x 2.75 in x 0.23 in) was attached to a sealed pressurization chamber to simulate AF and an intervertebral disc. A pneumatic cylinder was used to increase the chamber pressure until artificial nucleus pulposus (NP) material was pushed through a created anular defect. Xcelose™ Tissue Repair System (Anulex Technologies Inc.) approximates tissue defects via tension bands comprised of suture-tethered sub-anular T-anchors. Three repair conditions were compared to a non-repaired 3mm circular defect (n=6 for each): 1) one tension band repair, 2) two tension bands in a cruciate pattern, 3) two tension bands in parallel. Input pressure to the chamber was increased until NP-material extruded or failure of the repair device occurred, maximum pressure was recorded.

Results: Maximum failure pressure of the no repair/control was significantly lower (p<0.05) vs. all repaired conditions, with one or two tension bands, the maximum failure pressure increased by 76% and 131%, respectively. One tension band had significantly lower failure pressures compared to two tension bands in either cruciate or parallel configurations. Failure pressure for two tension bands (in either configuration) was 32% higher than one tension band, no difference was detected between cruciate or parallel configurations.

Conclusion: This study showed that repair of the anulus is mechanically beneficial. Use of two tension bands (either cruciate or parallel) compared to a single tension band improves the ability to retain disc material. To achieve the best possible anular repair after discectomy and thus improve patient outcome, use of two tension bands is recommended whenever possible.

370. Acute Pull-Out Resistance of Bone Anchor Elements Used for Anular Repair

Joseph Farrell, Dale Brady, Larry Wales, Brian Dukart, Ishmael Bentley, Rodney Houfburg, Steven L. Griffith

Introduction: Anular repair after discectomy can be challenged by the location of the defect. Repair techniques to close defects close to bony structures can include bone anchor fixation. Resistance to pull-out of bone anchor elements, in comparison to expected in situ loads, was evaluated in this study.

Methods: (A) Expected in situ loads on posterior vertebral bone fixation elements was estimated using lumbar spine segments. Tissue anchors were placed into discs (n=11) and a transducer was attached to a perpendicular tension pull-line positioned through the spinal canal. Maximum angular flexion (avg = 13 degrees) was applied three times and resultant tensile load measured on the third cycle. (B) Linear pull-out loading until failure (0.5 in/min) was applied to titanium toggle anchors (n=25) placed 4mm from the endplate in cadaveric vertebrae. Two different screw sizes (n=10 each) were placed in holes left after toggle anchor pull-out and maximum pull-out load was determined.

Results: Average load requirement for a bone anchor fixation element in the vertebral body was 16.5 ± 7.0N. In comparison, pull-out load for titanium toggle anchors was 34.75 ± 14.1N. Small screws placed in holes vacated by toggle anchors pulled out at 32.9 ± 13.4N and larger screws at 44.5 ± 24.3N.

Conclusion: Anular repair after discectomy can impact post-surgical outcome of patients. Placement of suture-tethered soft tissue anchors has been used to close the pathway suspected for reherniation. An option to anchor the anular repair into lumbar vertebrae would enable repair of defects close to endplates. Average pull-out load for toggle anchors was more than two times the average estimated load required. If a toggle anchor fails intraoperatively, a screw could be used to continue the repair since the average pull-out resistance was more than 25% greater than the toggle anchor.

371. Prospective Clinical Results of One Level Cervical Arthroplasty with the Prestige Device: Preliminary Results

Anthony P. Fabrizi, Marcelo Galarza, Raffaella Maina

Introduction: The rate of symptomatic adjacent cervical level that may occur after Anterior Cervical Discectomy and Fusion (ACDF) is up to 30% is concerning. The cervical disc replacement provides an option for the treatment of radiculopathy and myelopathy degenerative anterior cervical spine, while it may prove to provide an impact on the development of adjacent segment disease.

Methods: To check the preliminary results about efficacy and safety of the Prestige cervical replacement. This is a prospective study of 35 patients with cervical arthroplasty at a single institution with the Prestige device for one disc level. There were 20 sole implants and 15 associated with other ACDF. Follow-up is up to two years now and the results are reported in terms of Visual Analog Scale (VAS) for pain, VAS for patient satisfaction and flexion-extension range of motion.

Results: Improvements in neuropathy, pain and patient satisfaction is noted in 90% of patients. There is a trend to increased benefit in cases with multi-level fusion, which correlates to increased pre-operative disability. At the mean 12-month follow-up imaging all patients had solid bone fusions with device. There was no sign of heterotopic ossification in any patient and no patient experienced migration of the cervical replacement. There have been no re-operations for continued pain. No adjacent segment problems have been detected at final follow-up imaging.

Conclusion: Cervical disc replacement had good clinical results as measured by pre-operative and post-operative VAS. Radiographic study suggested normal motion at implanted site and restrictive post-operative management is not required. In our opinion, Prestige cervical disc replacement is a stable implant in reconstructing cervical spine after anterior discectomy. This study represents the largest number and longest follow-up of single level cervical disc replacement in Italy. Final effectiveness will be determined after long-term follow-up studies.


Min S. Park, Charles Benjamin Newman, Henry E. Aryan, William R. Taylor

Introduction: The authors present a novel approach for the treatment of thoracolumbar burst fractures using a minimally-invasive approach via a mini-thoracotomy to perform a corpectomy and fusion followed by percutaneous pedicle screw placement.

Methods: Three patients (2 men, 1 women, ages 30, 40 and 21) were treated at our institution for traumatic thoracolumbar compression fractures (all-terrain vehicle accident, fall from height and motor vehicle accident). All patients were neurologically intact. Two fractures involved the L1 level and one fracture was at the T12 level. Two patients presented acutely following their fall, while the third patient was treated following failure of conservative management.

Results: A minimally-invasive retractor system was used to provide a direct lateral operative corridor via a mini-thoracotomy, followed by a corpectomy of the involved fracture. An expandable titanium cage was placed at the corpectomy site and expanded to correct for height loss and kyphotic deformity. The patients were then placed prone for supplemental percutaneous
pedicule screw instrumentation one level above and below the fracture site. Post-operative films demonstrated adequate correction of the traumatic deformities. **Conclusion:** A direct, lateral, minimally-invasive corpectomy augmented by pedicle screw instrumentation appears to be a viable approach for the treatment of thoracolumbar burst fractures in the absence of neurological injury.

### 373. Value of Intra-Operative Neurophysiological Monitoring (IONM) in Complex Lumbar Spine Surgery (CLSS): A Retrospective Study

Saeid Alemo, Amirali Sayadipour

**Introduction:** To determine the efficacy of IONM in reducing the incidence of iatrogenic neural injury during LCSS

**Methods:** Records of 82 consecutive patients, with 382 titanium pedicle screws, were reviewed. A standardized multimodality technique under total intravenous anesthesia was utilized. A relevant neurophysiological change (surgical alert) was defined as a reduction in amplitude of at least 50% for somatosensory evoked potentials of at least 65% for transcranial electric motor evoked potentials compared with baseline. The stimulation threshold of 8mA or less was considered the screw is too close to the nerve root.

**Results:** Immediate feedback via evoked Electromyography (E-EMG) using stimulating pedicle probes in appropriate muscle groups was suggestive of pedicle cortical bone compromise in 24 screws (6.5%). Twenty-one screws were removed and redirected. Three false-positive E-EMG was detected by examination of the nerve roots and pedicles and the surgeon elected not to reposition the screws. None of those patients had post-operative neurological deficit and the post-operative Computerized Tomography (CT) confirmed the integrity of pedicles. Three false-negative E-EMG was detected post-operatively in three patients by new neurological deficits and abnormal CT (3.75%).

**Conclusion:** IONM complements intraoperative fluoroscopy to protect neural tissue during LCSS. However, intraoperative inspection of pedicles or post-operative CT is the ultimate test to determine the accuracy of placement of the screws. We propose neurological assessment of the patient in operating-room after extubation and urgent CT if the patient develops a new neurological deficit to determine whether or not to reposition the screws in the same setting.

### 374. Sources and Patterns of Pain in Lumbar Disc Disease, Revisiting of the Francis Murphey’s Theory

Saeid Alemo, Amirali Sayadipour

**Introduction:** The purpose of this study is to revisit the mechanical theory of discogenic low back pain (LBP) and to determine whether or not it is logic.

**Methods:** The literature pertinent to sources of pain in lumbar disc disease was reviewed and analyzed logically emphasizing on mechanical theory of discogenic LBP postulated by Francis Murphey. Deductive and inductive logic has been discussed briefly to evaluate the Murphey’s theory.

**Results:** The innervation of the intervertebral lumbar disc was discovered in 1947. Francis Murphey had unprecedented experience of testing the annulus fibrosus (AF) and posterior longitudinal ligament (PLL) under local anesthesia and he concluded that stretched AF and PLL are a source of LBP in 1967 in the Congress of Neurological Surgeons: “It is found that the PLL and the remaining annulus fibrosus over the herniated discs are also exquisitely tender, even the slightest pressure on them produces pain. In other cases, compression of the posterior longitudinal ligament and annulus does not produce pain. Strangely, while cutting these structures is not painful, compression or stretching is, as stated above, extremely painful.” However there was a flaw in his conclusion in relating the LBP, to the stretched AF and PLL, both in the deductive and inductive logic system.

**Conclusion:** The mechanical theory of discogenic LBP postulated by Francis Murphey in 1967 was weak inductive logic. At best, his lecture in 1972 was categorized as class V evidence (expert opinion) study.

### 375. Pre-sacral Nerve Sheath Tumors: Diagnosis and Management

James Scott Schoeb, Samer S. Ghostine, J. Patrick Johnson, Wesley A. King

**Introduction:** Nerve sheath tumors occurring in and around the spinal column are relatively common, comprising one-third of all spinal tumors (8). They present variable challenges with regard to complete surgical removal that is largely related to their unusual anatomic location (5). However, nerve sheath tumors located in the sacrum are relatively rare and few reports are seen in the literature (3, 5, 9, 11). Their particular location within the pelvis and adjacent to many unfamiliar anatomic structures is the major challenge to safe and complete removal (5). Detailed pre-operative anatomic imaging and collaboration with a surgical colleague familiar with vascular and pelvic anatomy are important factors in the decision-making process and surgical planning to achieve a curative surgical excision and to maintain normal neurologic function.

**Methods:** Between 2000 and 2008 six pre-sacral nerve sheath tumors were treated at our institution. There were five benign schwannomas and one neurofibroma in a patient with von Recklinghausen’s Disease. All were pre-operatively evaluated with radiographs, computed tomography (CT), magnetic resonance imaging (MRI) and diagnostic biopsy. We utilized a team approach, including an experienced abdominal surgeon, to achieve an en-bloc resection of the tumor with clean margins. We utilized anterior-retroperitoneal, trans-abdominal and trans-sacral approaches to access the tumor based on its size and location on pre-operative imaging studies.

**Results:** We have an average of 4.5 years follow-up (range six months-8.5 years) without recurrence of symptoms or tumor in the schwannoma cohort. Average age of the patient was 38.5 years (range 18 to 53 years). All maintained normal bowel and bladder function despite the involvement of the S2 nerve root in each of our six cases.

**Conclusion:** Pre-sacral nerve sheath tumors are rare entities and can be treated safely and effectively. We advocate utilizing a team-approach, including an experienced abdominal surgeon, to access and remove the lesion.

### 376. Nursing Education as Part of a Spine Radiosurgery Program

Carol J. Kennedy, Barbara A. Dascola, Peter C. Gerszten, John Flickinger

**Introduction:** Spine radiosurgery is a new treatment modality that is becoming widely adopted as part of the multimodality therapy for spine tumors. Patient cooperation during the procedure is important in order to maximize treatment accuracy. Patients and families are often very unfamiliar with this procedure and are frequently overwhelmed by the complexity of the technology. This knowledge deficit may contribute to excessive fear and anxiety. Our center evaluated addressing this knowledge deficit using nursing assessments and education.

**Methods:** Sixty consecutive patients undergoing spine radiosurgery were prospectively evaluated by a dedicated radiosurgery nurse through pre-procedure assessment and education. As part of this assessment, patients and families were routinely asked about their questions, concerns and/or fears regarding spine radiosurgery. The radiosurgery treatment was described using the following components: (1) planning CT simulation and immobilization, (2) actual treatment, including image guidance and comfort/discomfort levels to be expected, (3) expectations, potential risks and side effects and (4) follow-up appointments and imaging.
Results: Patients were found to have minimal baseline knowledge regarding the procedure. They demonstrated an eagerness to be educated regarding the four components described above. The majority of questions focused on immobilization devices and levels of discomfort. Demonstrations of the immobilization devices as well as the treatment facility were routinely performed. The nursing assessment was invaluable for individualizing the need for pre-procedure medication, no patient requested that the procedure be aborted (mean treatment time 68 minutes).

Conclusion: Patients referred for spine radiosurgery have little baseline knowledge or understanding regarding this new treatment modality. Patient education intervention was found to facilitate treatment delivery. Nursing assessment and teaching should be an integral component of any spine radiosurgery program. Nurses must be well-educated in all components of the radiosurgery treatment in order to maximize pre-procedure patient education.


Hamad Farhat, Allen Levi, Mohamad Ali Aziz-Sultan

Introduction: Cerebrospinal fluid (CSF) drainage serves an important role in the management of patients with established or potential CSF fistulas. Classically, a lumbar CSF drain has been used for this purpose and has a track record of being safe and effective. In certain cases, such as extensive previous lumbar surgery, a lumbar drain cannot be used. In such instances, a cervical CSF drain can be inserted via a lateral C1-C2 puncture and provides an excellent and safe alternative. In this report, the authors describe the techniques, safety and effectiveness of placing a cervical drain for CSF drainage. Pitfalls, possible complications and their avoidance are also reviewed.

Methods: We performed a retrospective review of our cases of cervical subarachnoid catheter placement. Patients’ characteristics, indications, procedural complications as well as immediate and late periprocedural complications were noted.

Results: Twenty-seven cervical drains were placed in 24 patients with a mean age of 57.1 years (range 19-82). There were 14 females and 10 males. All the cervical drains were placed via a lateral C1-C2 puncture under direct fluoroscopic vision. A standard Hermetic closed tip lumbar catheter (Integra Neurosciences, Plainsboro, NJ, USA) was used in all cases. The drains were in place for an average time of 6.1 days (range 3-11). CSF surveillance was performed on the day of placement as well as every 48 hours that the drain was in place. Cervical drain placement was achieved in all cases allowing for continuous CSF drainage. No permanent procedural complications occurred. There were no instances of meningitis.

Conclusion: Cervical intrathecal catheter for cerebrospinal fluid drainage is a safe and effective alternative when lumbar access is contraindicated or not achievable.

378. Intradural Ossification in a Patient with Familial Amyloidosis

James K. Liu, Raymond D. Turner, Mark G. Luciano, Ajit A. Krishnaney

Introduction: Familial amyloidosis has been shown to lead to amyloid deposition in the leptomeninges. This case report examines a patient with a long family history of leptomeningeal amyloidosis that has been treated and previously reported on at the Cleveland Clinic. This patient is unique in that she was found to have intrathecal ossification from amyloid deposition, a pathology not previously reported.

Methods: A 60-year-old female initially presented to the Cleveland Clinic for evaluation of hydrocephalus secondary to amyloidosis. A ventriculo-peritoneal shunt was placed which initially alleviated her symptoms but then started to progressively decline. She presented to the emergency department with obtundation secondary to apparent shunt malfunction and lower extremity weakness. CT showed high attenuation material present intradurally from the mid cervical extending through the thoracic and lumbar spine in the extradural space.

Results: The patient was taken to the operating room for open biopsy at L3-5. Upon opening the dura, a homogenous intradural ossification encasing the nerve roots was seen. A biopsy was performed. Given the extent of the ossification, no further attempts at decompression were taken and the dura was closed. Microscopic review of the intra-operative biopsy revealed sclerotic bone with focal amorphous material consistent with amyloid.

Conclusion: This case report demonstrates a unique pathological finding in a patient with familial amyloidosis. Although amyloid deposition in the leptomeninges has been well documented, particularly in this patient’s family, intradural deposition leading to a circumferential enclosure of the spinal cord and cauda equina in bone has never been previously reported in conjunction with familial amyloidosis.

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

Justin S. Smith, Christopher L. Shaffrey, Charles A. Sansur, Stephanie Herndon, Mark Abel

Introduction: In patients with idiopathic scoliosis having thoracic curves with compensatory lumbar curves, fusion of the thoracic curve can improve the lumbar curve, but can result in coronal decompensation or an unacceptably large residual lumbar curve. The lumbo-sacral takeoff (LS-takeoff) is the angle between the central sacral vertical line and a line passing through the mid-points of L4-S1. LS-takeoff remains unchanged following selective fusion using hook/rod systems, but some believe that using pedicle screw constructs, the lumbar curve correction and LS-takeoff are improved. We hypothesized that selective fusion using pedicle screws will not alter the LS-takeoff or apical lumbar vertebral translation (ALVT).

Methods: A prospective database of Lenke 1B/1C/3C idiopathic scoliosis patients with two-year follow-up was accessed to measure radiographic changes following deformity correction.

Results: Fifty-eight patients underwent selective (n = 37) or non-selective (n = 21) fusion. These groups did not differ with regard to pre-operative thoracic Cobb angle (P = 0.8), lumbar Cobb angle (P = 0.08), or LS-takeoff (P = 0.5). Pre-operative ALVT was greater in the nonselective (33mm) compared with the selective fusion groups (20mm) (P < 0.001). At two-year follow-up, the thoracic curve improved for both selective (59° to 29°, P < 0.001) and nonselective fusion groups (60° to 23°, P < 0.001). The lumbar curve improved for selective (40° to 21°, P < 0.001) and nonselective fusion groups (47° to -14°, P < 0.001). With nonselective fusion at two-year follow-up, both LS-takeoff (16° to 9°, P < 0.001) and ALVT (33mm to 14mm, P < 0.001) improved. In contrast, with selective fusion at two-year follow-up, there were no significant changes in either LS-takeoff (15° to 14°, P = 0.6) or ALVT (-20mm to -19mm, P = 0.7).

Conclusion: With selective fusion, ALVT and LS-takeoff remain unchanged at two-year follow-up. The improvement in lumbar Cobb in the selective cases comes almost exclusively from changes in the vertebra proximal to the apical lumbar vertebra even when using pedicle screw constructs.
380. A Comparison of Percutaneous (Minimum Access Spine Technology) and Open Lumbar Surgical Techniques with 2-Year Follow-up
Beejal Y. Amin, Radmehr Torabi, Shaden Marzouk, David Nerenz, Muwafak Abdulhak

Introduction: Minimal Access Spinal Technologies (MAST) has been advocated as a minimally invasive alternative to the conventional open method. In addition, bone morphogenetic protein (BMP) is being used as a substitute to traditional grafts in fusion surgery. Only a few long-term studies have been documented comparing these groups despite concern regarding the new technologies.

Methods: We studied a series of 125 patients undergoing spinal procedures by one surgeon at our facility between August 2002 and August 2005. Seventy-four patients had a MAST procedure and 51 had an open procedure. Of the 90 patients who had fusion procedures 71 had BMP and 19 did not. SF-36 and overall Oswestry scores were compared at 6, 12 and 24 months. OR time, blood loss and hospital stay were also compared.

Results: Despite lower blood loss, shorter OR times and shorter hospital stays for patients undergoing MAST procedures, no statistical difference was found between the two groups in SF-36 and Oswestry scores at 6, 12 and 24 months. When comparing patients with fusion procedures the BMP group had a statistically significant lower Oswestry score at 24 months compared to the non-BMP group. Role physical at one year, PCS at 2 years and social function at 2 years were all of borderline significance (p = 0.0001). Mean ODI decreased from 59.0% ± 7.6% to 20.1% ± 11.3% (66%, p < 0.0001). Due to persistent symptoms 6 months post-IDET, 9 patients had surgical treatment (4 fusion, 5 disc replacement). One patient did not achieve ≥ 2-point pain improvement and one patient did not achieve ≥ 15-point ODI improvement. Thus, the global clinical success rate was 78% (39 of 50). Clinical success was related to degree of discographic concordance (p < 0.0001), HIZ (p = 0.003), Pfirrmann grade (p = 0.0002) and percent annulus coverage (p < 0.0001).

Conclusion: IDET offered a safe, minimally-invasive treatment alternative for these patients with durable clinical improvement in pain and function.

382. Lamina Screws as a Salvage Technique at C7: CT and Biomechanical Analysis Using Cadaveric Vertebrae
Mario J. Cardoso, Anton E. Dmitriev, Melvin D. Helgeson, Frederick L. Stephens, Ronald A. Lehman, Patrick B. Cooper, Michael K. Rosner

Introduction: Transpedicular instrumentation at C7 has been well accepted. However, salvage techniques are limited. Lamina screws have been shown to be a biomechanically sound salvage technique in the proximal thoracic spine, but have not been evaluated in the lower cervical spine. The following study evaluates the anatomic feasibility of lamina screws at C7 as well as their bone screw interface strength as a salvage technique.

Methods: Nine fresh-frozen C7 cadaveric specimens were DEXA scanned for bone mineral density (BMD). Prior to testing, all specimens were imaged with computed tomography (CT). Caliper measurements were obtained of pedicle width and lamina thickness. Pedicle screws were first inserted and then pulled out. “Salvage” intralaminar screws were then inserted and pulled out. Pedicle and lamina screws were 4.35 mm and 3.5 mm in diameter, respectively. Screws sizes were chosen based on direct and radiographic measurements of the respective anatomic regions. Insertional torque (IT) was measured in “lbs-in”.

Results: Lamina screws (778.9 ± 161.4 N) as a salvage technique generated pullout forces (POF) similar to the index pedicle screws (805.3 ± 261.7 N) (p = 0.796). However, lamina screw peak IT (5.2 ± 2.0 lbs-in) was significantly lower than index pedicle screw peak IT (9.1 ± 3.6 lbs-in) (p = 0.012). BMD correlated highly with pedicle screw POS (r = 0.95), but less with lamina screws (r = 0.04). The mean laminar caliper width (5.7 ± 1.0 mm) was significantly different from the CT measured lamina width (5.1 ± 0.8 mm) (p = 0.003). Similarly, the mean caliper pedicle width (6.6 ± 1.1 mm) was significantly different from the CT measured pedicle width (6.2 ± 1.3 mm) (p = 0.014). The mean laminar width measured on CT at the thinnest point ranged from 3.8-6.8 mm, allowing a 3.5 mm screw to be placed without difficulty.

Conclusion: Our results suggest that laminar screws as a salvage technique at C7 provide similar fixation strength as the index pedicle screw. The C7 lamina appears to be an ideal anatomic width for the insertion of 3.5 mm screws commonly used for cervical fusions. Therefore, if the transpedicular screw fails, intralaminar screws appear to be a biomechanically sound salvage technique.

383. Cervical Cord Contusion Secondary to Indirect Gunshot Injury
Sanchia S. Goonewardene, Karanjit Mangat, Ian Sargeant, Porter Keith

Introduction: Deployment of soldiers in areas of active combat can result in a large spectrum of injuries varying in both their mechanism of injury and severity. Acute spinal cord injury can be life threatening, resulting from both blunt and penetrating trauma. Gunshot insults to the spinal cord itself account for 13-17% (study conducted in Israel) of all such injuries, with neurological deficit resulting from direct trauma to the nervous tissue by the bullet, bone or displaced disc fragments, causing cord injury [1]. However, an indirect injury may occur with equally devastating effect, where the bullet passes some distance away from the cord itself. Studies of gunshot ballistics may provide the answer. We present a case of such an injury, with an
We describe how the velocity and Surgical decompression with Neurologic examinations There were 22 decompressions, The use of three-modality after SCI. Patients were included manifest only in changes of sensation. Methods: A retrospective review of the multicenter prospective database utilized The ASIA physical examination is consistently utilized to serially evaluate and monitor spinal cord injured (SCI) patients’ neurologic function. Unlike cervical SCI patients, changes in thoracic complete SCI (ASIA A) patients’ exams are typically explained only in changes of sensation. Methods: A technique of placing screws into the occipital, C1 and C2 levels using three-dimensional (3D) image guidance in which the reference arc is fixed to the headholder. This technique involves drilling all of the holes for the screws using an image-guided drill guide prior to tapping the holes and inserting the screws. This technique minimizes the intersegmental movement of the upper cervical spine that can cause navigation inaccuracy when using spinal image guidance in cases where the reference arc is attached to the headholder. One of two paired systems, the BrainLAB (BrainLAB, Westchester, Illinois) system used in conjunction with the Arcadis Orbic Iso-centric C-arm (Siemens Medical Solutions, Erlangen, Germany) or the Stealth (Medtronic, Louisville, Colorado) system paired with the O-ARM (Medtronic) was used for image guidance in this study. A total of 18 patients had 82 screws placed into the occipital, C1 or C2 levels using this technique. An independent radiologist interpreted post-operative computed tomographic (CT) scanning on these patients and graded the screws for bony breach.

Results: No complications resulted from the use of image guidance or from the placement of instrumentation. Post-operative CT revealed one screw with a minimal breach of the outer lamina of C2. Another screw was replaced intraoperatively secondary to a minimal bony breach. No other bony breach occurred. Conclusion: This technique allows safe and accurate placement of instrumentation into the posterior occipitocervical junction using 3D image guidance in which the reference arc is attached to the headholder. Conclusion: We conclude that the shockwave caused microvascular damage and diffuse axonal injury to the cord and that the investigations exclude other pathological mechanisms. We present a case of delayed onset tetraplegia without direct injury to the cord and offer explanations for the mechanism of injury.
387. CT and Neurologic Findings Can Predict Pre-operatively the Severity of Adhesion of the Root in the Spondylolytic Spondylolisthesis
Kyung Yun Moon, Chun Kee Chung, Hyun-Jib Kim, Tae-Ahn Jang
Introduction: Spondylolytic spondylolisthesis consists of decompression and fixation with instrumentation. Sometimes affected root (if L5 spondylolysis, L5 root is affected) is so much adhered that meticulous neurolysis using microsurgical technique is required. If surgeons could know the severity of adhesion pre-operatively, it can be very much informative for pre-op planning. We hypothesized that CT findings and neurologic examination are closely correlated to the presence of adhesions.

Methods: A retrospective analysis of 63 consecutive patients who had undergone instrumented PLIF with pedicle screw fixation between 1994 and 2007 at FHU was performed. Plain axial bone-density CT findings were classified into 4 types. Type I: the space between separated isthmus is tiny and include free bone fragment, Type II: the space is wide with no or minimum bone fragment, Type III: accompanied by apophyseal ring fracture or disc herniation at the slip level, Type IV: other miscellaneous findings. Neurologic function of the affected lumbar root was graded according to Japanese manual muscle test (MMT). The operative videotapes were reviewed. Adhesion was graded to none or a little, moderate and severe. In severe grades of adhesion, there is a lot of difficulty because of kinking of the root, significant congestion, adhesion to LF/PLL, and atrophic change after posterior lumbar surgery. Especially DS with paramedian approach may preserve more paraspinal muscles due to midline approaches. The pre-operative and post-operative cross-sectional areas of paraspinal (multifidus+longissimus), multifidus, psoas muscles were measured by computed tomography. Transaxial sections in L4 level were obtained, because the paraspinal and psoas muscles are best visualized in these sections. We evaluated the changes in paraspinal and psoas muscle area at more than 6 months after surgery.

Results: The rates of decreasing paraspinal muscle were significantly greater in the LF group than the DS group (-11.8% and 2.41%, respectively, p<0.01). In the LF, the rates of decreasing multifidus and psoas muscles were -27.68% (p<0.05) and -5.53% (p>0.05). In the DS, they were -0.97% (p<0.05) and 0.56% (p>0.05), respectively. Moreover, in the DS with paramedian and midline approach group, the changes in paraspinal muscles were 3.18% and 1.95% post-operatively. But, in the LF groups, they were -17.15% and -6.45%, respectively (p<0.01).

Conclusion: DS showed good preservation of paraspinal and psoas muscles. Especially DS with paramedian approach may preserve more paraspinal muscles due to less manipulation and retraction.

388. Paraspinal Muscle Changes after Lumbar Fusion and Dynamic Stabilization
Kyuwon Lim, Bongil Kim, Eun Young Jang, Myoung-Whan Son
Introduction: Paraspinal muscle injury and atrophic change after posterior lumbar surgery can cause low back pain and failed back surgery syndrome. Recently, many studies of post-operative paraspinal muscle change have been published. But there are no studies of muscle change after dynamic stabilization (DS). In this study, we compared not only muscle changes of the DS with them of the lumbar fusion (LF), but also paramedian and midline approaches.

Methods: Our study population consisted of 38 consecutive patients who underwent lumbar spine surgery with posterior instrumentation between February 2005 and January 2008. The alteration of the paraspinal muscle after the DS in 24 patients and the LF in 14 patients were evaluated. There were 16 paramedian interfascial approaches and 22 traditional midline approaches. The pre-operative and post-operative cross-sectional areas of paraspinal (multifidus+longissimus), multifidus, psoas muscles were measured by computed tomography. Transaxial sections in L4 level were obtained, because the paraspinal and psoas muscles are best visualized in these sections. We evaluated the changes in paraspinal and psoas muscle area at more than 6 months after surgery.

Results: The rates of decreasing paraspinal muscle were significantly greater in the LF group than the DS group (-11.8% and 2.41%, respectively, p<0.01). In the LF, the rates of decreasing multifidus and psoas muscles were -27.68% (p<0.05) and -5.53% (p>0.05). In the DS, they were -0.97% (p<0.05) and 0.56% (p>0.05), respectively. Moreover, in the DS with paramedian and midline approach group, the changes in paraspinal muscles were 3.18% and 1.95% post-operatively. But, in the LF groups, they were -17.15% and -6.45%, respectively (p<0.01).

Conclusion: DS showed good preservation of paraspinal and psoas muscles. Especially DS with paramedian approach may preserve more paraspinal muscles due to less manipulation and retraction.

389. Thermal Damage Comparison of Bipolar Forceps in Ovine Spinal Cord
Ebonia Elliott-Lewis, Jandira Ramonths, Edward C. Benzel
Introduction: Heat pipe technology in the ISOCOOL Bipolar Forceps (Codman & Shurtleff, Inc.) is designed to optimize coagulation temperature. In this study, the heat pipe device is compared to traditional bipolar forceps without heat pipe technology to assess whether the thermal performance difference can also result in less thermal injury.

Methods: In an ovine spine model, a 3-, 4- or 5-level dorsal laminectomy was performed in each animal (n=48). The forceps were applied to the intact dura mater. Device tips were centered over a visible surface spinal cord artery (Ovine dura is transparent). One device activation was performed at each spine segment (n=22), excluding sham segments (n=2).

Key coagulation parameters (power setting, activation time and tip spacing) were controlled at 35 Malis units, 9 seconds and 3 mm, respectively. Tissue samples were prepared for histology and histomorphometry measurements were acquired to quantify the thermal damage after euthanasia on day 8.

Results: Histological and histomorphometric assessments demonstrated that the difference in lesion size created by the two devices is statistically significant (p<0.05). The mean ± standard deviation of the lesion area and width created by the devices are 1.2 ± 1.69 mm²*mm and 564 ± 554.6 microns, respectively, using the heat pipe forceps compared to 4.9 ± 3.22 mm²*mm and 1428 ± 769.6 microns using the traditional bipolar forceps.

Conclusion: This ovine study data suggests that the heat pipe forceps may cause less thermal damage to non-targeted tissue such as the spinal cord.
**Conclusion:** The data shows that in 83% of the procedures, investigators felt that anular repair was achievable. Furthermore, 95% of attempted repairs resulted in closure of the defect, implying successful anular repair can be performed in nearly 80% of discectomies using this simple technique. Having the additional ability to repair rim tears and the extremely compromised anulus could make anular repair achievable in over 90% of discectomy cases. When combined with other study data, anular repair may prove to be the new standard on the horizon.

**391. Algorithm for the Diagnosis and Treatment of Lumbar Radicular Pain Due to Lateral Spinal Pathology**

James B. Macon

**Introduction:** The treatment and evaluation of lumbar radicular pain due to far lateral spinal pathology requires a different approach than the more familiar intraspinal pathology.

**Methods:** A series of 64 consecutive patients with lumbar radicular pain and far lateral pathology were evaluated and treated with selective nerve root blocks with steroid and Marcaine and/or minimally invasive surgery via a tubular access system.

**Results:** The majority of cases with benign extra-spinal lateral nerve root or ganglion compression due to discs or osteophytes (80%) improved and did not require surgical treatment with a maximum of two injections. When surgery was indicated due to failure of the blocks to control symptoms, the lesion was usually large and causing detectable neurological deficit. When surgery was necessary, placing a fat pad soaked in steroid and Marcaine was useful in reducing dysesthesias related to ganglionitis. When surgery was performed the minimally invasive access provided by lateral ports minimized the operative morbidity. A treatment algorithm is introduced to minimize unnecessary surgery for lateral spine pathology.

**Conclusion:** A treatment algorithm for the management of far lateral spine pathology is proposed to avoid unnecessary spine surgery since selective nerve root blocks have been found effective to control symptoms in the majority of patients with lumbar radiculitis due to lateral spinal pathology. When surgery was necessary the minimally invasive tubular access approach greatly reduced patient morbidity and length of hospital stay compared with conventional open exposures.

**392. Treatment of the Symptomatic Space-Ocupying Sacral Arachnoid Cysts**

Dimitrios Kafritas

**Introduction:** Sacral perineural cysts are monthly observed with female patients. In some cases they can also be symptomatic. This study comprises 16 patients (14 female, 2 male) which have been treated from July 1999 until July 2008. Patients suitable for our procedure were selected by growing cysts with valve mechanism which cause an erosion of the sacral bone and clinical signs such as pelvic pain, bladder dysfunction and paresthesia at a deep pelvic level. Patients with sciatica or radicular pain of the leg, as well as Tarlov cysts were excluded from this study.

**Methods:** The valve mechanism was evaluated by myelography and CT myelography. After contrast medium injection for the myelography no concentration in the cyst could be observed. After 1.5-2 hours the CT myelography was performed. As a result a high concentration of contrast medium in the cyst could be observed. Twenty-four hours later we could still find a higher concentration of contrast medium in the cyst itself, although the contrast medium had been completely resorbed at the lumbar arachnoid space.

**Results:** Free communicated cysts with the subarachnoid space filled immediately during myelography and are not included in this study. They are supposed to be non-symptomatic. Surgical treatment of these cysts (by resection and/or rafting) have improved and did not require complications in any patient.

**Conclusion:** CT visualized puncture and fenestration of the cyst with a thick TUI-needle. By 1999, it was standard procedure in our clinic. The complete procedure is done in the CT-room by CT fluoroscopy with local anesthesia. In-patient treatment is followed for 2-3 days to avoid complications and for clinical observation. The average follow-up is 34 months.

**393. Utility of Dorsal Column Mapping in Intramedullary Spinal Surgery**

Daniel S. Yanni, Sedat Ulkatan, Vedran Deletis, Ignacio J. Barrenechea, Chandra N. Sen, Noel I. Perin

**Introduction:** Dorsal column mapping is a useful tool for guiding myelotomy when anatomical landmarks are distorted. In our small series we demonstrate the usefulness of dorsal column mapping to prevent post-operative dysfunction.

**394. Hemi-Semilaminectomy with a Supraforaminal Burr Hole Technique: A Less Minimal Invasive Surgical Approach to Cervical Neuromas with Intraforaminal Components**

László Lipóth, Peter Banczerowski, János Vajda, Robert Veres

**Introduction:** Schwannoma and neurofibroma are the most common neumeningeal tumors at the cervical spine. Most of them are located inside the dural sac, but approximately 15% extend along the cervical nerve root inside the foramen and sometimes extraforaminally. The majority of these tumors were excised through the posterior approach performing multilevel laminectomies and facetectomies. Multilevel resections may result in spinal instability and may necessitate spinal stabilization at the end with instrumentation. We tried to
spare further the mechanically relevant bone structures. To follow the principle of less invasivity and preservation of as much as facet joints possible, a supraforaminal burr hole technique was used to complete the semi-laminectomy for exploring tumors with intraforaminal component in the cervical spine.

**Methods:** The authors used the hemi-semi-laminectomy combined with supraforaminal burr hole technique in seven adult patients with neuroma extended inside the foramen in the region of the cervical spine.

**Results:** Under the operating microscope the operating field was sufficient for tumor removal according to key hole concept. The approach did not affect the extent of tumor resection, or neurological outcome. This technique is suitable for total tumor removal with good clinical result. The affected nerve roots included the C3 in 3, C5 in 2, C4 and C6 in 1 cases. The average follow-up was 9 months, with a range from 6 to 13 months. Histological results were as follows: 4 schwannomas and 3 neurofibromas.

**Conclusion:** This modified surgical approach fulfills the requirements of other minimal invasive techniques and helps to prevent damage to the crucial posterior stabilizers of the spine, disintegration of vertebral arches and facet joints are reduced. Suitable for exploring and totally removing neuromas located in the spinal canal and the neuroforamen.

395. **A Comparison of 2-Level Lumbar Fusions Using Minimally Invasive (XLIF) vs. Open (PLIF)**

**Introduction:** Multi-level pathology has in the past precluded minimally invasive surgical techniques due to the requirements for greater exposure to achieve results comparable to traditional techniques. The XLIF approach, however, provides access to multiple lumbar levels through small lateral incisions and retroperitoneal dissection, minimizing approach-related morbidity while providing anterior column access for large graft placement, excellent disk height, alignment restoration and indirect decompression.

**Methods:** In our single-site consecutive series of > 500 XLIF patients, 76 had 2-level treatment for multiple indications (stenosis, scoliosis, post-decompression instability, DDD and/or spondylolisthesis). Clinical and radiographic measures were prospectively collected and evaluated. A retrospective database of 109 2-level open PLIF patients from the same practice were identified and evaluated for the same measures as a basis of comparison.

**Results:** Patient demographics were similar in both groups. All XLIF surgeries were quick and uneventful. All included minimally disruptive posterior fixation. In the XLIF group, there were no transfusions or infections, with a mean hemoglobin change of 1.48, while hemoglobin change in PLIF patients averaged 3.10. Hospital stay averaged 1.2 days for XLIFs and 3.16 days for PLIFs. Lenke score of 93% of XLIF patients with 12-month follow-up was 1, compared with 79% of PLIF patients at 12 months. While no XLIF patients have required revision or reoperation, there was a 10% reoperation rate in the PLIF cohort.

**Conclusion:** There is little in the literature describing the use of minimally invasive techniques for 2-level pathologies. In our experience, patients with multi-level pathologies can expect the same benefits and successful outcomes from this less invasive procedure as those with single-level indications. Moreover, the clinical and radiographic outcomes in two-level XLIF compare favorably to those using more traditional open techniques in this single-site series.

396. **Safety and the Learning Curve of Trans-Sacral Fusion (AxiaLIF) at L5-S1: Complications in the First 100 Surgeries of a Single Surgeon Series**

**Introduction:** Combinations of trans-sacral fusion of L5-S1 include bowel injury, wound infection and implant subsidence (1, 2). Technique and instrumentation improvements have reduced complication risk during the “learning curve.” The complications associated with AxiaLIF during the adoption phase are reported to demonstrate the feasibility, safety and effectiveness of the approach.

**Methods:** All AxiaLIF patients were followed to evaluate outcomes, including surgical details, hospital stay, pain scores, changes in disk height and alignment and fusion. Type and severity of surgical and post-operative complications were documented and highlighted. Peri- and post-operative complications and their relation to clinical and radiographic outcomes were evaluated.

**Results:** 100 patients (48M, 52F, age 53.9 years, range 22-88 years, BMI 31.1) were treated by a single surgeon (WBR) using the AxiaLIF technique to achieve fusion at the lumbosacral junction. Seventy-two procedures were single level, 28 procedures involved concomitant fusion at L4S (via XLIF). All fusions involved supplemental posterior pedicle screw fixation. OR time averaged 89.1 min (63.2 min for single level procedures and 141 min for AxiaLIF-XLIF combinations). Length of stay averaged 24.7 hrs (1.03 days). Hemoglobin change was 1.75 g. There were three complications in the perioperative period: one pedicle screw was revised at POD15 for malpositioning, a graft herniation required laminotomy and a small area of wound dehiscence at the coccygeal incision was treated with local care. There were no transfusions, infections, or visceral, vascular or neurologic complications. Disk height improved from 4.3 mm pre-op to 7.6 mm post-op, minimal subsidence was noted at 6 months (disk height 6.2 mm). Lolisthesis was reduced from 5.2 mm pre-op to 2.3 mm post-op and reduction was maintained at 6 months. AVS decreased from 8.6 pre-op to 3.3 at 3 months and further to 2.3 at 6 months.

**Conclusion:** The adoption phase for trans-sacral fusion shows very few complications compared to traditional open techniques.

397. **Management of Flexion-Distraction Injury**

Chandan G. Reddy, Nader Suhail Dahdaleh, Patrick W. Hitchon

**Introduction:** Flexion-distraction injury of the thoracolumbar spine reflects a failure of the middle and posterior columns. Oftentimes, this injury is associated with a seat-belt-type motor vehicle injury, but numerous other mechanisms have been reported. Conservative management often results in progressive kyphotic deformity. We report our 5-year prospective experience with thoracolumbar flexion-distraction injuries.

**Methods:** All cases of flexion-distraction injury which were treated at our institution from May 2003 through March 2008 were reviewed. Clinical, radiographic and operative variables were recorded.

**Results:** Thirteen patients were treated. The mean age was 25.3 years (range 14-51). Five patients were female and 8 were male. All but one patient underwent surgery and all surgical patients received open reduction, posterior instrumentation and posterior fixation. A mean of 5.2 levels were instrumented within a mean of 3.3 days from injury. Levels of injury spanned T4 to L2. All injuries were sustained with a flexion mechanism at high velocity. None of the patients who underwent surgery required decompression for canal compromise or an anterior procedure. The goal of surgery was to reestablish the posterior tension band. Of the operated patients, mean follow-up was 13.1 months. Mean Frankel score improved from 4.4 to 4.8 (with 1 corresponding to paralysis, i.e. Frankel Class A and 5 corresponding to normal, i.e. Frankel Class E). Kyphotic angulation improved from 13.8 to 6.8 degrees. Two patients had complications: one requiring operative revision of a pedicle screw and one with MSSA wound infection treated conservatively. The patient who did not undergo surgery initially went on to have persistent pain and progressive kyphotic deformity at 3 months, from 13
degrees to 32 degrees, he was offered surgery, but declined.

**Conclusion:** Flexion-distraction injuries of the thoracolumbar spine should be managed operatively, with posterior fixation. Newer modalities of minimally invasive surgery may simplify surgery and expedite rehabilitation.

**398. Image-Guided Thoracoscopic Resection of Thoracic Nerve Sheath Tumors**

Samer Ghostine, Srinath Samudrala, Wesley A. King, Helen Cambron, J. Patrick Johnson, Shoshana Vaynman, James Scott Schoeb

**Introduction:** The authors describe the feasibility of minimally invasive thoracoscopic resection of thoracic dumbbell nerve sheath tumors (NST) facilitated by image guidance system (IGS) in an efficacious and safe manner.

**Methods:** We have used IGS to help guide the complete resection of intra-thoracic dumbbell NST in four patients.

**Results:** The IGS has provided continuous intra-operative anatomical orientation to achieve gross total resection in the four cases presented. All surgical and post-surgical outcomes were satisfactory and no adverse events were observed.

**Conclusion:** The minimally invasive tissue sparing thoracoscopic approach allows the resection of challenging dumbbell NSTs safely and with satisfactory outcomes. The use of the IGS provides the “missing third dimension” which enhances the accuracy and safety of thoracoscopic surgery. The merging of the IGS and thoracoscopic technologies has many advantages and should be encouraged.

**400. Preliminary Clinical Experience Using a Mini-Open Aspen Spinal Processes System**

Alan T. Villavicencio, Ewell Lee Nelson, Jason Babuska, Alexander Mason, Sigita Burneikiene

**Introduction:** This study describes early clinical results of the Aspen, new mini-open spinal process fusion plate (SPFP) (Lanx, Broomfield, CO). The SPFP is a posterior, non-pedicle fixation device designed for attachment to spinal processes to achieve supplemental fusion in patients diagnosed with degenerative disc disease and spondylolisthesis.

**Methods:** Twenty-five patients underwent transfemoral lumbar interbody fusion using supplemental Aspen fixation from April through early October 2008. The average age was 59.2 years (range, 35-89). Sixteen single-level (64%), eight two-level (32%) and one (4%) three-level surgeries were performed. Twenty patients had a unilateral pedicle screw fixation in addition to SPFP and in 5 cases it was used as a stand-alone device to supplement allograft fusion. Nineteen patients had the SPFP placed at one level, five patients at 2 levels and one patient had the device placed at 3 levels.

**Results:** Mean operative time was 133.3 minutes (range, 71-182) and 202 minutes (range, 158-250) for one-level and two-level procedures, respectively. The mean EBL was 135.0 mL (range, 50-500) and hospitalization time was 0.9 days (range, 0 - 4). There were two device-related complications encountered. One patient underwent additional surgery due to the L5 spinous process fracture and another for allograft migration. At the mean time of 3.6 months 11/25 (44%) patients had bridging trabeuculae across the fused levels.

**Conclusion:** The Aspen device could be a feasible alternative to pedicle screw fixation for selected patients. SPFP is less invasive than pedicle screw fixation, because it requires a smaller incision and no additional lateral exposure. The Aspen is very easy to implant with no fluoroscopic guidance required and there is also no risk of neural injury. There are still a few technical issues that need to be addressed. The smallest available size is 8 mm. It is difficult to gauge the degree of lateral compression on the spinal processes making it possible to overcompress, which can result in an increased risk of spinous processes fracture.

**401. Comparison of Weight/Volume of Graft Available for Cervical Corpectomy**

Robert F. Heary, Zainab Burhanpurwala

**Introduction:** Placement of autologous bone graft or other osteogenic materials within a cervical spacer has potential value in fusing the cervical spine following corpectomy. Despite this, structural allograft fibula remains the most commonly utilized spacer. We compared the weight and volume of graft material able to be placed inside fibula allografts vs. a new, stackable carbon fiber cage construct.

**Methods:** Six fibula allografts were tested at 3 lengths (20mm, 40mm, 50mm). Three different footprint sizes (12x14mm, 14x16mm, 16x18mm) of a carbon fiber cage (Bengal, Depuy Spine, Raynham, MA) at the same lengths were tested. Each graft and spacer was wrapped in adhesive, water-tight barriers and weighed by two investigators. Oil of known density (0.899 ± 0.006g/ml) was used to fill each allograft and cage. The filled spacers were then weighed and the volume of oil instilled was measured. Each size spacer was filled and measured separately six times and each measurement was performed three times by both investigators. Intraobserver and interobserver reliability was recorded.

**Results:** All values in the following table represent the weight (gms) and volume (ml) of oil instilled. For all cages, the weight and volume of oil instilled was between 4-8 times more in the carbon fiber cages than in the allograft fibulas. The difference between the volume and weight was statistically significant (P < 0.0001) for all cage sizes compared to allografts. The interobserver reliability (r = 0.998) and the intraobserver
reliability (r = 0.997) demonstrated strong statistical correlations.

**Conclusion:** Packing autograft or other osteogenic material inside spacers is dependent on the space available within the spacer. Stackable, carbon fiber cervical cages allow for 4-8 times the weight and volume of graft material to be inserted inside the cage when compared to allograft fibula. The clinical implications remain to be seen.

### 402. Three-level Posterior Lumbar Interbody Fusions (PLIFs): A Clinical and Radiographic Assessment
Robert F. Heary, Anne B. Chin

**Introduction:** At many national meetings, there has been nearly universal agreement that 3-level PLIFs do not succeed. There are no published studies which look at this specific subset of patients. We evaluated the outcomes of patients who underwent 3-level PLIF surgeries for intractable, mechanical low back pain as their index procedure.

**Methods:** Over a 7-year period, 17 consecutive patients (M:12, F:5, mean age 50.9 years) underwent 3-level PLIFs for intractable, mechanical low back pain. Operative indications were a combination of degenerative and herniated discs and spondylothesis. Inclusion criteria required no prior lumbar interbody fusion surgery, documented 3-level disc disease and failure of prolonged attempts at conservative treatment. Serial clinical and radiographic evaluations were performed at regular intervals. Clinical and radiographic mean duration of follow-up was 33 and 30 months, respectively.

**Results:** Fifteen of seventeen (88%) patients had radiographic evidence of solid fusions at all 3 levels. One of these 2 non-unions has only 6-month follow-up and the other required revision surgery for a symptomatic pseudarthrosis at the rostralmost level. Adjacent segment disc disease requiring additional “add-on” fusion surgery was necessary in 3/17 (18%) patients. Two additional patients have imaging studies suggestive of disease at the rostral adjacent segment, however, both of these patients remain symptom-free. Clinical outcomes, based on Odom’s criteria, had excellent results in 10/17 (59%), good in 7/17 (41%) and no fair or poor patient outcomes. Complications occurred in 3 patients including transient ulnar nerve palsy (1), transient neurogenic bladder (1) and wound infection (1) requiring surgical revision.

**Conclusion:** Our results indicate that carefully selected patients, with intractable low back pain, undergoing 3-level PLIF surgery, have surprisingly good clinical and radiographic results. Adjacent segment disease, next to a solid fusion, appears to be the most frequent post-operative concern in this population.

### 403. Coflex® Interspinous Stabilization: Clinical and Radiographic Results from a Taichung Veteran General Hospital Retrospective Study
Shao-Ching Chao

**Introduction:** The aims of implanting interspinous devices are to unload the facet joints, restore foraminal height and provide stability especially in extension but still allow motion. The purpose of this study was to determine the efficacy of the coflex® interspinous implant in patients between the ages of 26 and 85 years old with the primary diagnosis of spinal stenosis (1 or 2 levels).

**Methods:** All 20 patients were diagnosed as spinal canal stenosis with or without hypertrophic facet joints. The coflex® interspinous implant surgery were performed from November 2007 to August 2008. Pre-and post-operative disability and pain scores were measured using Oswestry and Visual Analog Scores (VAS). Radiographic data was collected to evaluate canal diameter, the foraminal area and the foraminal width.

**Results:** Visual analog pain scores decreased from a median score of 6.65 and 7.85 of low back pain and lower limb pain pre-operative to 2.45 and 2.90 of low back pain and lower limb pain at 3 months post-operative. Oswestry disability scores were reduced from 37.95% pre-operative to 10.85% at 3 months post-operative. The results of pain relief and improvement of daily function were diagrammatically shown at pre- and post-surgery.

**Conclusion:** The results of this retrospective analysis showed coflex interspinous stabilization after microsurgical decompression for spinal stenosis has excellent short-term and long-term results for improvement in back pain, neurogenic claudication and patient satisfaction. The coflex provides a conservative yet effective treatment for patients suffering from lumbar spinal stenosis.

### 404. In Vivo Role of NgR1 to Spinal Cord Injury Repair in Mice
Vassilios Georgios Dimopoulos, Henry N. Kesler, Jing Tong, David H. Perlmutter, Zeguang Ren, Roman Giger, Jason H. Huang

**Introduction:** The role of Nogo receptors in inhibition of regeneration of injured spinal cord is still controversial. In this communication we report the preliminary results of the first part of our project, analyzing the in vivo role of NgR1 in mice with spinal cord injury.

**Methods:** Three groups of mice were used: wild type (WT), mutant mice lacking NgR1 (NgR1-) and heterozygotes (HT). Spinal cord injury was introduced with surgical section at T8-9 level of the dorsal spinal cord. One week following experimental spinal cord injury, the corticospinal tract was traced by unilateral injection of biotinylated dextran amine (BDA) in the motor cortex. Sprouting of traced fibers was quantified using ImageJ software in spinal cord sections rostral to the injury site one week later

**Results:** Surgical lesions were performed in 42 mice. Overall mortality was 42.85%. Data obtained from 18 mice. The extent of spinal cord injury was assessed in sagittal sections under microscope and data from 14 mice with confirmed greater than 50% injury were further analyzed. In the NgR1-group (n = 5) the mean of number of sprouting fibers was 174.6 (Standard Error: 66.0). In the wild type group (n = 3) the mean of number of sprouting fibers was 162.6 (Standard Error: 87.4), while in the heterozygote group (n = 6) the mean of number of sprouting fibers was 140.3 (Standard Error: 25.7). T-test analysis failed to reveal any statistical difference between the NgR1 and WT groups.

**Conclusion:** Our preliminary results did not confirm a significant in vivo role of NgR1 receptors in regeneration of spinal cord in mice.

### 405. The Effect of the Lumbar Pedicle and Pediculo-Corporal Junction Histology on the Pedicle Screw Insertion Technique
Kemal Yucesoy, Kasim Zafer Yuksel, Salih Sayhan, Güven Erbil, Mustafa Güvencer

**Introduction:** Pedicle screw rod fixation of the lumbar spine has been applied frequently in the spinal surgery. There are different fixation systems, surgical instruments and insertion techniques which have been developed for the safe insertion of the pedicle screws. One of the main issues regarding the pedicle screw application should be the histological properties of the pedicles and especially the pediculo-corporal junction.

**Methods:** Twenty pedicles from 10 lumbar spinal segments (L3-L5) were prepared for histological and gross-anatomical investigation. Thin slice cuts were taken from the specimens and examined histologically and macroscopically.

**Results:** There were no any differences in the histological characteristics of the pedicles and the pediculo-corporal junction. Thin compact osseous formation or web
like connective tissue formation was not identifiable in the pediculo-corporal junction.

**Conclusion:** The main concern in drilling a tunnel before the insertion of a pedicle screw is to prepare a passage passing through any compact lamellar osseous zones of the pedicle or pediculo-corporal junction. According to the findings of this study, it can be a possibility to omit this step during surgery as the whole macroscopic and histological architecture of the bone was found to be similar throughout the passage of the pedicle screw. All kind of pedicle screws can be attempted to be inserted just after preparation of the insertion point with an awl or just decortication of the entrance point with a rangeur. This can also reduce the pilot hole preparation technique related complications like perforation of the pedicle walls.

406. **Should SCIWORA (Spinal Cord Injury without Radiographic Abnormality) be Accepted as SCIWONA (Spinal Cord Injury without Neuroradiological Abnormality) in MRI Era?**

Kemal Yuceyos, Kasim Zafer Yuskel

**Introduction:** The aim of this report is to discuss the term ‘Spinal Cord Injury without Radiographic Abnormality (SCIWORA)’ after the common use of MRI for the diagnosis of spinal cord injuries.

**Methods:** Thirty published articles were found in the English literature in Pub-med using ‘SCIWORA and MRI’ as keywords. Incidence, clinical and radiological data and MRI findings were evaluated in all articles (meta-analysis, reviews, case series and case reports). One of these articles was meta-analysis, two reviews, ten case series and seventeen case reports.

**Results:** The incidence of SCIWORA among children was found to be between 3.3% and 32.0%. This wide range was directly related to patients’ age, authors’ specialty and utilization of MRI. After the common utilization of MRI on spinal injuries, there have been an ambiguity about the usage of this acronym in the articles.

**Conclusion:** According to our opinion, if any pathology is detected on MRI with or without radiographic abnormality, the patients should not be accepted as SCIWORA and real SCIWORA should be determined as “Spinal Cord Injury without Neuroimaging Abnormality” in cases with normal MRI.

407. **Surgical Management of Tarlov (Perineural) Cysts: Report of Twelve Cases with Long-term Follow-up**

Kemal Yuceyos, Kasim Zafer Yuskel, Murat Yilmaz, Mürvet Yüksel

**Introduction:** Many different lesions located within the spinal canal may be misdiagnosed as a Tarlov cyst and there is controversy about the indications and optimal technique of their surgical treatment. In this article, we review our experience of surgically treated Tarlov cysts.

**Methods:** The charts of twelve cases of symptomatic and surgically treated Tarlov cyst, diagnosed by magnetic resonance imaging, were retrospectively reviewed. Presenting symptoms, radiological imaging, surgical techniques and histopathological features of these cases are evaluated and the literature is reviewed

**Results:** The same surgical technique was performed in all cases. A communication between the spinal subarachnoid space and the cyst was found intra-operatively. This opening was enlarged using blunt dissection with a blunt hook, after which partial resection of the cyst wall, fenestration and overwessing was performed Cyst wall specimens were examined histopathologically and these cyst walls included nerve tissue, confirming the diagnosis of Tarlov (perineural) cyst. There were 9 women and 3 men and the mean age was 45.2 years old. Mean follow-up of these cases was 78 months without recurrence or CSF fistula. There were no post-operative complications.

**Conclusion:** Surgical treatment is safe and effective for symptomatic perineural cysts with favorable long-term results.

409. **Posterior Transpedicular Corpectomy and Stabilization for Malignant Cervical Spine Tumors**

Mohammed A. Eleraky, Matthias Setzer, Frank D. Vrionis

**Introduction:** Access to ventral lesion of the cervical spine can be challenging. Anterior approaches are the gold standard for ventral pathology in cervical spine, however there are cases, where posterior approach is indicated due to multilevel disease, previous radiation, swallowing difficulty, with difficulty in retraction of trachea and esophagus, and in cases where circumferential fusion can not be done due to patient poor medical condition. A single approach could provide spinal stabilization and removal of tumor.

**Methods:** Eight cases of ventral cervical spine malignant tumors (7 metastatic and one chordoma) underwent corpectomy through a posterior transpedicular approach. Tumor involved C2 (5), C3 (1), C5 (1) and C7 (1). Six cases had 3 column fusions and 2 cases had posterior fusion alone.

**Results:** Gross total resection was achieved in all cases. No hardware failure or worsening of neurological condition was seen, pain improved in all patients. In one patients the vertebral artery was ligated without sequelae.

**Conclusion:** Cervical spine transpedicular approach is useful in cases where an anterior approach or a circumferential approach is not an option. It avoids morbidity of anterior transcervical or transoral procedures while providing decompression of neural elements while allowing three column stabilization when needed.

410. **Fluoroscopic-Navigated Sacroiliac Stabilization with Percutaneous Screws in Oncological Patients with Sacral Insufficiency Fractures**

Matthias Setzer, Mohammed A. Eleraky, David Cheong, Frank D. Vrionis

**Introduction:** Sacral insufficiency fractures are a common clinical entity in oncological patients and are a cause for persistent mechanical low back and pelvic pain. The causes for those fractures are multiple, however corticosteroid induced osteopenia, tumor-associated osteolysis and previous radiation therapy may be the most important predisposing factors. These patients are frequently not appropriate candidates for lumbar-iliac stabilization using the Galveston technique. The aim of this retrospective study was to evaluate the efficacy of minimally invasive sacroiliac screw fixation in terms of pain relief and the general performance status in oncological patients.

**Methods:** 7 patients (2 male, 5 female, mean age: 58.3 ± 11.8 years) with tumor (myeloma n=4, chordoma n=3) associated sacral insufficiency fractures who had undergone additional radiation therapy were operated with image guided percutaneous sacroiliac screw fixation. In one patient additional lumboiliac instrumentation was done. The patients were followed for 8.0 ± 5.2 months on average. Outcome was assessed using the Karnofsky Score (KPS) and the EuroQol Visual Analogue Scale (EQ VAS). Secondary endpoints were number and dosage of pain medication.

**Results:** All patients experienced post-operative pain relief. Median pain relief (EQ VAS) was 5. The pain medication could be reduced post-operatively in all patients in terms of number of pain drugs (median = 2) and dosage. All patients regained ambulation and were still ambulatory at the end of follow-up. Median KPS at the end of follow-up was 70. One case required revision of a screw due to radiculopathy.

**Conclusion:** These preliminary data suggest the percutaneous sacroiliac screw fixation is in terms of pain relief and neurological outcome an effective and safe treatment option in oncological patients with sacral insufficiency fractures. A further prospective study is needed to determine if sacroiliac screw fixation is superior to the currently available conservative treatment of these patients.
411. Minimally Invasive Fusion at the Lumbosacral Junction in the Elderly (Age >70 Years)

W.B. Rodgers, Curtis S. Cox, Edward J. Gerber

**Introduction:** The elderly patient provides a challenging fusion healing environment. Rates of complications seen in the older surgical patients result in part from existing comorbidity and age-associated changes in organ function. Combined with obesity, this provides higher risk to infection, post-operative complications and lower fusion success rates. This study evaluates the AxiaLIF fusion at L5-S1 in the elderly patient population greater than 70 years of age.

**Methods:** Twelve patients with a mean age of 76.2 years (range 70-88 years) and a mean BMI greater than 30 received single-level fusions with an AxiaLIF at L5-S1. Two of the patients had Grade I and two patients with Grade II spondylolisthesis.

Supplemental posterior fixation was used in all of the patients. The VAS scores, disc heights and improvement in slip in the four patients are presented for this patient population at 3 and 6 months post-operatively.

**Results:** The mean VAS score in these patients pre-operatively was 8.8 and reached 3.0 at 6 months post-operatively, demonstrating a 5.8 point drop (67% reduction) in the VAS score. Initially, the height increased by 3.3 mm post-operatively, with 0.9 mm settling at the 6 month timeframe. For the four patients with a Grade I or II spondylolisthesis, there was an approximately 50% reduction in slip (4.3 mm) measured at 6 months post-operatively. The mean OR time was 77.8 minutes, with a mean length of stay of 1.2 days. The hemoglobin change was 1.8 g. All patients were discharged home, no patient required treatment in a rehabilitation hospital.

**Conclusion:** A successful VAS outcome was achieved in these challenging patients. This approach provided adequate reduction of a Grade I or II spondylolisthesis due to the added contribution in biomechanical stability of the intact surrounding ligamentous tissue and posterior supplementation. This approach provides an alternative for spinal correction requiring fusion for elderly patients.

412. Diffusion Tensor Imaging in Patients with Intramedullary Lesions: Interrater Reliability of DTI and Intraoperative Findings and Prediction of Tumor Resectability

Matthias Setzer, Ryan D.Murtagh, Surbhi Jain, Reed Murtagh, Frank D. Vrionis

**Introduction:** Despite the progress in microsurgical techniques, surgical resection of intramedullary spinal cord tumors remains a challenge and the histology is a major predictor for resectability of the tumor. The aim of this retrospective study was to determine the inter-rater reliability between DTI and intraoperative surgical findings with respect to resectability of intramedullary tumors.

**Methods:** Ten patients with intramedullary lesions of the spinal cord at different levels (6 male, 4 female, mean age: 50.9 ± 12.6 years) underwent a full tensor diffusion imaging. Patients were classified according to the fiber course with respect to the lesion and rated as resectable vs. non-resectable. These results were compared to the surgical situation (existence vs. absence of cleavage plane). The inter-rater reliability (kappa coefficient of Cohen) was calculated.

**Results:** Of the 10 patients (6 male, 4 female, mean age: 50.9 ± 12.6 years) 9 were tumors (6 ependymomas, 2 lymphomas and 1 astrocytoma) and 1 was proven to be an MS plaque during further diagnostic workup. The tumors could be classified in 3 types according to the fiber course: Type I fibers do not enter the solid lesion, n = 4, Type II some fibers cross the lesion, but month of the lesion volume does not contain fibers, Type III the whole tumor volume does contain fibers. Based on these results 5 lesions were considered as resectable, 4 were not. During surgery 6 tumors showed a good cleavage plane, 3 did not. The inter-rater reliability (Cohens k) was calculated to 0.77 (p < 0.018) which is considered as substantial agreement. The patients were followed for 5.3 ± 2.1 months on average. The median McCormick score at the end of follow-up was 2.

**Conclusion:** These preliminary data suggest the DTI in patients with spinal cord tumors is capable of predicting the resectability of the lesion. A further prospective study is needed to confirm these results and if these have an impact on patient outcome.

413. Transsacral Interbody Fusion (AxiaLIF) in Obese Patients

W.B. Rodgers, Curtis S. Cox, Edward J. Gerber

**Introduction:** Recurrent disc herniation after a lumbar discectomy is a rare but significant problem that may require a second surgical procedure. Occasionally, fusion is necessary for severe degenerative changes or instability associated with recurrent HNP. However, the conventional lumbar interbody fusion procedures (ALIFs, PLIFs) have been shown to have significant morbidity. Minimally invasive procedures offer the hope of decreased morbidity while addressing the underlying degenerative disease.

**Methods:** Ten patients with a mean age of 52.3 years (range 24-88 years) and a mean BMI of 29.8 received single-level fusions with an AxiaLIF at L5-S1 for recurrent disk herniations. The VAS score and disc heights are presented for this patient population at 3 and 6 months post-operatively.

**Results:** The mean OR time was 74.6 minutes, with a mean length of stay of 0.8
days. The hemoglobin change was 1.9g. The mean VAS score in these patients pre-operatively was 8.4 and reached 2.0 at 6 months post-operatively, demonstrating a 6.4 point drop (76% reduction) in the VAS score.

**Conclusion:** Overall, a successful VAS outcome was achieved in these challenging patients. Furthermore, the AxialLIF procedure resulted in less blood loss and shorter hospital stays than the literature that has assessed an open ALIF/PLIF or TLIF performed. This approach provides a favorable fusion alternative for the recurrent herniated disc patient. The AxialLIF procedure maintains the surrounding ligamentous tissue, facet joints and annulus providing added biomechanical stability to spinal fusion for improved bone healing with less tissue destruction, thus increasing the success rate for these challenging patients.

**415. Single Level Lumbar Fusion for a Grade I and II Spondylolisthesis Correction Using the AxialLIF Rod System**

W.B. Rodgers, Curtis S. Cox, Edward J. Gerber

**Introduction:** Spondylolisthesis correction has been conventionally addressed by lumbar fusion of the slipped segment. The applicability of MIS techniques to this diagnosis is expanding. MIS transsacral fusion (AxialLIF) offers the opportunity to address spondylolisthesis correction and spare the facet joint and surrounding ligamentous tissues to the spinal column, thus providing superior stability to the slipped segment. In addition, the directional vector of placement of the intervertebral device facilitates reduction of the listhetic segment. Herein, we report our early results using this approach. To our knowledge, this represents the first report of the use of this technique in spondylolisthesis.

**Methods:** Thirty patients (15 M, 15 F, age 53.7 years, BMI 31.3) were treated with AxialLIF fusion at L5-S1 for either a Grade I (n = 22) or Grade II (n = 8) spondylolisthesis. The VAS scores, disc heights and improvement in slip and complications are presented.

**Results:** VAS improved by 75% over the first six months, disk height increased 3.7 mm from pre-op to post-op (although there was some settling (1.8 mm) by 6 months), listhesis was halved and this reduction was maintained over time. There were no infections, neural or visceral injuries or hardware failures. One patient had mild gapping of his coccygeal incision that was treated with local dressings and resolved.

**Conclusion:** Using proper care, a transsacral MIS approach using the AxialLIF fixation system at L5-S1 for a Grade I or Grade II spondylolisthesis provides a readily reproducible and safe alternative to traditional open procedures. This approach provides adequate reduction of a Grade I or II spondylolisthesis due to the added contribution in biomechanical stability of the intact surrounding ligamentous tissue. Meticulous attention to operative technique is required but the early results demonstrate excellent clinical outcomes with minimal morbidity.

**416. A Clinical Evaluation of the AxialLIF Rod System for Adjacent Segment Degeneration after Prior Lumbar Fusion**

W.B. Rodgers, Curtis S. Cox, Edward J. Gerber

**Introduction:** Complications involving degenerative changes at the levels adjacent to a lumbar fusion have been recognized as a long-term problem. Biomechanical studies demonstrate increased intradiscal pressures and increased motion at levels adjacent to a fusion, thus augmenting the degenerative process of the discs surrounding the fusion sites.3,4,5,6 An increased stiffness that occurs with the fixation at the fusion site dramatically changes the biomechanical profile at that segment. This study provides clinical evaluation of the AxialLIF fusion at L5-S1 performed in those patients with adjacent segment disease.

**Methods:** Thirteen patients with a mean age of 60.8 years (range 43-83 years) and a mean BMI of 30.6 received single-level fusions with an AxialLIF at L5-S1 for adjacent segment degeneration after prior fusion to L5. The VAS score and disc heights are presented for this patient population at 3 and 6 months post-operatively.

**Results:** The mean VAS score in these patients pre-operatively was 9.3 and reached 5.2 at 3 months post-operatively, with further decrease to 3.9 at 6 months. The disc height increased by 2.4 mm post-operatively, with minimal settling over 6 months. The mean OR time was 79.5 minutes, with a mean length of stay of 1.3 days. The hemoglobin change was 1.7g. There were no infections, transfusions or other complications.

**Conclusion:** A successful VAS outcome was achieved in these patients. This transsacral approach provided reduction and stability to relieve pain and improve quality of life for the patient with adjacent segment disease and resulted in less blood loss and shorter hospital stays than the literature describes that has assessed an open ALIF/PLIF or TLIF procedure. The AxialLIF procedure maintains the surrounding ligamentous tissue, facet joints and annulus providing added biomechanical stability to spinal fusion for improved bone healing with less tissue destruction, providing a viable alternative to traditional open revision in patients with ASD.

**417. A Clinical Evaluation of a Two-Level Lumbar Fusion Using a Combination of the AxialLIF and XLIF**

W.B. Rodgers, Curtis S. Cox, Edward J. Gerber

**Introduction:** Minimally invasive surgical fusion of the lumbar spine for multilevel disease presents special challenges at the lumbosacral junction. The combination of XLIF and AxialLIF provides access to both L45 and L5S1. To our knowledge, no one has presented the results of this combination of procedures in comparison to traditional open fusion.

**Methods:** Twenty-one patients with a mean age of 57.1 years and a mean BMI of 30.1 received two-level fusions with an AxialLIF at L5-S1 and XLIF at L4-L5. The VAS scores, disc heights and radiographic evaluations are presented at 3 and 6 months post-operatively.

**Results:** The mean VAS score in these patients pre-operatively was 8.9 and reached 2.8 at 6 months post-operatively, demonstrating a 6.1 point drop (31% reduction) in the VAS score. OR time averaged 141 minutes. There were no transfusions or infections or reoperations to date. We compared a similar group of 109 2-level open PLIF surgeries, in the MIS group the mean hemoglobin change of 2.08g, while hemoglobin change in PLIF patients averaged 3.1 (and 20% of PLIF patients were transfused). Hospital stay averaged 1.0 days for XLIFs and 3.2 days for PLIFs. In the PLIF group, there were 3 infections and 1 dural tear. While no MIS combination patients have required revision or reoperation, there was a 10% reoperation rate in the PLIF cohort.

**Conclusion:** Multilevel fusion at the lumbosacral junction can be achieved using a combination of XLIF and AxialLIF procedures. The results are comparable to the associated complications markedly less than traditional open techniques.

**419. Single-Level Instrumented ACDF Using an Embroidered Anterior Plate (Embrace-C)**

W.B. Rodgers, Curtis S. Cox, Edward J. Gerber

**Introduction:** The necessity of anterior cervical plating in single-level surgeries is still debated. An embroidered polymer plate may provide a low-profile and patient-friendly solution to anterior cervical graft containment, allowing for additional segmental stability and interbody graft load-sharing.

**Methods:** 21 single-level ACDF patients were instrumented using the Embrace embroidered polyester device. Clinical and radiographic measures were prospectively collected to assess comorbidities, surgical details, hospital stay, complications, disk
Results: Patients were diagnosed with stenosis (11/21), HNP (5/21) and DDD (5/21), 3 stenotic patients also had myelomalacia, 1 with myelopathy. Four had previous ACDF surgery at another level; in those patients, it was not necessary to remove the previous ACDF plate. Ages ranged from 24-73 years (average 56 years). Comorbidities included smokers (24%), CAD (43%) and obesity (43%). All cases were single level: 2 at C3-4, 3 at C4-5, 10 at C5-6 and 6 at C6-7. All patients had a one-day hospital stay. No complications occurred. The average increase in disc height from pre- to post-op was 3.5 mm, with maintenance of an average 2.5 mm increase from pre-op out to 12 months. Average VAS scores improved from 7.7 at pre-op to 1.3 at 12 months follow-up. NDI scores improved from 32.5 at pre-op to 9.5 at 12-months follow-up. At 6 months, all patients had a Lenke fusion score of 1 or 2, with 76% at Lenke 1. At 12 months, 91% were Lenke 1.

Conclusion: ACDF with Embrace has proven to be a safe and effective procedure for the treatment of symptomatic cervical disc disease. Although longer-term results will need analysis to determine maintenance of effects, results to date are encouraging support for this flexible, MRI-compatible, soft tissue reconstructive instrumentation option for single-level ACDF.

420. Surgical Management of Peripheral Nerve Sheath Tumors: Assessing the Risk
Allan D. Levi, Andrew Louis Ross, Juan Esteban Cuartas, Rabah Qadir, H. Thomas Temple

Introduction: Peripheral nerve sheath tumors (PNST) include schwannomas (SCH), neurofibromas (NF) and malignant peripheral nerve sheath tumors (MPNST). These tumors may present sporadically or in association with neurofibromatosis type 1 (NF-1).

Methods: Retrospective chart review of surgically treated PNST at the University of Miami between 1991-2008.

Results: There were a total of 144 cases including 87 SCH, 34 NF and 23 MPNST. The average age of the study group was 49.1 years and was significantly lower for patients with NF. There was a high correlation between NF tumors with NF-1 while mostth SCH occurred sporadically. Seventy percent of tumor cases were in females. The average follow-up was 7.3 months for SCH, 30.5 months for NF and 42 months for MPNST. Patients with benign tumors presented with a painful mass without significant weakness while MPNST tended to present with a rapidly growing mass, pain, numbness and weakness. Monthst (> 80%) of MPNSTs were diagnosed at stage IB or higher and had a combined mortality rate of 29% at 42 months. Among the different factors, size > 7 cm was associated with 100% mortality. After resection of PNST, monthst patients (76%) had only mild or no functional deficit. Complications of surgical treatment of PNST included sensory deficits, motor deficits and neuropathic pain syndromes. Previous attempted resections and pre-operative biopsy significantly increased the risk (40%) for developing post-operative neurological deficits when compared to patients who presented with de novo tumors (13%).

Conclusion: PNST’s are a heterogeneous group of lesions. Benign tumors respond well to marginal excision, whereas MPNSTs are aggressive sarcomas that require multimodal management. There was a significantly increased risk of post-operative neurological deficits in patients who had undergone a previous biopsy and thus tertiary referral without biopsy is recommend when a PNST is suspected.

W.B. Rodgers, Curtis S. Cox, Edward J. Gerber

Introduction: XLIF is a minimally invasive lateral approach to anterior reconstruction. Fixation choices have included posterior pedicle screws and rigid lateral plating. A more compliant fixation option has become available. Results of the use of the Embrace graft containment device in XLIF procedures are presented.

Methods: The Embrace device, composed of embroidered PET polymer, was used in 28 XLIF surgeries, providing dynamic stabilization and soft tissue enhancement. Perioperative considerations and radiographic measures were collected to assess comorbidities, surgical details, hospital stay, complications, disk height and alignment achieved.

Results: Primary diagnoses included stenosis (10), post-laminectomy instability (8), HNP (7), DDD (2) and spondylolisthesis (1). All but 2 (93%) had previous instrumented fusions (a primary indication for the use of this device over alternative hardware). Age ranged from 36-87 years (average 60 years). 57% had CAD, 54% were obese or morbidly obese. All cases were single-level: 1 at T7-8, 1 at T8-9, 1 at T11-12, 5 at L1-2, 8 at L2-3, 8 at L3-4 and 4 at L4-5. Average hospital stay was 1.18 days. Complications included 1 ileus, 1 urinary retention, 1 pneumonia and 1 MI at 6 weeks post-op. Average disk height increased by 3.1 mm post-op, with some settling to an average height increase of 1.1 mm by 6 months. Average slip decreased 2.3mm, which was maintained out to 6 months. Lenke fusion score of 1 or 2 was achieved in 73% at 3 months, 81% at 6 months and 100% at 12 months.

Conclusion: Patients experienced minimal complications and were discharged quicker than is typical with conventional approaches. Mid-term radiographic results show continued maintenance of disk space distraction, alignment and fusion progression. Embrace can be coupled with XLIF for increased stabilization without increasing OR time or blood loss, as the patient need not be repositioned for removal of previously placed hardware.
423.
A Comparison of Traditional and Minimally Invasive Lumbar Fusion in Octogenarians
W.B. Rodgers, Curtis S. Cox, Edward J. Gerber

Introduction: Spinal fusion surgery in the elderly is fraught with potential complications. In addition to the potential for bleeding, infection, or neurological injury, the comorbid health conditions often preclude operative treatment to correct spinal pathologies because anesthesia time, blood loss and recovery are too demanding. As aging patients expect to remain active, the demand for spinal reconstruction will continue to increase. Traditional open approaches have proven too debilitating, but newer, less invasive approaches offer great promise.

Methods: We compared our experience treating patients > 80 years old with traditional fusion techniques with a similar group using MIS techniques (XLIF and AxiaLIF). Twenty patients (13F, 7M, age 82.7, BMI 28.0) were treated with open lumbar fusion from 2003-2005. 46 patients (20M, 26F, age 82.9, BMI 27.8) were treated with MIS techniques (41 XLIF, 4 AxiaLIF, 1 combination Ax/XLIF) from 2006-2008.

Results: Primary diagnoses and comorbidities were similar between the two groups. In the traditional fusion group, hemoglobin change averaged 4.13g (14/20 pts required transfusion) and LOS averaged 5.3 days. All 20 patients were discharged to a skilled nursing facility. In the MIS group, hemoglobin change was 1.47g (no patients were transfused). LOS averaged 1.3 days and only 2/46 went to SNF (all others returned to their homes). Complications occurred in 15/20 (75%) patients in the traditional group. In the MIS group, there were 2 complications (2/46, 4.3%).

Conclusion: The comparison of the two groups is striking and demonstrative of the potential of minimally invasive techniques. None of the complications seen in the open PLIF group occurred in the MIS XLIF/AxiaLIF group. Prior to our adoption of MIS techniques, we had routinely refused surgical intervention to elderly patients based on our results. In our opinion, elderly patients require MIS techniques to avoid the severe complications seen with open fusion procedures.

424.
Minimally Invasive Treatment of Adjacent Segment Degeneration via XLIF
W.B. Rodgers, Curtis S. Cox, Edward J. Gerber

Introduction: The XLIF approach provides a minimally disruptive alternative to anterior column access that allows for large graft placement, disk height restoration and indirect decompression, while avoiding posterior scar tissue from the previous procedure. Results of ASD treated minimally invasively using XLIF are presented.

Methods: Of our single-site consecutive series of > 500 XLIF patients, 107 were treated for ASD. Clinical and radiographic measures were prospectively collected and evaluated to assess a variety of pre-operative factors and outcomes.

Results: Age ranged from 34-87 years (average 62 years). Comorbidities included smoking (33%), chronic steroid use (11%), diabetes (27%), CAD (56%) and COPD (7%). Fifty patients (56%) were obese (BMI >30), 17 of those morbidly obese (BMI >38). All but one case included supplemental fixation: 47% unilateral pedicle screws, 3% bilateral pedicle screws, 29% lateral embossed plate and 23% laterally tabbed interbody implant. In 15 cases with prior posterior instrumentation, the pre-existing rods were removed unilaterally and revised on that side, in all other cases with prior instrumentation, adjunctive lateral fixation was used. Hospital stay averaged 1.1 days, with no blood transfusions or wound infections. Complications included intraoperative hardware failure (2, revised during same procedure with no incident), ileus (2), urinary retention (1), peritoneal catheter occlusion (1), atrial fibrillation (1), MI at 6 weeks post-op (1) and post-operative quadriiceps weakness (1, resolved within 4 weeks of surgery). Average pain scores (VAS) improved by 4.5 points from pre-op to 12 months follow-up. Average disk height improved from 6.9 to 9.8 mm, slip from 3.1 to 0.0 mm. Definitive signs of fusion (Lenke 1-2) were present in 77% at 3 months, 86% at 6 months and 100% at 12 months.

Conclusion: Our experience using XLIF in the ASD population has shown that clinical and radiographic indicators improve commensurately and the overall outcome is encouraging.

425.
CT Fusion Assessment in XLIF Patients at One Year
W.B. Rodgers, Curtis S. Cox, Edward J. Gerber

Introduction: XLIF has proven to be a safe and effective procedure. This is the first report specifically highlighting fusion rates of XLIF by CT assessment. High rates of fusion can be reasonably expected using this minimally invasive interbody fusion procedure.

Results: Patient age ranged from 34-87 years (average 62 years). Eighty-nine levels were treated: 51 1-levels, 10 2-levels and 6 3-levels, 16 at L2-3, 32 at L3-4 and 37 at L4-5. Grafting materials included a composite of DBM, local bone graft and bone marrow aspirate. Twelve surgeries included supplemental unilateral pedicle screw fixation performed in the same surgical position. Average disk height improved from 5.7mm to 10.1mm at one-year follow-up. Signs of fusion by Lenke scores of 1 or 2 were 100% at 6 and 12 months. Fusion by CT criteria of > >50% area fused was achieved in all but 3 levels (96.8%). Average VAS pain scores decreased from 8.9 at pre-op to 1.7 at 12 months. At 1 year, 86.5% of patients were satisfied or very satisfied with their outcomes. The surgeon-reported clinical assessment was good or excellent in 79.1%.

Conclusion: XLIF has proven to be a safe and effective procedure. This is the first report specifically highlighting fusion rates of XLIF by CT assessment. High rates of fusion can be reasonably expected using this minimally invasive interbody fusion procedure.

426.
Extreme Lateral Access to the L4-5 Disk Space
W.B. Rodgers, Curtis S. Cox, Edward J. Gerber

Introduction: Access is limited to lumbar levels above L5-S1 due to the impediment of the iliac crest laterally. Results of XLIF procedures performed at the L4-5 level demonstrate the feasibility, safety and effectiveness of the approach at this level.

Methods: In our single-site consecutive series of > 500 XLIF patients, 286 (60%) included the L4-5 level. Eight of these were lumbarized sacral levels (L5-S). Clinical and radiographic data were prospectively collected and reviewed to assess the feasibility and success of the XLIF procedure at the L4-5 level.

Results: Ages ranged from 54-79 years (average 66 years). Diagnoses included stenosis (41.9%), spondylolisthesis (23.5%), HNP (11.5%), DDD (11.5%), scoliosis (6.9%) and post-laminectomy instability (4.6%). 76.2% had one or more comorbidities. 29.6% had prior lumbar surgery. 129 (49.6%) were obese, 39 of those morbidly obese. All procedures were successfully accessible using a breakable radiolucent table, significantly bent at the patient’s greater trochanter. Hospital stay averaged 1.2 days. Complications included 4 transient lower leg weaknesses (3 quads, 1 anterior tibialis, only one persisting longer than 6 weeks), 1 endplate fracture (at L3, which resolved without intervention), 1 post-operative fracture of vertebral osteophytes which required reoperation, 2 broken cages on insertion (replaced at time of surgery without incident), 2 later-term
Minimally invasive treatment of posterior lumbar interbody fusion: The XLIF technique

**Introduction:** The XLIF procedure provides a minimally invasive alternative to traditional posterior lumbar interbody fusion (PLIF) by accessing the interbody space laterally. This approach aims to minimize the risk of adjacent segment degeneration and postoperative kyphosis, while providing direct access to the interbody space with minimal disruption to the posterior soft tissue structures.

**Methods:** A retrospective review of 100 consecutive patients who underwent XLIF procedures was conducted. The patients were followed for a minimum of 12 months, and radiographic and clinical outcomes were assessed.

**Results:** Postoperative lumbar lordosis was maintained in 95% of cases. The average fusion rate was 98%, with no evidence of adjacent segment degeneration. Complications were minimal, with no major medical events reported. Patient satisfaction was high, with 90% reporting significant improvement in pain and function.

**Conclusion:** The XLIF procedure offers a minimally invasive approach to posterior lumbar interbody fusion, with excellent fusion rates and minimal complication profiles. It is an effective alternative to traditional PLIF procedures, providing direct access to the interbody space with minimal disruption to the posterior soft tissue structures.

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**427. Extreme Lateral Interbody Fusion (XLIF) in the Morbidly Obese**

W.B. Rodgers, Curtis S. Cox, Edward J. Gerber

**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 XLIF procedure 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 > 500 XLIF patients, 254 were identified as obese (BMI > 30) and 82 of those were morbidly obese (BMI > 38). Comorbidities included smoking (33%), prior spine surgery (48%), diabetes (22%), and COPD (9%). Thirty-one (9.96%) were obese (BMI > 30), 11 of those morbidly obese (BMI > 38). Eighty-six levels were treated: 48 levels, 132 2-level and 4 3-level, 74% of cases included the L4-5 level. All cases included supplemental fixation: 97% unilateral pedicle screws, 3% transfacet screws. There were no blood transfusions or wound infections. Hospital stay averaged 1.3 days. Complications included 1 case of pneumonia and 2 cases of neural trauma with transient lower limb weakness, both resolving within 2 to 6 weeks. Average VAS pain scores improved from 8.4 at pre-op to 2.9 at 12 months follow-up. Average disk height improved from 6.7 to 10 mm, slip from 4.0 to 0.1 mm. At 3 months, Lenke fusion scores averaged 1.98 at 6 months 1.30 and at 12 months, 1.08. 92.3% of patients with 12-month follow-up have a Lenke score of 1.

**Conclusion:** Our results demonstrate the usefulness and safety of the XLIF technique in treating morbidly obese patients minimally invasively. Complications are minimal, procedures timely and outcomes similar to non-obese patients.
evaluated to assess surgical details, hospital stay, complications, pain scores, changes in disk height and alignment and fusion.

Results: Ages ranged from 31-86 years (average 61years). Comorbidities included CAD (55%), smoking (30%), diabetes (35%) and chronic steroid use (5%). Eleven patients (55%) were obese (BMI > 30), 2 of those morbidly obese (BMI > 38). Twenty-nine levels were treated: 12 1-level (4 at L3-4, 8 at L4-5), 7 2-level (4 at L2-4, 3 at L3-5) and one 3-level (L2-5). All cases included unilateral pedicle screw fixation, save one where a lateral instrumented plate was used. There were no blood transfusions or wound infections. Hospital stay averaged 1.05 days. Complications included 1 ileus and 1 transient tibialis anterior weakness, both of which resolved without intervention. Average VAS pain scores improved from 8.1 to 1.0 at 12months follow-up. Average disk height improved from 6.4 to 10.5 mm, slip from 3.6 to 1 mm. At 3 months, 94% showed early signs of fusion (Lenke 1-2), at 6 and 12 months, 100%.

Conclusion: Patients with large disk herniations and significant canal compromise, severe disc degeneration and instability could be decompressed across the intervertebral space without extensive dorsal exploration of the spinal canal and, coupled with distraction decompression, marked improvement of symptoms was achieved. Results demonstrate the usefulness and safety of the XLIF technique in treating r-HNP.

431. Extreme Lateral Interbody Fusion (XLIF) in Smokers
W.B. Rodgers, Curtis S. Cox, Edward J. Gerber

Introduction: The peri- and post-operative results of XLIF were collected to assess feasibility and clinical and radiographic success in smokers.

Methods: In our single-site consecutive series of > 500 XLIF patients, 156 were smokers at the time of surgery. Comorbidities, surgical indications, levels treated, hospital stay, complications, improvements in pain and disability, changes in disk height and alignment and fusion were assessed.

Results: Patients ranged in age from 22-84 years (average 57 years). Indications for surgery included stenosis, DDD, HNP, post-laminectomy instability, scoliosis and spondylolisthesis. 358% had previous spine surgery. Twenty percent had diabetes, 56% had CAD, 10% had COPD and 13% were chronic steroid users. Forty percent were obese or morbidly obese. 181 levels were treated: 123 1-levels, 20 2-levels and 6 3-levels, 1 at T6-7, 1 at T10-11, 6 at L1-2, 23 at L2-3, 55 at L3-4, 95 at L4-5. Grafting materials included a composite of DBM, local bone graft and bone marrow aspirate.

All but two surgeries included supplemental fixation, monthsth performed in the same surgical position. There were no transusions or infections. Complications included 1 pneumonia, 1 reintubation, 1 urinary retention, 1 endplate fracture (healed without intervention), 2 intraoperative hardware failures (replaced without incident) and 1 quad weakness (resolved without intervention). Hospital stay averaged 1.2 days. From pre-op to 12 months post-op, average disk height improved by 3.2 mm, average slip improved by 3.5 mm, average VAS pain scores decreased by 5.5 points. Signs of fusion by Lenke scores of 1 or 2 were 85% at 3 months, 94% at 6 months and 100% at 12 months – not significantly different from the greater non-smoking (283 pts) cohort (90%, 95% and 99%, respectively).

Conclusion: XLIF results show no significant difference in the clinical and radiographic outcomes between smokers and nonsmokers. XLIF affords an effective minimally invasive surgical option for the smokers.

432. Grade II Spondylolisthesis Treated by XLIF
W.B. Rodgers, Curtis S. Cox, Edward J. Gerber

Introduction: The XLIF approach is a less disruptive alternative to anterior column reconstruction allowing for large graft placement, disk height and alignment restoration and indirect decompression. A review of Grade-II slips treated by XLIF is reported.

Methods: In our single-site consecutive series of > 500 XLIF patients, 48 had Grade-II spondylolisthesis, w/ and w/o concomitant stenosis, DDD, post-laminectomy instability, HNP and/or scoliosis. Clinical and radiographic data were reviewed to assess comorbidities, surgery details, hospital stay, complications, pain scores, changes in disk height and alignment and fusion.

Results: Ages ranged from 25-87 years (ave 65.3 years). Comorbidities included smoking (31.2%), diabetes (22.9%), CAD (58.3%) and COPD (83.8%), Obesity (45.8%) and prior surgeries (18.8%). Thirty-eight procedures were single-level (36 at L4-5, 2 at L3-4), 8 were two-level (all at L3-5), the XLIF approach was successfully accessible in all cases. All cases included supplemental fixation. Hospital stay averaged 1.2 days. Complications included 1 pulmonary embolism requiring anticoagulation and 1 late-term hardware failure (screw fracture at 1 year). Post-operative thigh discomfort was routine and slight thigh numbness rare, resolving completely within 4-6 weeks in all cases. No significant hip flexor weakness was noted beyond 6 weeks. VAS pain scores improved from 8.7 at pre-op to 2.4 at 3 months, 2.1 at 6 months and 1.4 at 12 months. Disk height improved from an average of 5.4 mm at pre-op to 10.98 mm post-op and was maintained at 9.8 mm at 12 months. Slip improved from 10.8 mm at pre-op to 2.9 mm post-op and was maintained at 3.1 mm at 12 months. Lenke fusion scores averaged 2.0 at 3 months, 1.3 at 6 months and 1.1 at 12 months.

Conclusion: Grade-II spondylolisthesis is a challenging application to treat minimally invasively, but access, alignment and fusion are shown to be achievable using the XLIF approach, without the concomitant morbidity seen in traditional open fusion.

433. Radiographic Outcomes in Two-level ACDFs: Comparison of PEEK and Allograft Interbody Devices at 1-Year Follow-up
W.B. Rodgers, Curtis S. Cox, Edward J. Gerber

Introduction: In an effort to decrease complications and costs associated with harvesting of iliac crest bone graft (ICBG), demineralized bone matrix (DBM) combined with local bone was employed as a fusion adjunct inside the interbody devices of ACDFs.

Methods: 157 patients underwent instrumented 2-level ACDFs. Patients were assigned to one of two treatments arms that included a composite of DBM plus autogenous endplate reamings, incorporated into allograft bone dowels or PEEK spacers and stabilized with dynamic anterior plating. Fusion was defined as, uninterrupted bridging of well mineralized bone across the interbody space and no significant motion on flexion-extension radiographs. Both operative levels were assessed for fusion using a modified Lenke score. Any pseudarthrosis at either level was considered a failure.

Results: Of 104 patients, 39 were treated with allograft interbody dowels (13M, 26F, age 61.5 years, 11 smokers) and 65 were treated with PEEK spacers (23M, 42F, age 52.4years, 15 smokers). Average 12-month Lenke score across all subsets was 1.03 (allograft 1.08, PEEK 1.00). There were no infections, neurologic complications or plate breakages. Only one patient (allograft) developed a clear pseudarthrosis.

Conclusion: The combination of a demineralized bone matrix-locall bone composite contained within allograft dowels or PEEK spacers resulted in similar fusion rates (> 97%) at 12 months post-operatively. Based on Lenke scores, allograft dowels appear to fuse more slowly than PEEK spacers but this may be perceptive.
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Min S. Park, David Daniel Gonda, Chiao Amene, Choll Kim, William R. Taylor

Introduction: We describe a novel technique for the surgical treatment of a lumbar burst fracture via a minimally-invasive, unilateral, posterior approach.

Methods: A 66-year-old male was struck by an automobile and developed immediate low back pain without radiation or neurologic deficit, as well as multiple other orthopaedic injuries. Work-up, including a CT scan, demonstrated an L4 burst fracture with significant height loss.

Results: The patient was positioned prone on the operative table. The L4 level was localized using fluoroscopic guidance. An approximately 6 cm longitudinal incision was made 5 cm off of the midline. Using a Wiltse paraspinal type approach, the minimally-invasive retractor was docked onto the junction of the transverse process and facet joint. The unilateral lamina, facet, pars interarticularis, pedicle and vertebral body were removed using a high speed drill. An expandable titanium cage was positioned within the corpectomy site and expanded to restore height loss. Percutaneous pedicle screws were then placed at the level above and below the affected level. Post-operative radiographs demonstrated restoration of height loss and decompression of the spinal canal.

Conclusion: The minimally-invasive, unilateral, posterior approach for the treatment of lumbar burst fractures appears to be effective in the correction of deformity following traumatic injuries in the neurologically intact patient.

435. Radiographic Outcomes in Two-Level ACDFs: Comparison of Smokers and Non-Smokers at 1-Year Follow-up
W.B. Rodgers, Curtis S. Cox, Edward J. Gerber

Introduction: Multi-level fusion procedures are associated with higher risk of failure. Smoking has been cited to potentiate post-operative infections and interfere with bone graft incorporation. In an effort to decrease complications and costs associated with harvesting of iliac crest bone graft, demineralized bone matrix (DBM) combined with local bone was employed as an adjunct to the interbody grafts.

Methods: 104 patients underwent instrumented 2-level cervical fusion. Patients were assigned to one of two treatments arms that included a composite of DBM plus autogenous endplate reamings, incorporated into allograft bone dowels or PEEK spacers, all surgeries were stabilized with dynamic anterior plating. Anteroposterior and lateral radiographs were obtained at three, six and twelve month intervals. Fusion was defined as, uninterrupted bridging of mineralized bone across the interbody space without motion on flexion-extension radiographs.

Results: Of 104 patients, 26 were smokers (10M, 16F, age 52.7 years) and 78 nonsmokers (26M, 52F, age 56.9 years). Average 12-month Lenke score across all subsets was 1.05 (smokers 1.08, nonsmokers 1.04). There were no infections, neurologic complications or plate breakages. One patient, a 59-year-old diabetic male smoker, developed a pseudarthrosis, at the 6-month follow-up, the patient remained asymptomatic and declined re-operation.

Conclusion: The combination of a demineralized bone matrix-local bone contained within allograft dowels or PEEK spacer resulted fusion rates (> 96%) for smokers and nonsmokers at 12 months post-operatively.

436. Two-Level Instrumented ACDF Using Demineralized Bone Matrix and Local Bone: 104 Cases at 1-Year Follow-up
W.B. Rodgers, Curtis S. Cox, Edward J. Gerber

Introduction: In an effort to decrease complications and costs associated with harvesting of iliac crest bone graft, demineralized bone matrix (DBM) combined with local bone was employed as a fusion adjunct in 2-level ACDF procedures.

Methods: 157 patients underwent instrumented 2-level anterior cervical discectomy and fusion procedures. Patients were assigned to one of two treatments arms that included a composite of DBM plus autogenous endplate reamings, incorporated into allograft bone dowels or PEEK spacers. Fusion was defined as definitive, uninterrupted bridging of mineralized bone across the interbody space and no significant motion on flexion-extension radiographs. Both operative levels were assessed for fusion using a modified Lenke score. Any pseudarthrosis at either level was considered a failure.

Results: 104 patients, 36 male and 69 female, with average age of 55.8 years (range 31-81 years) presented for 12-month follow-up. Average 12-month Lenke score was 1.03. There were no infections, neurologic complications or plate breakages. One 59 year-old diabetic male smoker, had a pseudarthrosis at the time of 6-month follow-up.

Conclusion: The combination of a DBM-local bone composite contained within allograft dowels or PEEK spacers and dynamic cervical plating resulted in fusion in 103/104 patients at 12 months post-operatively. This combination achieved fusion results comparable to earlier literature reports for autograft or instrumented allograft dowels without the incumbent expense and documented complications of BMP.

437. Biomechanics of a Lumbar Interspinous Anchor with TLIF
U. Kumar Kakarla, Phillip M. Reyes, Randall W. Porter, Taro Kaibara, Ali Yaqoobi, Seok Kwang Choi, Dean G. Karahalios, Neil R. Crawford

Introduction: The Aspen (Lanx Inc., Broomfield, CO) is a clamping lumbar interspinous anchor (ISA) that allows for fusion. Stability offered by this device was compared in applications utilizing transforaminal lumbar interbody fusion (TLIF).

Methods: Seven human cadaveric L3-S1 specimens were tested (1) intact, (2) after bilateral pedicle screws-rods at L4-L5, (3) after disconnecting rods and placing ISA, (4) after TLIF with ISA, (5) with TLIF, ISA and unilateral pedicle screws-rods, (6) with TLIF and unilateral pedicle screws-rods (ISA removed), (7) with TLIF and bilateral pedicle screws-rods. Pure moments (7.5 Nm maximum) were applied in each plane while recording angular motion optoelectronically. 400N compression was also applied while measuring foraminal height.

Results: All instrumentation reduced angular range of motion (ROM) significantly from normal (Figure 1). The ISA was most effective in limiting flexion and extension, allowing equivalent ROM to pedicle screws-rods (p < 0.05). The ISA was least effective in reducing lateral bending, although this mode was reduced to 81 % of normal. TLIF with unilateral pedicle screws-rod was the least stable configuration. Addition of the ISA to this construct significantly improved stability during flexion, extension, lateral bending and axial rotation (p < 0.04). Constructs including the ISA increased the foraminal height an average of 0.7 mm more than the other constructs (p < 0.05).

Conclusion: The ISA grips bone effectively and limits flexion and extension equivalently to pedicle screws-rods. It also provides increased foraminal height. When used with TLIF, a construct of ISA plus unilateral pedicle screws-rods may offer an alternative to bilateral pedicle screws-rods.
In an effort to decrease in vitro testing of the 45 smokers and 59 non-smokers, 101 of 110 patients, with average This study compares the rate of fusion surgeries. The fusion rate for smokers and non-smokers was 94.8% and 92.5%, respectively and failed to show a significant difference between the two groups. Slightly better (intertransverse) Lenke scores were noted in the nonsmokers.

Conclusion: Smoking is often identified as a contributing factor to increased pseudoarthrosis (non-union) rates in spinal fusion surgeries. The fusion rate for smokers and non-smokers was 94.8% and 92.5%, respectively and failed to show a significant difference between the two groups. Slightly better (intertransverse) Lenke scores were noted in the nonsmokers.

Introduction: This study determines the viability of a graft composite composed of demineralized bone matrix (DBM) coupled with bone marrow aspirate (BMA) and locally harvested bone (LB) in 2-level posterolateral interbody fusion (PLIF) procedures.

Methods: 110 instrumented, 2-level PLIF procedures were performed by a single surgeon using a graft composite prepared from ground lamellar bone, supplemented with DBM and posterior iliac crest bone marrow aspirate (BMA). The composite was placed in the aperture of PEEK or machined polyethyletherketone (PEEK) spacers (n = 56) or the medullary canal of machined fibular allograft wedges (n = 45) prior to being implanted in the interbody space. Anteroposterior and lateral flexion/extension radiographs were evaluated utilizing a modified Lenke scoring. Fusion was defined as uninterrupted bridging bone across the interbody space without motion on the flexion-extension radiographs.

Results: 101 of 110 patients, with average age of 57.6 years (range from 32 to 85 years) at 12 months. 98.2% of PEEK patients and 86.7% of allograft patients were considered fused. Noted complications include: infection (n = 3), wound disruption (n = 2), pneumonia (n = 1), pulmonary embolus (n = 1) and dural tear (n = 1), 6 reoperations were performed for adjacent segment degeneration.

Conclusion: The results indicate excellent 12-month fusion rates in both cohorts. We believe that it is easier to assess PEEK graft incorporation, which might account for the different fusion rates between the two groups.

Introduction: This study compares the rate of fusion between smokers and non-smokers, using a commercially available demineralized bone matrix (DBM) coupled with bone marrow aspirate and local bone in 2-level posterolateral interbody fusion (PLIF) procedures.

Methods: 110 patients underwent 2-level instrumented PLIFs. Patients were assigned to one of two treatment arms that included a composite of DBM + BMA + LB that was placed in the aperture of polyethyletherketone (PEEK) spacers (n = 56) or the medullary canal of machined fibular allograft wedges (n = 45) prior to being implanted in the interbody space. Anteroposterior and lateral flexion/extension radiographs were evaluated utilizing a modified Lenke scoring. Fusion was defined as uninterrupted bridging bone across the interbody space without motion on the flexion-extension radiographs.

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Conclusion: The results indicate excellent 12-month fusion rates in both cohorts. We believe that it is easier to assess PEEK graft incorporation, which might account for the different fusion rates between the two groups.


**442. Fusion Results Using DBM and BMA in Extreme Lateral Interbody Fusion (XLIF)**

W.B. Rodgers, Curtis S. Cox, Edward J. Gerber

**Introduction:** The XLIF approach is a less disruptive alternative in lumbar fusion procedures. Fusion rates using various grafting alternatives have not been reported.

**Methods:** Ninety-one patients underwent XLIF using a graft composite composed of demineralized bone matrix (DBM), iliac crest bone marrow aspirate (BMA), allograft chips and local bone harvested from the central vertebral body. Fusion was defined as definitive, uninterrupted bridging of mineralized bone across the interbody space and no significant motion on flexion-extension radiographs.

**Results:** Fifty-two patients (23M, 29F, Avg 62.0 years, Avg BMI 30.0, 42LVL, 9 21VL, 1 31VL, LOS 1.65 days, 0 infections) were available for follow-up 12 months after surgery. VAS pain scores improved from 8.33 to 1.77. Disk height improved from 6.4 mm pre-op to 10.3 mm post-operatively and was 8.0 mm at 12 months. Lysisis (33 pts) improved from 4.3 pre-op to 0.65 mm at 12 months. Modified Lenke scores were 2.1 (3 months), 1.2 (6 months), 1.1 (12 months). No patient had a pseudarthrosis by motion criteria and none has been re-explored.

**Conclusion:** The combination of a DBM-BMA-allograft-local bone composite contained within PEEK spacers 52/52 patients at 12 months post-operatively. Little has been reported about fusion rates in MIS procedures but this combination achieved fusion results comparable to earlier literature reports for Autograft or BMP in posterior or anterior lumbar fusions without the incumbent expense and documented complications.

**443. Aperius PercLID System in Degenerative Lumbar Spinal Stenosis with Neurogenic Intermittent Claudication: 1-year Clinical Outcomes of 22 Patients**

Anthony P. Fabrizi, Marcelo Galarza, Raffaella Maina

**Introduction:** The Aperius PercLID system offers rapid improvement in symptom severity and quality of life for degenerative lumbar spinal stenosis (DLSS) patients with neurogenic intermittent claudication (NIC). The aim of this study was to evaluate whether clinical improvement is detectable after 12 months.

**Methods:** Twenty-two DLSS patients with NIC (age 72.7 ± 8.08 years) were studied. Symptom severity, physical functioning, quality of life and self-rated pain were assessed pre-operatively and at 12-months follow-up using the Zurich Claudication Questionnaire (ZCQ), the EuroQol 5

Domain Questionnaire (EQ-5D) and the Visual Analog Scale (VAS). The Aperius procedure was conducted under general or spinal anesthesia (as applicable) using biplanar fluoroscopy for visualization.

**Results:** Single level treatment was performed in 12 patients while 10 patients had 2 levels treated. Based on time recordings of 16 cases, mean procedure time was 21.9 ± 6.0 minutes. Mean pain VAS score improved significantly from 7.6 ± 1.89 at baseline to 2.86 ± 3.11 at 1-year follow-up (p < 0.0001). Mean % improvement in ZCQ score for symptom severity and physical function at 1 year were 31.6 ± 33.2 (p = 0.002) and 31.8 ± 21.8 (p < 0.0001) respectively and both proved to be statistically significantly. The ZCQ score for patient satisfaction showed that 81% of the patients were satisfied with the procedure. The average EQ-5D value improved significantly from 39.6 ± 17.2 at baseline to 64.1 ± 13.9 at 1-year follow-up (p < 0.0001). Monthst improvement was seen in mobility, pain/discomfort and ability for self-care.

**Conclusion:** The Aperius system provides clinically significant improvement after 1-year follow-up in DLSS patients with NIC. In this generally older or high risk population, this short minimally invasive procedure represents a treatment option with important added value to traditional spinal surgery.

**444. Intrinsic Back Pain: Increased Self-Awareness or Impairment of True Functionality? A Pilot Study**

Sanchia S. Goonewardene, Ian Sargeant, Keith Porter

**Introduction:** Pain in back is a common problem with a lifetime prevalence of 59% [1]. The economic impact of this in terms of days lost from work, invalidity benefit and health service utilization as a result of chronic back pain is enormous. We aim to investigate impairment of function caused by psychological perception of pain in back pain sufferers and non-pain sufferers and compare it to the true level of functioning in NHS Staff.

**Methods:** A cross-sectional cohort based study was conducted on the target population of staff of wards S2-4. For each cohort with/without pain the following information was collected: pain intensity levels and pain levels within back disability categories. The relationship between pain intensity and level of functioning was determined. Data was analyzed via averages and percentages.

**Results:** For non-back pain sufferers, pain was demonstrated, with limitation in categories of the back disability index and good correlations were demonstrated. Average general health was ranked as 8.7, with an average physical activity level of 6.32, with limitation of movement in 11% associated. For those with back pain, a far higher pain intensity was experienced with less limitations in each category of the neck disability index and range of movement is limited in only a few, indicating it is not a good indicator of functional ability. Interestingly, the level of general health and physical activity were very similar in both cohorts even though those with neck pain have higher pain intensities.

**Conclusion:** We discovered although those with neck pain reported higher pain intensities, this did not correlate with the pain experienced during daily activities or with range of movement. We conclude somatization and affective disorders may be playing a part as well as psychological factors.

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**Conclusion:** We discovered although those with neck pain reported higher pain intensities, this did not correlate with the pain experienced during daily activities or with range of movement. We conclude somatization and affective disorders may be playing a part as well as psychological factors.
446. **Biomechanics of a Lumbar Interspinous Anchor with Anterior Lumbar Interbody Fixation**


**Introduction:** Like a lumbar interspinous spacer, an interspinous anchor (ISA) prevents extension. Additionally, it is intended to immobilize the motion segment to allow for fusion. Stability provided by the Aspen (Lax Inc., Broomfield, CO) ISA was studied in applications utilizing anterior lumbar interbody fixation (ALIF).

**Methods:** Six human cadaveric L3-S1 specimens were tested (1) intact, (2) after placing ISA at L4-L5, (3) after ALIF (PEEK interbody lordotic) with ISA, (4) after ALIF with ISA and anterior locking plate, (5) after removing ISA (ALIF with plate only), (6) after removing plate (ALIF only), (7) after applying bilateral pedicle screws-rods. Pure moments (7.5 Nm maximum) were applied in each plane while recording angular motion optoelectronically.

**Results:** All instrumentation except ALIF—only reduced angular range of motion (ROM) significantly from normal in all directions of loading. The ISA was most effective in limiting flexion and extension (25% of normal) and less effective in reducing lateral bending (69% of normal) or axial rotation (69% of normal). ALIF with ISA provided stability that was equivalent to ALIF with bilateral pedicle screws-rods (p < 0.37. RM-ANOVA/Holm-Sidak). ALIF with ISA allowed less ROM than ALIF with plate during flexion, extension and lateral bending (p < 0.03).

**Conclusion:** Used with ALIF at L4-L5, the ISA effectively immobilizes the motion segment, allowing nearly equivalent ROM to pedicle screws-rod and smaller ROM than an anterior plate. When used with ALIF, the ISA may offer an alternative to anterior plate fixation or bilateral pedicle screws-rods.

447. **The Relationship Between Lordosis and Flexion/Extension in the Intact Cadaveric Lumbar Spine**

Mithulun Jegapragasam, Daniel Cook, Mathieu Cuchanski, Adam S. Kanter, Boyle C. Cheng

**Introduction:** The role that facet anatomy plays in physiologic movement is not fully understood. Hypolordosis has been implicated in abnormal loading of the facets and adjacent level deterioration. This study attempts to elucidate the relationship between lordosis, sagittal angle and combined angles on flexion/extension in the lumbar spine.

**Methods:** Two fresh-frozen human cadaveric lumbar spines from L1-L5 were imaged in a CT scanner. The lordotic angle was measured by constructing lines parallel to the inferior and superior vertebral body endplates of adjacent levels and measuring the included angle. Similarly, the sagittal angle was measured from the construction lines parallel to the superior and inferior facets. The combined angle was found by extending a line parallel to the inferior endplate and finding the intersection with a line parallel to the superior facet surface. The spines were then tested in flexion/extension using a 6-axis spine tester. The three-dimensional motion of the vertebral bodies was captured via an optoelectronic tracking system. Analysis was performed to obtain a correlation coefficient.

**Results:** Lordotic angle was more highly correlated (r2 = .721) with range of motion in flexion/extension than the sagittal angle (r2 = .141) or the combined angle (r2 = .033).

**Conclusion:** Increased lordosis may be correlated with a greater range of motion for a functional spinal unit. This characterization is a first step in understanding the relationship between anatomy and kinematics in the lumbar spine. Further research, including comparison of lordosis and range of motion on a lumbar level by level basis, is needed.

448. **Methods of Therapeutic Cellular Injection into the Spinal Cord: A Literature Review**

Howard B. Levene, Allan D. Levi

**Introduction:** Discovering novel therapies for spinal cord injury (SCI) remains a challenge as the pathophysiology of spinal cord injury is not fully understood. It is difficult to create a treatment modality from first principles so animal models of spinal cord injury are used. There has been considerable interest in transplanting cells (e.g., Schwann cells) via injection to ameliorate and to repair SCI. A practical but important consideration is the mechanism of delivery of the therapeutic cells. Determining the safety of cellular injections into the injured spinal cord is a critical step in bringing this form of therapy to people. Current mechanisms for transplanting cells via injection are reviewed.

**Methods:** Data was accumulated from a literature review. Keywords: Schwann cells, olfactory ensheathing cells, spinal cord injury, cell therapy, injection. The focus of the review was on injections of cells into the spinal cord to treat SCI.

**Results:** Fifteen studies were determined to be particularly relevant. Many of the studies did not provide certain parameters for injection (e.g. method, rate, duration, testing needle placement injury, testing medium injection injury) No studies examined needle placement injury. Three tested the effects of injecting carrier. Four studies did not list depth/exact injection location. Nearly half of the sample set (seven), did not report injection rate. Six studies did not list needle retention time. The rates of injection varied from 0.25 to 2 microliters/minute. Cell density ranged from 10,000 to 100,000 cells/microliter. The needle retention time varied from one to five minutes after injection.

**Conclusion:** There are many variables in treatment for transplanting cells via injection in SCI. Investigators should consider and report specific details of their delivery techniques to allow for these variables to be considered and controlled in therapeutic research.

449. **Cervical Myeloradiculopathy and Co-existent Multiple Sclerosis: Surgical Treatment of Nine Patients with Two-Year Follow-up**

Paul M. Arnold, R. Kyle Warren

**Introduction:** Multiple sclerosis and cervical myeloradiculopathy share clinical signs, including gait dysfunction, motor weakness and hyperreflexia. Distinguishing between these two entities may be difficult and rarely they may co-exist. Controversy exists regarding the use of surgery in patients with multiple sclerosis as treatment for degenerative cervical spondylotic disease. We report a series of nine patients with co-existing multiple sclerosis and progressive myeloradiculopathy who were successfully treated with surgical decompression, fusion and fixation.

**Methods:** Nine patients (6 females, 3 males, average age 48) with a confirmed diagnosis of multiple sclerosis presented with worsening cervical myeloradiculopathy. Evaluations included neurological and radiographic assessment and subjective reports of pain and parasthesias. Six patients had neck pain, four had UE pain and/or paresthesias, six had worsening UE weakness, five had progressive LE weakness and one had new bladder incontinence. The average duration of symptoms prior to presentation was six months. All patients had MRI evidence of cervical spinal cord compression from an abnormal disk/osteophyte complex, hypertrophied ligament, or both. Eight patients underwent anterior cervical discectomy and fusion and one underwent C6 vertebrectomy and fusion.

**Results:** Patients were followed an average of 30 months. Eight patients showed objective improvement in neurologic function, including increased LE and UE strength. One patient’s symptoms stabilized. Eight of nine patients also had improvement in neck and/or UE pain or parasthesias. The patient with bladder incontinence did not improve. All patients went on to radiographic fusion. There were
450. Anterior Cervical Fusion Using a Silicate-Substituted Calcium Phosphate: 1-year Results of a Prospective Study Assessing Efficacy and Fusion Rates
Paul M. Arnold, Joan K. McMahon, Karen K. Anderson, Philip L. Johnson
Introduction: Autograft has been the standard for anterior cervical fusion but is associated with significant morbidity, allograft use can be complicated by issues such as cost, availability and disease transmission. To overcome these obstacles, we assessed the use of a bone graft alternative, a silicate-substituted calcium phosphate (Actifuse™, ApaTech Ltd., Elstree, UK) for patients undergoing one- and two-level anterior cervical fusions (ACF) for myelopathy and/or radiculopathy.
Methods: A prospective, observational case-control study at one academic medical center involved 34 patients (10 smokers, 14 males, 20 females) who underwent standard ACF with Actifuse™, PEEK spacers and anterior fixation. Outcome measures included neurological and radiographic fusion assessment. Fifteen patients had two-level fusion. Twenty-seven patients have had six-month follow-up and 18 have had one-year follow-up. Patients were evaluated for pain, neurologic outcome and fusion at baseline, 3-, 6-, 12- and 24-month follow-up.
Results: At six months post-op, 25 of 27 patients had significant improvement in upper extremity radiculopathy, two patients did not improve. All 27 (16 one-level, 11 two-level) had CT evidence of fusion at six months, with no movement on flexion-extension films. (Fig 1) There were no surgical complications and no patient was worse neurologically after surgery.
Conclusion: Silicate-substituted calcium phosphate is a safe, efficacious bone graft alternative to allograft or autograft in selected patients undergoing one- or two-level ACF. Because further data is required to assess long-term outcomes in this population, these patients will continue to be followed post-operatively for 2 years.

451. 12-Month Prospective Study of Serum Metal Ion Levels in Patients with Titanium Ceramic Composite Metal Cervical Disc Replacements
Wade Ceola, Matthew F. Gornet, Anastasia Skipor, Joshua Jacobs
Introduction: Total disc replacement is an alternative treatment for degenerative disc disease. Corrosion of wear particles can lead to increased metal ion release. This study examines the serum titanium (Ti) levels in patients with disc replacements.
Methods: This is a prospective study consisting of thirty patients implanted with the PRESTIGE® LP Cervical Disc replacement (Medtronic, USA), a metal-on-metal, titanium ceramic composite which consists of a matrix of titanium-alloy mixed with titanium carbide. Serum samples were collected pre-operatively, three, six and twelve months post-operatively and assayed using a high-resolution inductively-coupled plasma-mass spectrometry (Finnigan MAT, Germany). The detection limit was 0.2ng/mL for Ti. Longitudinal statistical comparisons were made using the Friedman test.
Results: Median Ti levels were 0.10, 1.22, 1.15 and 1.27ng/mL at pre-op, three, six and twelve months, respectively. The difference was statistically significant (p < 0.01) between Ti levels at post-operative time periods compared with pre-op levels. Kasai et al (Spine, 2003) reported on a cohort of patients with titanium posterior spinal instrumentation where ~1/2 had Ti serum levels greater than 20ng/mL. The median Ti levels in our total disc cohort were lower than the values reported in a cohort of metal-on-UHMWPE total hip replacements with titanium alloy components (Jacobs, JBJS, 1998). Caution should be used in comparing the Ti levels in the total disc cohort with the reported values due to differences in methodologies, analytical instruments and detection limits.
Conclusion: These results indicated that short-term metal levels are lower than those observed in posterior spinal instrumentation and metal-on-UHMWPE hips with titanium components.

452. Spinal Wound Infection Avoidance: Identification of Risk Factors Associated with Post-operative Spinal Infections
Donald John Blaskiewicz, Walter P. Jacobsen, Mohamed Mudathir Abdulhamid, Catherine Murtagh-Schaffer, Ross R. Moquin
Introduction: Infections arising in post-operative spine patients are very costly to the patient and to the health care system. Early identification of modifiable risk factors may help to limit the occurrence of post-operative spine infections, reduce the medical morbidity associated with infections and diminish the financial burden placed on the patient, medical institution and insurance carriers.
Methods: A retrospective chart review was conducted on all patients undergoing instrumented spinal surgery between August 2006 to August 2008. 710 patients were identified. The following patient data points were analyzed as predictive factors for post-operative wound infections: Patient age, presentation (trauma, degeneration, deformity), other injuries at the time of presentation, BMI, medical comorbidities, history of tobacco use, spinal segment(s) operated on, number of operative levels, presence of an intraoperative CSF leak, length of time for procedure, blood loss, whether or not a drain was used post-operatively, presence of elevated blood sugar pre-, post-operatively, number of days before mobilizing from bed, LOS in the hospital.
Results: There may potentially be identifiable risk factors for spinal wound infections.
Conclusion: Infections arising in post-operative spine patients are very costly to the patient and to the health care system. Early identification of modifiable risk factors may help to limit the occurrence of post-operative spine infections, reduce the medical morbidity associated with infections and diminish the financial burden placed on the patient, medical institution and insurance carriers.

453. O-ARM Assisted Fixation of Type II Odontoid Fractures via the Direct Anterior Approach
Donald John Blaskiewicz, Igor Richard Yusupov, Walter P. Jacobsen, Mohamed Mudathir Abdulhamid, Catherine Murtagh-Schaffer, Ross R. Moquin
Introduction: Advances in image-guided surgery (IGS) have permitted safer and more accurate placement of spinal instrumentation (3, 4). In addition, the use of IGS, may decrease radiation exposure for the surgeon, patient and operative staff (6, 9). Currently, the O-ARM® (Medtronic Sophamore-Danek, Memphis TN), intraoperative CT scanner and the StealthStation® Treon® (Medtronic Surgical Navigation Technologies, Louisville, CO) image guidance work-station represents the newest generation in IGS. The
The fracture was successfully verified with realtime AP and lateral fluoroscopy.

Methods: This is a retrospective review of a patient with an unstable Type II odontoid fracture who underwent anterior stabilization with screw fixation utilizing spinal navigation. The navigation system was verified with realtime AP and lateral fluoroscopy.

Results: The fracture was successfully stabilized with spinal navigation assisted placement of the odontoid screw.

Conclusion: From our experience with the O-ARM and StealthStation® Treon system, we have found that the navigation system is easily adapted for use with a variety of spinal pathologies. We have found the navigation images to be as reliable and as accurate as directly compared to real-time fluoroscopy. This system offers several distinct advantages over the conventional method of using fluoroscopy: 1) The radiation exposure to the surgical team is diminished, 2) Using the virtual tip modality, the screw trajectory can be accurately directed and the screw length can be confirmed and 3) The surgeon is not diminished, 2) Using the virtual tip radiation exposure to the surgical team is diminished, and StealthStation® Treon® image guidance workstation for operative fixation of an unstable odontoid fracture via the direct anterior approach as previously described by Apfelbaum, et al. 1

455. Total Subaxial Reconstruction
Vincent C. Traynelis

Introduction: Outcomes for one and two level anterior cervical decompression and fusion are well understood. Less is known regarding the outcome of 3-4 level surgeries.

Methods: Data were prospectively accumulated for 30 consecutive patients undergoing segmental decompression and reconstruction for the entire subaxial spine.

Results: Seventeen men and 13 women were followed for an average of 18 months. Two patients had five levels and the remainder had 6 levels decompressed and fused anteriorly. All patients had posterior instrumentation. Twenty-four patients had myelopathy with a mean pre-operative Nurick score of 2.59, the post-operative score was significantly decreased to 1.26 (p = 0.002). All patients had pre-op neck pain with the average VAS of 6.1. This decreased significantly to 2 at last follow-up (p = 0.001). There was also a significant decrease in mean NDI scores following surgery: pre-op 27, post-op 18 (p = 0.05).

Conclusion: Our findings are consistent with the infiltrative nature of astrocytoma tumors. Although further clinical correlation for validation of this technique is required, MRI fiber tract tracing holds promise in allowing improved identification of how

456. Spinal Cord Tractography of Intramedullary Astrocytoma and Teratoma
Fahad A. Alkerayf, Arturo Cardenas-Blanco, Brien G. Benoit, Eve C. Tsai

Introduction: Tractography is a novel magnetic resonance imaging (MRI) technique that utilizes diffusion weighted images (DWI) to delineate white matter tracts. Its use in the spinal cord has been limited. We used this technique to study the difference between different types of intramedullary tumors.

Methods: Patients’ consent and ethical committee approval were obtained. Clinical status and image files of patients that underwent MRI tractography from December 2006 to September 2008 were obtained from the tractography database. Imaging was performed on a 1.5T Siemens MR Imager and the protocol began with the acquisition of a sagittal T2-weighted fast spin echo sequence with a subsequent axial diffusion-weighted single-shot echo planar imaging sequence. 3D white matter fiber tracts were created using the principal diffusion directions method. MEDINRIA version 1.7.0 and DTIStudio Version 2.02 software were used to generate the fiber tracking images and to count the number of fibers in different areas of the spinal cord. Those areas include normal spinal cord area (standard area or reference) and areas in the middle of the tumor (lesion area). The ratio between the two was also calculated.

Results: Five patients with intramedullary spinal cord tumors: astrocytoma (3) and teratoma (2) were identified. In all patients, tractography images were able to be obtained and processed as well as their final pathology reports. We found the number of fibers in the middle of the tumors were statistically different between the 2 groups (the final statistic numbers to be finalized soon). Numbers were close to zero in the teratoma group while in astocytoma group a number of fibers. Those fibers in the astrocytoma group were statistically different than the reference area. Also tractography images were able to show these differences

Conclusion: Our findings are consistent with the infiltrative nature of astrocytoma tumors. Although further clinical correlation for validation of this technique is required, MRI fiber tract tracing holds promise in allowing improved identification of how
white matter tracts are affected among different intramedullary tumors. Tractography also holds promise with respect to improved diagnosis of these lesions.

457. Preliminary Clinical Experience with the O-arm for Complex Spinal Instrumentation

Ewell Lee Nelson, Sigita Burneikiene, Alexander Mason, Alan T. Villavicencio

Introduction: A growing tendency towards increased safety and accuracy in spinal surgery is evident in recent years, but that would be impossible without innovations in the field of intraoperative image guidance technology. Introduction of the O-arm (Medtronic Navigation, Louisville, Colorado) is another step forward and the current state-of-the-art operating room technology. We report our initial clinical experience with this system in the setting of complex spinal surgery.

Methods: O-arm in conjunction with the Stealth Treon computer volumetric navigational system was utilized in 27 spinal surgery cases. The main objective of this retrospective study was to evaluate accuracy, radiation exposure and feasibility of the technique in a clinical setting. A total of 96 pedicle screws were inserted during transforaminal lumbar interbody fusion (TLIF) surgery (21 cases), 12 transpedicular cannulations performed (3 thoracic and 3 lumbar kyphoplasties) and odontoid screw placement (1 odontoid fracture). TLIF included 1 to 3 level interbody fusions, with 2 to 8 levels (mean 3.1 levels) instrumented postero-lateral fusions performed.

Results: The mean biplanar fluoroscopy utilization time was 48.4 seconds (range, 15-206) for TLIF or 8.4 seconds (range, 2.5-34.3) per pedicle screw placement. Two intraoperative O-arm pins were performed for each case, with the exception of 5 cases in which additional pins were required to verify repositioned pedicle screws. As a result, all pedicle screws were accurately placed and verified intraoperatively. An average operative time for TLIF cases was 328 minutes (range, 259-431). The mean estimated blood loss (EBL) was 469 mL (range 25-1200) and length of stay (LOS) 5.9 days (range, 1-18). One patient was treated for type II odontoid fracture with an odontoid screw and 137 sec biplanar fluoroscopy time in addition to 4 O-arm spins utilized. The mean biplanar fluoroscopy time was 51.3 seconds (range, 48-58) for kyphoplasty cases with one O-arm spin utilized to guide pedicle cannulation.

Conclusion: The O-arm is useful in assisting optimal placement of pedicle screws and transpedicular cannulations. Its particular usefulness is in providing intraoperative evaluation of the hardware and replacement if necessary.

458. Clinical Evaluation of Osteogenic Protein (OP-1) for Instrumented Posterolateral Fusion

Alan T. Villavicencio, Sigita Burneikiene, Ewell Lee Nelson, Alexander Mason

Introduction: OP-1 is available for wide utilization in clinical practice despite the fact that no superiority was demonstrated in the prospective clinical trials involving lumbar spine surgery. This study will discuss OP-1 use for posterolateral fusion in patients that were undergoing revision for failed back surgery syndrome, multilevel surgery, or heavy smokers and diabetics. Therefore, this study will assess the use of OP-1 for indications that the FDA approval was granted for and was not evaluated in the prospective clinical studies.

Methods: A total of 34 patients underwent transforaminal lumbar interbody fusion (TLIF) procedure for spondylolisthesis, stenosis, or revision of failed previous surgery. Bone morphogenetic protein (rhBMP-2) was used to promote interbody fusion and OP-1 for posterolateral fusion. Sufficient clinical information or radiographic studies were not available for 11 patients, so these patients were excluded from the analysis. The mean follow-up for the remaining 43 patients was 26 months (range 21-32). There were 28 female and 15 male, average age 59 years (range, 28-82). Twenty-eight (65%) patients had previous lumbar surgical procedures performed, of which 19 (68%) were fusion surgeries. Fifteen patients had pseudarthrosis from previous fusion procedure. Twelve patients (28%) were heavy smokers.

Results: Seventeen (39.5%) had definite radiographic signs of non-union. The mean time to fusion was 8.8 months (range 3-17 months) for the rest of the patients. The average surgical estimated blood loss was 728 mL (range 75-2000 mL). Statistical analysis was performed that compared patients who had fusion to those who failed to fuse. There were no statistically significant differences in regards to age (p > 0.2), smoking (p = 0.54), previous surgeries/pseudarthrosis (p > 0.18), number of interbody/posterior levels (p > 0.09) that were attempted to fuse, estimated blood loss (p = 0.32) or complications. Logistic regression analysis was performed to analyze if outcomes could have affected the summation of these factors. This also failed to demonstrate any correlations (p = 0.1 for complications and p = 0.74 for other factors).

Conclusion: Our results suggest insufficient efficacy of OP-1 for the indications that the exemption approval was granted.

459. Venous Stasis and Iliac Vein Obstruction Secondary to Prominent ALIF Plate Profile Post-Anterior Lumbar Interbody Fusion (ALIF): Report of Five Cases with 2-Year Follow-up

Keun-Young Anthony Kim, Farzad Massoudi, Robert J. Jackson, Michael Y. Wang

Introduction: Venous stasis and obstruction of the iliac veins remain concerns after Anterior Lumbar Interbody Fusion (ALIF) secondary to (a) intraoperative manipulation and (b) implant profile causing anatomical narrowing of the veins. We present five cases of plate thickness-associated venous narrowing causing venous thrombosis.

Methods: Retrospective review was performed on 250 consecutive patients (2003-2007) who had ALIF with plating for severe radiculopathy and low back pain refractory to conservative treatment > 6 months. Five patients were noted clinically and by venography to have focal venous narrowing or occlusion of the left deep venous system secondary to plate profile.

Results: Five patients (4F:1M, ages 34-55) developed severe left deep venous thrombosis (DVT) post-operatively extending to pelvic and iliac veins. All five patients had had prior posterior operations (laminectomy, discectomy and/or fusion). Diagnosis was obtained at post-operative day 1, 2 weeks and 4 months. All 5 patients underwent angiography noting “kinking” or “focal narrowing” of the left iliac vein secondary to plate. All patients underwent IVC filter placement and coumadin anti-coagulation. Two patients required thrombolysis and stent placement in the iliac vein at 1 month with recommendations for life-long anti-coagulation. All patients have been followed 2 years with interval resolution of swelling in four patients.

Conclusion: In our series, a high plate profile in Anterior Lumbar Interbody Fusion led to clinically symptomatic iliac vein occlusion or narrowing in 2% of patients. Two patients benefited from stenting of the left iliac vein for resolution of swelling.

460. Comparison of the Effect of Intramuscular Injection of Pethidine and Diclofenac Suppository in Relief of Pain following Laminectomy Surgery

Liza M. Ahmadi

Introduction: Pain, particularly after surgery, can create many side effects, such as delay in wound healing. Different drugs are used for relieving patient’s pain after surgery, such as pethidine and non-steroidal anti-inflammatory drugs. The purpose of this research was comparing pethidine’s effect to diclofenac suppository in relief of
pain after laminectomy surgery due to disc herniation.

Methods: In this research, 100 patients, who were qualified for researching, came for laminectomy. The easy method for choosing people was used for selection. They were divided into two pethidine (P) and diclofenac (D) groups. The patients’ pain score was measured with Visual Analog Scale (VAS) method and finally the information was analyzed with using statistical software SPSS.10, F and test and t-test significance was set at P < 0/05.

Results: The mean pain score 24 hours after surgery was calculated. In group P, 2/8 2/0 and group D, 4/46 2/30. There is a statistical significance between decreasing pain score after surgery in two groups (P < 0.05). Nausea is the most common side effect which has been observed in group P (20%) and Epigastric pain is the most common one in group D (18%). There wasn’t any statistical significance between side effects in these two groups.

Conclusion: There was statistical significance between pethidine injection and diclofenac suppository in decreasing pain after laminectomy surgery.

462. Epidemiology of Traumatic Spinal Injury in Guilan, Iran
Líza M. Ahmadí, Shahrókh Yousefzadeh, Omíd Taghínéjádi, Haniye Mohammádi, Leylá Koochakínéjad

Introduction: Acute injuries of the spine and spinal cord are among the causes of severe disability and death after trauma. Data about spine fracture with or without spinal cord damage are different. The aim of this study was to determine epidemiology and demographics of spinal injury in the main trauma center, Guilan.

Methods: The present study was a descriptive study of all cases of traumatic spine and spinal cord injury who were admitted to Poursina Hospital, main trauma center of Guilan. The scoring Systems used to evaluate severity of injury were American Spinal Injury Association (ASIA) and The Injury Severity Score.

Results: Among a total of 245 cases, 71.8% were male and 28.2% were female. Male/Female ratio was 2.55:1. The most common site of injury was lumbar (64.5%) followed by cervical (26.1%) and thoracic (9.4%). The most common cause of injury was motor vehicle accidents and falls. The most frequent causes were motor vehicle accidents and falls. The most common causes were motor vehicle accidents and falls. The most common cause of injury was motor vehicle accidents and falls. The most frequent causes were motor vehicle accidents and falls.

Conclusion: Among forty four patients with abnormal findings on neurological examination, fifteen of them had complete spinal cord injury (class A of ASIA) and twenty-nine had incomplete spinal cord injury (class B, C, D of ASIA).

Our focus on the spinal injury and its major etiology revealed prevention efforts should be made. More detailed information about the causes of spin 463. The Effects of XSTOP on Lumbar Lordosis and Its Correlation with BMI
Rizwan Ahmed, Christine Snyder, Khalid A. Sethi

Introduction: We evaluated the effects of the XSTOP interspinous process decompression device in vivo and correlated changes seen in global and segmental lumbar lordosis pre-operatively and post-operatively. We also correlated the body mass index with the outcome of the procedure objectively by assessing any changes seen on radiographical analysis and subjectively by correlating them with pain-scores in order to assess if BMI is an important entity for patient selection for the XSTOP procedure.

Methods: Twenty-eight consecutive patients with symptoms of lumbar spinal stenosis underwent placement of the XSTOP. Of these 15 patients’ pre-operative and post-operative (1 month-6 months) lateral films, VAS pain-scores and BMIs at the time of patient presentation were obtained. Radiographical analysis evaluated changes in global and segmental lumbar lordosis these changes were further correlated with BMI and pain-scores.

Results: The patient comprised of 10 females and 5 males, aged ranged from 48-90 years, mean, 70 years. The body mass index ranged from 21.99-59.06 kg/m², mean 32.83 kg/m². There were seven patients who had the device placed at a single level and eight patients at two levels. Pre-operative global lumbar lordosis (L5-S1) had a mean of 50.8±11.64 degree vs. post-op mean of 46.53±12.56 degrees. This change was found to be statistically insignificant (p=0.10). Analysis of segmental lumbar lordosis showed a mean of 7 ±3.96 pre-op vs. 6.13+4.49 post-op. This change in angle was also statistically insignificant (p = 0.56). Correlation of patients BMI with the degree of change in global lumbar lordosis and difference in pain scores after the placement of the XSTOP device did not show a statistically significant difference (p = 0.96 and 0.35 respectively)

Conclusion: The placement of XSTOP does not cause significant changes in the degree of global and segmental lumbar lordosis, further more BMI had no effect on the changes seen in lumbar lordosis. Variation in patient BMI did not correlate with changes seen in pre/post-operative pain scores.
Asdrubal Falavigna, Orlando Righesso, Daniel Volquind, Alisonn Teles

Introduction: Evaluate the efficacy of hydroxyapatite (HA) grafts associated with cervical plates in terms of clinical outcome, fusion, restoration and maintenance of cervical lordosis.

Methods: Prospective study with 40 patients who underwent anterior cervical fusion in which an HA graft and plate system were used. Clinical and radiological assessments were made one-month post-operatively and at the last consultation.

Results: At the mean follow-up time of 31.8 months, 80% had excellent clinical outcome, 15% good and 5% fair according to the Odom classification. All patients achieved lordotic alignment in the immediate postoperative. Graft breakage was observed in 25% of cases. The patients who had breakage in their HA block were 4.9 times more likely to have a loss of cervical alignment exceeding 3° and 12.4 times more likely to have migration in the plates comparing the patients with normal HA grafts. Of the 10 patients who had the graft broken, seven had lost graft height at the last follow-up compared with three of the no-broken group. There was no difference in the fusion rates between the groups.

Conclusion: Despite the good clinical results observed in this study, the breakage in the grafts was a common complication, presenting in 25% of the patients.

465. Ultrasound Guided Posterior Approach for a Thoracic Discectomy: Operative Technique and Early Experience
Rakesh Kumar C. Luhana, Satoru Tochigi, Howard J. Ginsberg

Introduction: Various operative approaches have been described for treatment of herniated thoracic discs, posterior, posterolateral and anterior approaches. Transfacetal pedicle sparing approach is appealing as it allows complete disc removal with limited soft tissue dissection and spinal column disruption. But it is limited by poor visualization anterior to cord and potential risk to cord injury. To aid visualization and to make the transfacetal approach safer and more effective, application of ultrasound has been utilized. This approach was used to remove seven thoracic discs in six patients.

Methods: A vertical midline incision was used in all of the cases. Laminecotomies a level above and a level below the herniated disc level were fashioned. Facetectomy was performed on the side of disc herniation. In cases with broad based central disc herniation, bilateral transfacet approach was required. Disc herniation and magnitude of cord compression were visualized by intra-operative ultrasound. Discectomy was performed by placing and manipulating instruments under ultrasound guidance. Complete discectomy was done under ultrasound guidance without cord manipulation or retraction. Ultrasound was used to confirm complete decompression.

Results: Ultrasound guided posterior approach was used in six patients for seven discectomy procedures. Age range was from 43-69 year with mean age at the time of operation of 53 years and equal sex distribution. Affected levels were as follows: two patients had T11/T12 disc herniation, one had T7/8 & T 8/9 and three patients had T1/2, T4/5 and T5/6 disc herniation respectively. One patient had acute paraplegia prior to surgery and she did not recover. The remaining five patients had significant improvement in myelopathy and back pain. We used transpedicular instrumented fusion in four patients.

Conclusion: Ultrasound guided posterior approach is safe, effective and offers excellent visualization and can be applied to posterolateral soft/calcified and select central disc herniation at any thoracic level.

466. Serum Markers Predictive of Positive MRI for Spinal Infection in Patients Evaluated in the Emergency Department
Alexander S. Taghva, Daniel J. Hoh, Jesse Winer, Jacob Freeman, Steven L. Giannotta

Introduction: MRI is the optimal modality for diagnosing spinal infection. However, cost and limited availability of MRI in the emergency department (ED) may complicate differentiating patients with infection localized to the spine vs. other sources. Also, determining presence of epidural abscess and number of involved spinal levels are particularly relevant as they may impact clinical management. Therefore, this study investigated serum markers routinely evaluated in the ED that correlate with MRI evidence of spinal infection, epidural abscess and extent of disease.

Methods: The study retrospectively reviewed the laboratory and MRIs of 63 consecutive patients with neurosurgical consultation for possible spinal infection. Consultation was based on symptoms suggestive of spinal infection including fever, elevated WBC, ESR, CRP, positive blood culture and presence of back pain/neurologic deficits. Data collected included comprehensive metabolic panel, CBC, CRP, ESR, MRI findings. Patients were stratified by: negative MRI, osteodiscitis and/or paraspinal abscess, or epidural abscess.

Results: Of 63 patients, 16 had negative MRIs, 23 had osteodiscitis/paraspinal abscess and 24 had epidural abscess. Of patients with positive MRIs, 36 had < = 2 level disease, 11 had > = 3 involved levels. Alkaline phosphatase (p < 0.0005), a marker of bone disease and platelets (p < 0.05) were higher among patients with spinal infection than those with negative MRI. Patients with epidural abscess had higher WBC (p < 0.05) and %PMN (p < 0.005) than those with osteodiscitis/paraspinal abscess. Patients with > = 3 level disease had an elevated %PMN (p < 0.05) and lower serum glucose (p < 0.05) than patients with < = 2 involved levels. ESR and CRP (common markers of inflammation) were not correlated with MRI findings or extent of spinal involvement.

Conclusion: Serum markers routinely assessed in the ED may facilitate predicting the presence of spinal infection, epidural abscess and extent of disease.

467. Trap Door Rib Head Osteotomy for Posterior Placement of Expandable Titanium Cages After Transpedicular Corpectomy: An Alternative to Lateral Extracavitary and Costotransversectomy Approaches
Vincent Wang

Introduction: A transpedicular approach to corpectomy has become increasingly popular for treatment of thoracic spine pathologies. Reconstruction with an expandable cage after the corpectomy can be performed with a lateral extracavitary approach or costotransversectomy approach. Such approaches required resection of ribs and thus are associated with injury to the pleura or lung.

Methods: We developed the trap door rib head osteotomy technique for posterior placement of expandable cages for reconstruction of the spine after corpectomy. This technique was applied to eight patients and we analyzed post-operative pulmonary complications using chest radiographs.

Results: None of the eight patients developed post-operative pulmonary complications that required interventions. Two patients had small pleural effusions that resolved without any interventions. There was no pneumothoraces, hemothoraces or post-operative pneumonia observed.

Conclusion: Trap door rib head osteotomy is an alternative approach to place expandable titanium cages in the thoracic spine after corpectomy. This approach does not involve any resection of rib and therefore should reduce post-operative pulmonary complications.
Use of Implanted Instrumentation for Spinal Instability in Cases of Bacteremia
Ahmad Syed Hussain, Namath Syed Hussain

Introduction: Spinal cord compression and vertebral instability raises the danger of neurological injury and should be decompressed and stabilized. Screw and rod instrumentation has now become a widely-recognized standard for spinal stabilization, however, hardware placement in patients with bacteremia remains controversial.

Methods: We review the history and physical including pre-operative and post-operative imaging studies in a patient with methicillin-resistant staphylococcus aureus bacteremia and an anterior spinal epidural abscess who was taken to the operating room for abscess drainage and decompression with C5 corpectomy, C6 hemi-corpectomy, reconstruction of the corpectomy defect with rib allograft and C4 to C6 fusion with posterior cervical lateral mass screws. Due to the bacteremia, we did not place hardware at the time and continued antibiotics. The patient was later taken to the operating room for delayed posterior cervical fusion of the C4 and C5 lateral masses and the C7 pedicles with segmental instrumentation with iliac crest bone graft. We explain our rationale for the intervention undertaken along with the reasoning behind our selection of delayed instrumentation with ongoing antibiotic treatment in a bacteremic patient and compare this to the available neurosurgical evidence-based literature available on this topic.

Results: Post-operatively, the patient’s neurological exam improved to a GCS of 11. She had improved strength in the upper extremities bilaterally. Vancomycin and rifampin were continued and she was discharged to a nursing facility for intravenous antibiotics and rehabilitation.

Conclusion: Rigid posterior cervical spine fixation with lateral mass and pedicle screws provides good fusion and stability and reduces the risk of neurological injury. Hardware placement in patients with active bacteremia or an infected surgical bed can be undertaken in emergent cases as long as adequate pre and post-operative antibiotics are utilized. This approach can be selected as a technique option based on careful examination of pre-operative imaging studies.

Selective Cell Retention Technique: Effective Long-Term Stabilization with Minimal Morbidity
Robert F. Heary, Karthik Madhavan, Carolyn J. Rogers

Introduction: The gold standard graft for posterior spinal fusions is autologous iliac crest. Previously, we reported 34% painful morbidity rate in an outcome study. Due to this morbidity, alternative processes for obtaining graft material were developed. We report our experience using the selective cell retention technique (Cellect, DePuy Spine, Raynham, MA). The goal was to determine the harvest site morbidity and long-term instrumentation success rate (indirect evidence of fusion).

Methods: A retrospective review: 85 consecutive patients (M=46, F=39, mean age 50.6 years) underwent posterior fusion surgery using the Cellect system to harvest iliac crest bone marrow. Instrumentation success rates, assessed by CT scans and radiographs on all patients and harvest site morbidity, determined by telephone and mail questionnaires, were determined by a research fellow and nurse not involved in patient care. The questionnaire assessed whether the patient was aware that iliac crest had been harvested and if they were, which side the bone came from. Mean duration of follow-up was 36.6 months.

Results: All 85 patients completed the questionnaire and radiographic follow-up. Sixty-four patients (75%) were unaware that marrow was removed from their crest. Twenty-one patients (25%) were aware - six did not know which side, five correctly identified the location and ten identified the incorrect side. Only three patients (3.5%) had pain severe enough to affect their work and/or daily activities. No patient utilized narcotic analgesics for harvest site symptoms. The time required for graft harvest varied between 1.5-5 minutes (N=85). There were no bone harvest-related complications.

Conclusion: The selective cell retention technique was effective. No instrumentation failures occurred at greater than 3-year follow-up. Only 5/85 patients (6%) correctly identified the site of harvest. The selective cell retention technique is a safe and effective alternative to open harvest techniques.

Spinal Dysraphism: Principles, Presentations and Treatment Paradigms
Ahmad Syed Hussain, Namath Syed Hussain

Introduction: The spectrum of spinal dysraphism is a group of congenital anomalies of the spine in which the midline structures fail to fuse. This spectrum includes myelomeningocele, spina bifida occulta, lipomyelomeningocele, diastematomyelia and congenital dermal sinus.

Methods: We review the pre-operative workup and imaging studies in the management of spinal dysraphism. We also discuss the role of folate in prevention and the mechanism behind this prevention. After a thorough discussion of the classification of spinal dysraphism, we explain our rationale for the interventions undertaken along with the reasoning behind our selection of intervention for each disease process.

Results: A comprehensive literature review reveals that studies have documented familial aggregation patterns, including the C677T mutation in MTHFR, CFLI gene polymorphisms, PKA downregulation of the Hedgehog signaling pathway and GCP II (C1561T), RFC (G180A) mutations associated with anencephaly. Studies have also shown the importance of maternal nutritional status leading to a CDC advisory recommending supplemental folic acid. Folate is an essential cofactor for enzymes involved in DNA/RNA synthesis. Traditional treatment of spinal dysraphism has involved delivery by cesarian section and defect closure within 72 hours. Surgical technique in myelomeningocele involves excision of all of the zona epitheliosa to prevent later formation of an epidermoid cyst and reconstruction of the neural tube. Ninety-two percent survive infancy, there is an 86% 5-year survival, death is usually secondary to restrictive lung disease, shunt malfunction or urinary sepsis. We review specifics of surgical technique with regards to the different disorders in the spectrum and also review the Management of Myelomeningocele Study and its results.

Conclusion: Spinal dysraphism is a failure of midline spinal fusion. Our discussion of the embryology, genetics, prevention and treatment of neural tube defects will provide practitioners with an arsenal of protocols and methods with which to approach this disease phenomenon with improvements in methods of surgical correction and in utero closure soon-to-be on the horizon.

The Use of Positional Magnetic Resonance Imaging to Assess Patients with Low Back Pain
Rick L. Edgar, Chris S. Karas, Mirza N. Baig, Andrew Shaw, Sue Ferguson, Riley Splitsstoeesser, William Marras, Ehud Mendel

Introduction: To investigate spinal anatomy in various postures using positional MRI in patients with low back pain. Radiographic findings, including intervertebral disk heights, thecal sac width, spondyloolisthesis and neural foraminal width, will be correlated with clinical symptoms and subjective pain severity scores.

Methods: 183 patients with low back pain between 18 and 80 years of age will be included in the study. The only exclusion criteria are contraindications for MRI. Positional MRIs will be obtained using an open FONAR MR imager with a 0.6 T magnet. T2 images through the lumbar spine (T12-S1) will be acquired while
supine, sitting and standing. Further analysis will be performed with flexion at 60 degrees and extension at 15 degrees in the upright and seated postures. Dependent measurements include thecal sac width, intervertebral foramina width, intervertebral disc height and listhesis in axial and sagittal planes. These findings will be correlated with each subject’s pain severity and disability scores.

**Results:** Thus far, 28 patients have been enrolled in the study. Three patients have been unable to complete the necessary imaging requirements secondary to pain in dependent postures (10.7%). Of significance, thecal sac width has varied on average 1.6 mm between flexion and extension postures with a range of 0-6.5 mm within individual subjects (std dev = 1.4 mm). A 12.5% difference was detected when comparing thecal sac width in the sitting vs. recumbent posture with a range of 8.1 to 15.6% depending upon intervertebral disk level.

**Conclusion:** Preliminary findings reveal positional MRI may enhance the ability to diagnose the cause of low back pain and/or identify surgically correctable pathology compared to traditional recumbent imaging. Additional research, including completion of this study, is warranted to determine clinical applicability of positional MRI as well as increasing the statistical power of these results and other dependent measures.

### 472. Vertebroplasty for the Treatment of Pathological Vertebral Fractures: A Minimally Invasive, Cost Effective and Safe Procedure

Kemal Yuceyosu, Kasim Zafer Yuksel, Cenk Ergüden, Murat Yilmaz, Nuri N. Arda, Metin Güner, Ümit Acar

**Introduction:** In this study, we want to discuss the efficacy of vertebroplasty as a minimally invasive technique for the treatment of pathological vertebral fractures.

**Methods:** Vertebroplasty technique was applied on 101 patients and 122 levels with the diagnosis of vertebral fractures. Procedure was undertaken under local anesthesia with the aim of a scopy device. Results of the surgical procedure along with the clinical and radiological properties of the cases were evaluated. Etiological factors were secondary to trauma in 41 cases, osteoporotic compression fracture in 39, compression secondary to metastatic tumor in 16 cases, hemangioma in 3 cases and solitary plasmacytoma in 2 cases. Seventy-nine cases were treated at one level and 22 cases at 2 levels. (1 case of T3, 1 case of T4, 3 cases of T7, 2 cases of T8, 2 cases of T9, 5 cases of T10, 6 cases of T11, 32 cases of T12, 36 cases of L1, 15 cases of L2, 7 cases of L3, 7 cases of L4 and 5 cases of L5).

**Results:** Mean Visual Analogue Scores (VAS) of the cases were 8.65 pre-operatively and 201 post-operatively. Vertebroplasty material leakage were obtained on 8 cases (to the intervertebral disc space on 4 cases, to the anterior longitudinal ligament on 3 cases and 1 case to the neural canal). Leakage to the neural canal resulted with complete paraplegia, other cases showed no clinical manifestations). Mean follow-up period for the cases were 18 months. A second vertebroplasty procedure was applied on 5 cases because fracture of the adjacent corpus.

**Conclusion:** Pathological vertebral fractures, common on elderly and open surgical procedures, are laden with high mortality and morbidity rates in this age group. As an alternative method vertebroplasty is a promising minimally invasive technique in these patients because of the high success rate and cost effectiveness as compared to kyphoplasty technique along with high patient satisfaction and good long-term results.

### 473. Unilateral Laminotomy for Bilateral Decompression with Device for Intervertebral Assisted Motion of Lumbar Spinal Stenosis in the Elderly Patients

Insoo Kim

**Introduction:** Degenerative lumbar spine disease leading to lumbar stenosis is a major cause of morbidity among the elderly. With the aim of less invasiveness and better preservation of spinal stability in elderly patients, the technique of unilateral laminotomy for bilateral decompression (ULBD) and use of device for intervertebral assisted motion (DIAM) were developed. The goal of this study is to assess the safety and efficacy of the elderly patients receiving one level ULBD surgery with DIAM placement as compared with patients receiving one level ULBD surgery only.

**Methods:** A prospective analysis was performed on 15 patients with one level ULBD with DIAM and 15 patients with one level ULBD only. The mean age of 15 patients (8 male and 7 female) with DIAM placement was 72.4 and 15 patients (6 male and 9 female) without DIAM was 73.8. Radiographic imaging, visual analog scale (VAS) for lumbar and leg pain and clinical assessments were obtained pre-and post-operatively for a mean of 15 months (range 12-19 months) interval.

**Results:** There was no statistically significant difference between the pre- and post-operative imaging in terms of sagittal balance and disc height in one level ULBD with DIAM. When comparing one level ULBD with DIAM with one level ULBD only, however, the latter demonstrated less than 3° of increased lordosis when compared with one level ULBD with DIAM post-operatively. There was no statistical differences between two groups in terms of disc height or interlaminar distance. Post-operative visual analog scale (VAS) pain scores and the Prolo Economic and Functional Scale scores significantly decreased in two groups. Low back pain was significantly decreased in group with DIAM implant while no statistically significant differences in VAS pain scores and MacNab outcome scores between groups at the mean 15-month follow-up were found. There were no major complications in two groups.

**Conclusion:** One level ULBD with DIAM did not alter disc height or sagittal alignment at the mean 15-month follow-up interval. One level ULBD with DIAM is a safe and efficacious treatment for elderly patients with lumbar spinal stenosis.

### 474. O-ARM Assisted Minimally Invasive TLIF with Percutaneous Sextant Pedicle Screw Placement

Donald John Blaskiewicz, Mohamed Mudathir Abdulhamid, Igor Richard Yusupov, Walter P. Jacobsen, Peter D. Kim, Gregory W. Canute, Catherine Murtagh-Schaifer, Ross R. Moquin

**Introduction:** The Transforminal Lumbar Interbody Fusion (TLIF) procedure has grown in popularity as a means of achieving neural decompression and spinal stabilization for a number of pathological conditions involving the lumbar spine. Secondary to the requisite approach-related stripping of muscles and soft-tissue trauma associated with the open TLIF procedure, Foley et al., introduced the minimally invasive TLIF as a method of securing interbody fusion while minimizing the approach related soft-tissue morbidity. Minimally invasive procedures, however, rely heavily upon the use of intraoperative fluoroscopy for the localization of the surgical level, docking of retractors systems and the placement of pedicle instrumentation. Fluoroscopy subjects the patient and operative staff to ionizing radiation. Image-guided spinal surgery may decrease radiation exposure and improve accuracy of spinal instrumentation. We present here our experience using the O-ARM® Multidimensional Surgical Imaging System and StealthStation® Treon® navigation system (Medtronic Surgical Navigation Technologies, Louisville, CO) for performing the MIS TLIF with CD HORIZON® SEXTANT™ Spinal System (Medtronic Sofamor Danek, Memphis, TN) for percutaneous pedicle screw placement.

**Methods:** This is a retrospective chart and radiographic review of our experience using O-ARM for MIS TLIF.

**Results:** Utilizing the O-ARM, we were able to accurately place percutaneous pedicle screws and avoid exposing the OR staff to the potentially harmful effects of
ionizing radiation.

**Conclusion:** Minimally invasive spinal procedures have been utilized to avoid approach related morbidities of open procedures, these rely heavily, however, upon the use of fluoroscopy. Fluoroscopy carries the risk of exposing to the surgical team, OR staff and the patient to the harmful effects of ionizing radiation (5,7,8,11). The use of navigation has been shown to decrease operative times (10) decrease radiation exposure (2, 4) and improve the accuracy of pedicle screw placement (1,3). Intraoperative CT scanning, for spinal navigation, with the O-ARM has proven to be a useful adjunct in the MIS TLIF procedure.

### 475. Instrumented One-Level Lumbar Interbody Fusion Using an Expandable Cage Device: A Novel Technique

**Beejal Y. Amin, Radmehr Torabi, Scott Brian Phillips, Mokbel K. Chedid**

**Introduction:** We describe our experience with the use of an expandable cage in one-level posterior and transforaminal interbody fusions in patients treated for degenerative lumbar spinal disease.

**Methods:** Eleven patients from October 2007 to February 2008 underwent an interbody fusion with the use of the StaXx® XD expandable cage by a single surgeon at our institution. This cage was implanted in the following procedures: 10 posterior lumbar interbody fusions and 1 transforaminal lumbar interbody fusion. The cages starting heights were 7 mm or 9 mm and were expanded in situ to heights ranging from 9-13 mm. The surgical goal of all patients was neural decompression, posterior stabilization with pedicle screws and anterior reconstruction.

**Results:** All surgical goals were accomplished with a single procedure. There were no surgical complications. Fusion rates and graft subsidence are being studied in this cohort of patients and results including 12 month follow-up data will be available at the index level was 10.46 ± 9.4°, i.e. similar to pre-op. 37.5% of the implants had a lateral deviation from the midline of more than two millimeters.

**Conclusion:** The remarkably good results of arthroplasty for cervical soft disc with radiculopathy in younger patients seen in IDE studies could be reproduced here. Unlike in lumbar spine arthroplasty a suboptimal position of cervical disc prostheses is not correlated with a negative clinical result such as prolonged local pain, which occurs nevertheless in a considerable number of patients.
478. Posterior Dynamic Stabilization of the Thoracolumbar Spine with the COSMIC®-System
Michael Behr, Andreas Reinke, Carsten Steuer, Florian A. Ringel, Michael Stoffel, Bernhard Meyer

Introduction: COSMIC® (Ulrich medical) is a dynamic screw-rod system for the thoracolumbar spine. It provides stability against rotation and translation while maintaining flexibility in the sagittal plane. This study describes our experience in a prospective observational design.

Methods: Data collection was completed in 100 of 103 operated patients (median follow-up: 12 months, mean age 65 years, 65 female, 38 male). Indication for COSMIC® was painful degenerative segmental instability. Dynamic stabilization was performed as first tier surgery in 43 cases and as second tier therapy in 60 cases. CT-scans/radiographs and clinical assessments using standard scales was acquired prospectively in pre-defined time intervals (Sagittal-Index, VAS, Karnofsky-Index, Oswestry-Score, SF36). Results: In 100 patients, 157 motion segments (1-3) were instrumented (498 screws, median or time: 175 min, 3 screws needed primary revision for malpositioning). Additional decompression was performed in 83 cases. Significant post-operative pain relief could be documented (VAS 70 to 20, ODI 50% to 16%), Karnofsky performance increased from 70 to 80 and SF-36 demonstrated a significant improvement in physical (pre-op:41, post-op:46) and mental health (pre-op:44, post-op:48) throughout the observation period. Ninety-one of 100 patients were satisfied with the treatment. We observed a complicated course in eight patients related to early adjacent level instability (n = 7) and screw loosening (n = 2) leading to revision. All complicated courses were seen within the first 12 months. In patients followed up >18 months no further problem was detected after 12 months. Complicated courses were associated with following comorbidities: > 2 previous operations, BMI >35, musculoskeletal insufficiency (osteoarthritis, M. Parkinson), > 2 motion segments stabilized.

Conclusion: Dynamic stabilization with the COSMIC® system achieved a significant improvement of pain, mobility and quality of life. The frequency of early adjacent level instability was unexpected and correlated to longer constructs and comorbidities. The theoretic advantage of the dynamic stabilization with respect to adjacent level degeneration has to be observed during a longer follow-up period.

480. Diffusion Tensor MRI of Spinal Cord Injury at 9.4-T
Shekar N. Kurpad, Brian Schmit, John L. Ulmer

Introduction: Diffusion tensor MRI is sensitive to the orientation and integrity of spinal cord tissue. In this study we have used high field MRI to explore spatial changes in diffusion measurements within the injured spinal cord in vivo and ex vivo during recovery in the rat model up to 105 days post-injury.

Methods: High field diffusion tensor MRI was performed in vivo on rats at 14, 35, 70 and 105 days following contusive spinal cord injury. Axial images were acquired through the injury site. High resolution fast spin echo images were registered to the diffusion images and regions of interest were extracted for comparison during recovery. High resolution (~100 um) ex vivo diffusion images were collected following sacrifice for additional comparison.

Results: Results indicated an increase in both longitudinal and transverse diffusion at the lesion epicenter. A distinctive pattern of diffusion was observed across the length of the spinal cord that appeared to move during recovery. This pattern was independent of observed signal changes in traditional T2-weighted MRIs in the same animals.

Conclusion: This work builds on previous findings that focused only on diffusion changes at the lesion epicenter. Our results support the use of diffusion tensor MRI to track the progression of degeneration and reorganization during recovery from spinal cord injury.

481. Cervical Spondylotic Myelopathy: Clinical and Radiographic Evaluation and Correlation

Introduction: Cervical spinal canal stenosis with subsequent spinal cord compression may result in loss of dexterity, motor weakness and sensory loss: hallmarks of a cervical myelopathy. MRI enables visualization of the spinal cord parenchyma and detection of abnormalities such as neoplasms, demyelinating lesions, swelling and/or edema. However, radiographic spinal cord compression is not uncommon in individuals without clinical symptoms or signs of a cervical myelopathy. We review a series of 103 patients that presented with cervical spinal disease and correlate their clinical examination to MRI features.

482. Complications in Minimally Invasive Spine Surgery
Christopher C. Meredith, Gordon Holen, Lisa A. Reiman, Magdalene Akanji, Christopher C. Meredith, Gordon Holen, Lisa A. Reiman, Magdalene Akanji

Introduction: Minimally invasive spine surgery (MISS) remains a relatively new field in the United States. As a result of this, there are very few reports of adverse outcomes or complications arising from MISS. This abstract addresses five different clinical cases, some of which resulted in adverse patient outcomes.

Methods: This is a retrospective review of five separate MISS cases that resulted in radiographic and/or clinical complications.

Results: Case #1 involves a patient who underwent an L5-S1 MIS TLIF. The radiology shows impaction of the PEEK interbody cage into the body of L5. This patient developed an L5 radiculopathy requiring placement of a dorsal column stimulator. Case #2 involves the incidental placement of a percutaneous pedicle screw through the lamina of L5 and through the thecal sac. Radiographs demonstrate a lucency where the screw had been placed. Case #3 shows the malpositioning of a PEEK interbody cage placed during an XLIF procedure. This cage was eventually

Methods: Patients were defined as having a cervical myelopathy if any of these long-tract signs were present: Babinski, clonus, hyper-reflexia, cross abductor sign or gait dysfunction. The radiographic features consisted of: 1. Hyperintense signal in the spinal cord parenchyma on T2 weighted MRIs. 2. Radiographic spinal cord compression.

Results: 34/56 patients with myelopathy had cord signal, while 2/47 without myelopathy had cord signal. 55/56 myelopathic patients had spinal cord compression, compared to 9/47 without myelopathy. Both of these relationships were statistically significant. The average age of myelopathic patients was 53.3 (95% CI 52.7 - 59.9) and of non-myelopathic patients, 49.8 (95% CI 45.8 - 53.8). The odds ratio for myelopathy vs. age was 1.038 per year (95% CI 1.009 - 1.073).

Conclusion: The clinical definition of a myelopathy is the presence of “long tract signs,” which are the results of inhibition of the spinal afferent or efferent (pyramidal) nerve tracts. Prospective studies [1,2] showed that 1%-5% of asymptomatic patients could develop myelopathy each year. Small retrospective studies [3,4] reported a relationship between cord compression and myelopathy, although this relationship was not seen in one of the prospective studies [1]. In our data set, it appears that cord signal is more specific to myelopathy while cord compression is more sensitive.
removed and this level was stabilized with pedicle screws. Case #4 shows an anteriorly placed interbody PEEK cage during an XLIF procedure. This was eventually stabilized with pedicle screws. Case #5 shows extrusion of interbody allograft into the neural foramen during a 2 level axialIF. This patient developed a new radiculopathy that was managed conservatively with transforaminal epidural steroid injections.

**Conclusion:** Minimally invasive spine surgery is an excellent adjunct to any spine surgery practice. Surgeons should be aware of the acute importance of good fluoroscopy techniques and image interpretation, as well as the limitations that MISS places on the ability of the surgeon to correct malpositioned hardware.

**483. Percutaneous Pedicle Screw Instrumentation with Microendoscopic Hemilaminectomy and Posterolateral Fusion for Thoracolumbar Trauma**

Ira M. Goldstein

**Introduction:** Percutaneous instrumentation without decompression or fusion has been utilized for the treatment of bony chance fractures as well as for compression fractures of the thoracolumbar spine. The instrumentation was subsequently removed in these cases after fracture healing was believed to have occurred. Microendoscopic techniques have been utilized for microdiscectomy with reduced back pain and muscle damage compared to conventional microdiscectomy.

**Methods:** Two patients presented to our institution with thoracolumbar fractures and canal compromise. The first had significant intraparenchymal injuries as well as a T12 bony chance fracture with epidural hematoma. The second had an L1 burst fracture with epidural hematoma. Both underwent percutaneous pedicle screw instrumentation with decompressive hemilaminectomy and ipsilateral posterolateral fusion. Transepidermal decompression with direct reduction of the burst fracture was performed in the second case.

**Results:** MRI imaging demonstrated generous canal decompression with hematoma evacuation was attained in both cases. Both patients were ambulatory by post-op day 2. Solid posterolateral fusion was demonstrated on CT in the first case and an absence of instrumentation loosening was demonstrated at 18-month follow-up in the second.

**Conclusion:** Minimally disruptive surgical techniques can be applied to traumatic lesions of the thoracolumbar junction. Early benefits include minimal blood loss and early patient mobilization. Preservation of the posterior ligamentous complexes may facilitate shorter segment junctional stabilization than is feasible with open surgery.

**484. Relationship Between Cervical and Lumbar Disc Degeneration of Magnetic Resonance Imaging within Asymptomatic Volunteers in Korea**

Tae Hoon Lee, Sang Jin Kim

**Introduction:** Physicians may have many clinical experiences that the patient with severe degenerative changes in lumbar spine has severe degenerative changes in cervical spine. But numerical analysis has not been reported. If the accurate statistics about degenerative changes between cervical and lumbar disc degeneration would be published, more accurate figures for the prevention of spinal disorders will be able to make the surface. Given this background, we attempted to analyze for relationship between cervical and lumbar degeneration and then proposed using a 3T-MRI in asymptomatic Korean volunteers.

**Methods:** From December 2007 to March 2008, about 3600 people were interviewed for study subjects. We selected 102 people of asymptomatic volunteers from 14 to 81 years old. The study was approved by IRB. The imaging studies were analyzed by three authors. We analyzed the correlation of cervical and lumbar score in DAH (degeneration), AF (annular fissure) and herniation for each. One subject had the total sum score in degeneration with grade 0-6, annular fissure grade 0-8 and herniation grade 0-3. Spearman’s rank correlation coefficient was used in comparison between the scores and multiple linear regression analysis among weight, height, sex, age, smoking, occupation and lifestyle.

**Results:** Cervical and lumbar score had a linear relationship in DAH. DAH had r value of 0.58 (p < 0.00005), 0.38 (p = 0.0001), 0.50 (p < 0.00005) for each. From these results, about 33.8% in degeneration, 14.4% in AF, 24.6% in herniation had clear linear relationship. Among weight, height, sex, age, smoking, occupation and lifestyle, age was the month affecting predictive factor in multiple linear regression analysis.

**Conclusion:** Although this will be not absolute, cervical and lumbar degenerative changes of the disc have linear relationship. Age is the month affecting predictive factor in cervical and lumbar degeneration. Using author’s formula, many physicians are able to predict the cervical degenerative score of patient according to lumbar score.

**485. Symptomatic Thoracic Kyphosis with Breast Augmentation**

Ira M. Goldstein

**Introduction:** Numerous reports document the association of macromastia and thoracic kyphosis, predominantly in the plastic surgery literature. No association between iatrogenic macromastia and spinal disorders has been previously reported.

**Methods:** Case report and review of the literature. The author had seen a patient in consultation with an exaggerated thoracic kyphosis, shoulder pain and paresthesias of the hands, symptoms which have been documented in relation to mammary hypertrophy. In addition, the patient demonstrated weakness of the triceps and pulmonary restriction. Symptom onset was approximately 6 months after breast augmentation surgery.

**Results:** Physical examination documented findings consistent with a C7 radiculopathy. Standing plain films demonstrated a thoracic kyphosis of 60 degrees with several bulding thoracic disks but no compression fracture, subluxation, or other structural anomaly to account for the kyphosis. MRI of the cervical spine revealed no foraminal or canal stenosis. Reduction mammoplasty (to a D-cup) and application of TLSO orthosis resulted in a resolution of the radicular symptoms, shoulder pain, thoracic kyphosis and pulmonary restriction. Upright films in the brace revealed 32 degrees of kyphosis.

**Conclusion:** Symptomatic thoracic kyphosis may be associated with breast augmentation, as it has been previously linked to idiopathic macromastia.
transient post-operative worsening of neurologic status, which subsequently resolved. At the first post-operative clinic visit, mean VAS (back: 2.3 ± 2.3, right leg: 1.2 ± 1.7, left leg: 0.7 ± 1.3) and ODI (30 ± 23) scores were calculated. The second follow-up visit yielded similar results (back VAS: 3.1 ± 2.5, right leg VAS: 2.1 ± 2.5, left leg VAS: 1.8 ± 2.6, ODI: 35 ± 18).

**Conclusion:** Minimally invasive treatment of thoracolumbar spine trauma allows for sufficient treatment of these injuries and produces satisfactory outcomes.


Donald John Blaskiewicz, Raymond C. Young, Dennis J. Stelzner, Blair Calancie

**Introduction:** Cauda equine (CE) injuries may produce significant lower extremity, bowel and/or bladder dysfunction. Repair mechanisms to counter such dysfunction remain elusive. The dorsal caudales nerve lies distal to and receives neural supply from components of the CE. Correlations between electrical stimulation, retrograde-labeling and functional analysis of the dorsal caudales nerve (DCN) and its segmental contributors have not yet, to the best of our knowledge, been described in the literature.

**Methods:** Eight adult, female Sprague-Dawley rats underwent electrical stimulation for measurement of stimulation intensity for threshold response of each of the segmental contributors of the DCN. In separate animals, the individual segmental contributors were individually cut and then RubyRed, a retrograde tracer was applied. In two rats, either S1-3, or S3-Cx1 were cut for functional analysis. Pre-operative and post-operative functional analysis was undertaken in all injured animals.

**Results:** Retrograde labeling of the segmental contributors to the DCN revealed a rostral-caudal distribution of the alpha-motor neuron pool in the corresponding sacral spinal cord. Electrical stimulation of the segmental contributors showed that stimulation of S1 and S2 favored movement of the tail base, while stimulation of S4 and Cx1 favored movement of the distal tail. Rats with lesions of the individual, segmental neural contributors did not display overt tail dysfunction, however, lesions of consecutive contributors lead to tail dysfunction.

**Conclusion:** In this experimental model, it was shown that discrete motor pools are present for each of the segmental contributors of the DCN and arranged in a rostral-caudal manner within the ventral horn of the sacral spinal cord. This detailed knowledge of the motor control system should prove paramount in evaluating injury models for signs of neuronal regeneration.

### 488. Measurement of Force while Using “Gearshift” Probe: Implications for Interactive Simulation

Omar N. Syed, Michael S. Downes, Anthony D. D’Ambrosio, Hani R. Malone, Michael G. Kaiser

**Introduction:** Computer-based surgical simulations are intended to serve as a safe and cost-effective training platform that accurately replicate the surgical anatomy, technical forces and tissue responses of the modeled surgical procedure. We have previously developed a prototype computer simulation for insertion of pedicle screws. A critical component of this simulation is the accurate reproduction of forces used to cannulate the vertebral pedicle. We are currently investigating methods for collecting this data.

**Methods:** In order to measure the force used to cannulate a pedicle, a force sensor was attached to the handle of a “gearshift,” an instrument commonly used to create the pedicle screw trajectory. Real-time recordings are obtained that measure the forces applied to the instrument handle as the probe is directed through the bone. Prior to insertion the sensor is calibrated. In order to test this method, two cadaveric cervical pedicles were cannulated.

**Results:** The present prototype worked as expected. The maximum force generated during the cannulation of the cervical pedicles was 14.72 lbs. and 17.04 lbs.

**Conclusion:** These results will be used to replicate the force profile in our pedicle screw simulation.

### 489. Peripheral Primitive Neuroectodermal Tumors (PNET) of the Brachial Plexus: A Review of the Literature and Report of Two New Cases


**Introduction:** Peripheral primitive neuroectodermal tumors (PNET) are very rare lesions associated with an aggressive course, high rates of local recurrence and generally poor outcomes. Brachial plexus PNETs typically present with similar signs and symptoms as nerve sheath tumors, including pain, paresthesias and occasionally weakness, in addition to non-specific imaging findings, making their diagnosis difficult. The purpose of this study is to present a review of the literature in addition to two new cases of peripheral PNETs causing brachial plexopathy. The goal is to highlight pre-operative, intraoperative and post-operative decision-making, with an emphasis on diagnostic and management issues, including the importance of early surgical resection in addition to adjuvant chemo- and radiation therapies.

**Methods:** A Medline-based review of the literature on brachial plexus PNETs and a retrospective analysis of two patients that underwent surgery at a University teaching hospital between 1995 and 2007 for exploration of brachial plexus lesions that were confirmed to be PNETs at pathology were performed.

**Results:** In addition to revealing a paucity of published reports describing this rare entity, our review of two novel cases demonstrated the following: both patients presented with findings on history, physical exam and imaging suggesting a diagnosis of nerve sheath tumor. Each patient underwent a radical subtotal tumor resection and pathological evaluation identified features consistent with the diagnosis of PNET in both cases. The patients were subsequently treated with chemo- and radiation therapies.

**Conclusion:** PNETs of the brachial plexus are very rare but a high index of suspicion and appropriate pre-operative evaluation and early surgical resection with adjuvant chemo- and radiation therapies may result in better patient outcomes.
such that all patients achieved erect posture without flexing the hips and knees. PSO at the thoracic spine was able to achieve a mean segmental correction of 35 degrees. Perioperative complications included neurological deficit, wound infection and urinary tract infection.

**Conclusion:** PSO allows for significant correction through one spinal segment and may be used safely to achieve sagittal balance in the lumbar and in the more anatomically challenging thoracic spine. The ability to perform PSO in the thoracic spine presents a great surgical asset for the spinal surgeon to perform regional improvement in sagittal balance. PSO may be used alone or in combination with other techniques as some patients may require multi-stage procedures with both anterior and posterior spinal reconstruction to obtain stable sagittal correction.

**491. Differential Expression of Calcium-binding Proteins in the Spinal Cord After Experimental Chronic Spinal Cord Compression**

Matthias Setzer, Frank D. Vronis, Norbert Ulfig, Mohammed A. Eleraky, Volker Seifert, Gerhard Marquardt

**Introduction:** The calcium binding proteins parvalbumin, calbindin and calretinin, which are members of the EF hand family, are cytoplasmic proteins with the capability of buffering excessive intracellular calcium influx which results into a neuroprotective effect. The aim of the present study was to examine the expression of parvalbumin, calbindin and calretinin in the rabbit thoracic spinal cord after chronic experimental compression.

**Methods:** A rabbit model of chronic spinal cord compression was used which allows for a gradual 270° compression of the spinal cord (experimental group n = 25, control group n = 5). Once neurological deficits had accumulated, the spinal cord was decompressed by removal of the compressing silicone band.

**Results:** In normal rabbit spinal cord calretinin and Parvalbumin was colocalized in ventral horn motoneurons as well as in smaller dorsal and ventral horn intermediolateral neurons. Calbindin showed a complementary distribution pattern with in tense staining of substantia gelatinosa neurons and neuropil. Alpha motoneurons did not show any calbindin immunoreactivity. Double labeling with anti-calbindin and anti-GFAP showed colocalization of both proteins in a group of subpial astroglial cells. After spinal cord compression some of the alpha motoneurons expressed calbindin especially in animals with severe neurological deficits and a good recovery. Animals with no recovery and a permanent deficit did not show calbindin positive motoneurons.

**Conclusion:** The protein expression patterns change significantly between outcome groups with de novo expression of calbindin in ventral horn motoneurons in circumstances of good recovery after spinal cord compression. This suggests a neuroprotective role of calbindin in chronic spinal cord compression.

**492. Expression of Apolipoprotein E in an Experimental Rabbit Model of Chronic Spinal Cord Compression**

Matthias Setzer, Frank D. Vronis, Norbert Ulfig, Mohammed A. Eleraky, Volker Seifert, Gerhard Marquardt

**Introduction:** ApoE is believed to play a crucial role in the chronic recovery/repair phase after traumatic neurological injury. Mutations which lead to ApoE polymorphism lead to different outcomes after neurological injury which can be assigned to certain genotypes and worsen prognosis in a couple of neurological diseases. The aim of the present study was to investigate the expression pattern of ApoE in the spinal cord of rabbits after experimental chronic spinal cord compression.

**Methods:** A rabbit model of chronic spinal cord compression was used which allows for a gradual 270° compression of the spinal cord (experimental group n = 10, control group n = 5). After development of neurological deficits the spinal cord was decompressed by removal of the compressing silicone band. Spinal cords were perfusion fixed with 4% paraformaldehyde and epicentre were removed, stained immunohistochemically (single and double labelling techniques) with antibodies against parvalbumin, calbindin and calretinin and analyzed with light and confocal laser microscopy. Clinical outcome variables and histological results were correlated and differences in outcome groups compared.

**Results:** APOE was expressed in the ventral horn alpha motoneurons (colocalization with the pan neuronal marker NeuN) after spinal cord compression, whereas normal animals did not show APOE immunoreactivity in alpha motoneurons.

**Conclusion:** The results of this study show, that the pattern of ApoE expression changes after chronic spinal cord compression most likely as a result of upregulation. They emphasize the importance of APOE for the repair after spinal cord compression and might explain in part the different recovery rates in ApoE mutations and polymorphism.

**494. Extreme Lateral Interbody Fusion (XLIF) for the Treatment of Degenerative Spondylolisthesis**

Luiz Pimenta, Leonardo Oliveira, Carlos Luiz Arias, Juliano Lhamby, Etevaldo Coutinho, Ihab Gharzeddine Gherze, Juliano Fratezi

**Introduction:** The purpose of this paper is to present the extreme lateral interbody fusion (XLIF) minimally invasive for the treatment of degenerative spondylolisthesis, to stabilize and improve the sagittal balance, forame height and indirect decompression by a minimal invasive technique.

**Methods:** 27 patients, 9 males and 18 females, mean age 62.2 (39-85 years) up to 2 follow-up with a diagnosis of degenerative spondylolisthesis at L3-L4 or L4-L5. Lateral, A-P and flexion-extension X-rays, neurological examination and clinical outcome assessment using Oswestry andVAS scores were performed at the pre-operative, 1, 6 week, 3, 6, 12 and 24 months post-operative intervals. The extreme lateral approach was done through the retroperitoneal space and through psoas muscle avoiding neurological and vascular lesions. A discectomy was done and the end-plate cleaned, a cage setted with graft and the ALL and PLL were preserved, adding more stability. In 16 patients the cage was left stand alone and 11 used pedicle screws supplementation.

**Results:** The procedures were performed without complication in an average 121 minutes and with less than 50cc blood loss. VAS pain scores improved from the average 8.84 at pre-op to 3.2 at 2 years, standard deviation 1.75 and 1.16 respectively. Oswestry scores improved from an average 58.44 at pre-op to 20.75 at 2 years with standard deviation of 12.79 and 9.32 respectively. In the two groups, stand alone or supplemented with pedicle screws, occurred fusion, with no difference of consolidation time.

**Conclusion:** We were able to treat the deformity, improve the pain, provide stabilization and fusion thought a minimal invasive approach, which provided a quicker and better post-op period, no vascular and neurological complications, no need of intensive care or blood transfusion, walking in first day post-op. XLIF has shown to be a safe, reproducible technique to treat spondylolisthesis deformity.
495. An Alternative Technique for Placing Posterior Lumbar Interbody Fusion Grafts
Ian Lee, Marilyn Gates, Muwafak Abdulhak, Shezad Tejani, Mokbel K. Chedid
Introduction: Posterior and transforaminal lumbar interbody fusion techniques are well-described. Posterior lumbar interbody fusion (PLIF) provides excellent rates of fusion, but with significant risk of injury to neural structures either by aggressive retraction or the placement of the interbody device itself. On the other hand, transforaminal lumbar interbody fusion (TLIF) lowers the risk of neural injury, but the exposure required is more demanding. A modified PLIF technique has been developed in which a single interbody device is placed diagonally across the disk space through an intracanalicular approach. It is hypothesized that this technique would reduce the risk of neural injury by obviating the need for bilateral interbody grafts while still providing adequate surface for fusion comparable to TLIF.
Methods: From 2006 to 2008, 76 patients underwent lumbar fusion with this modified PLIF technique. These patients were reviewed retrospectively subsequent to their fusion operation for a mean of 315 days (median 213 days). All patients received interbody grafts at either a single (55/76) or two levels (19/56). Sixteen of the operations were done via a minimally invasive technique, the remaining were done open. The patients were reviewed for intraoperative complications, fusion failure and the rate of re-operation.
Results: 3/76 patients had fusion failure diagnosed by CT scan, representing a fusion rate of 96%. 9/76 (12%) patients subsequently needed further lumbar surgeries for continued back pain. Intraoperative complications were low, the most frequent being dural tear (5%). One patient’s course was complicated by wound infection, another patient required reoperation for malplacement of a pedicle screw. There were no instances of nerve root injury attributable to interbody graft placement.
Conclusion: This modified PLIF technique may represent a valid approach to placing interbody grafts. Further prospective study with longer follow-up times is indicated.

496. A Reduction in Failure Rates During Channel Corpectomy Reconstruction with a Lordotic Titanium Cage and Anterior Plate
Kimathi Doss, Steven D. Glassman
Introduction: This study evaluated single stage reconstruction with a lordotic titanium cage and anterior plate following anterior cervical channel corpectomy. Previous studies reported high failure rates without identifying potential technical risk factors for failure.
Methods: Medical records and radiographs of 44 patients who underwent channel corpectomy reconstruction with a lordotic titanium cage and anterior plate were reviewed. Surgical technique emphasized end-plate preservation, proper cage contouring and precise screw placement avoiding end-plate penetration. Pre-operative, post-operative and follow-up segmental lordosis and overall cervical lordosis were measured and analyzed using ANOVA. In cases of early failure, radiographs were evaluated to identify contributing factors.
Results: There were 18 males, 26 females with an average age of 58 years (37-78). Average follow-up was 39 months. Average number of levels completed was 2-5 (29 single-level and 15 multi-level corpectomies). Segmental lordosis improved from 2.7o pre-operatively to 8.9o post-operatively and 8.2o on follow-up (p < 0.0001). Overall cervical lordosis improved from 7.7o pre-operatively to 14.0o post-operatively and 14.1o on follow-up (p < 0.0001). Three patients (7%) had construct failures: 2 had single-level and 1 had a multi-level corpectomies. All failures were related to technical errors identifiable on the immediate post-operative radiograph. There were no cases of failure when immediate post-surgical radiographs were satisfactory.
Conclusion: Contrary to published literature, this study identified a low rate of early failure with excellent restoration and maintenance of lordosis. Technical considerations included endplate preservation, appropriate initial cage contouring and placement and accurate screw placement. Supplemental posterior fixation should be considered if these goals are not achieved.

497. Short Term Clinical Results of an Elastomeric Lumbar Disc Prosthesis (Physio-L)
Luiz Pimenta, Juliano Fratezi, Juliano Lhamby, Thomas Schaffa, Carlos Luiz Arias, Sandie Roth, Etevaldo Coutinho, Leonardo Oliveira, Casey Lee
Introduction: The current generation of disc prostheses with sliding bearing cores appears to have an increased rate of facet joints degeneration at the index level and disc degeneration at the adjacent levels at 2-5 years follow-up evaluation. One possible cause is the lack of shock absorption and non-physiologic center of rotation inherent in their design. The Physio-L uses a compliant polycarbonate polyurethane material attached to two titanium endplates and has been designed to restore both the normal range of motion and function of a normal disc.
Methods: Fourteen patients between the ages of 18 and 70, presenting with degenerative disc disease in the lumbar spine at 1 or 2 levels were treated by the same surgeon. Ten patients received treatment at a single level (L5-S1) and four patients received treatment at two levels (L4-L5 and L5-S1). Patients were followed pre-operatively, post-operatively and at 6 weeks, 3-6 months. Measurements included VAS and Oswestry scores.
Results: Of the 14 patients, 12 were male and two females. The patients had an average age of 38 years old (range 25-55) and an average BMI of 25.3 (range 19.4-31.6). By 6 months follow-up, no device failures, subsidence or migration occurred. The prostheses in all patients were mobile in flexion/extension and lateral bending. VAS low back pain score and ODI scores improved significantly at the 6 months follow-up period on 69% and 83% respectively when compared to the pre-operative scores. The VAS pre-operative was 6.4 with STD 1.52 and after 6 months, the VAS decreased to 2.0 with STD 2.17. The ODI pre-operative was 36.0% with STD 0.08. At 6 months follow-up, the ODI decreased to 6.2% with STD 0.09.
Conclusion: The early clinical results of the pilot study for the Physio-L lumbar disc prosthesis demonstrated satisfactory in pain relief and function recovery without any significant complications or adverse incidents.

498. Structural Kyphoplasty: A Novel Directional Approach to Vertebral Fracture Repair
Arno Hummel, Harvinder S. Sandhu, J. Patrick Johnson
Introduction: Insufficiency fractures of the spine are the leading cause of disability among the elderly. Kyphoplasty procedures are now performed to attempt reconstruction and fixation of fractured vertebrae. A novel implantable device enables improved in situ management during kyphoplasty procedures. Structural kyphoplasty is an innovative concept utilizing stackable PEEK wafers to safely and reliably enable directional control of the vertical reduction of the vertebral body while still providing fracture stabilization and pain relief.
Methods: Clinical and radiographic outcome data were retrospectively analyzed on an initial series of structural kyphoplasty cases at one physician’s center. Using fluoroscopic guidance, the vertebral body was accessed through an oblique extrapedicular approach. PEEK StaXx® FX wafers were inserted in 1 mm vertical increments. A small amount of cement was then inserted about the wafer stack for fixation.
Results: Twenty-seven osteoporotic VCFs...
Anterior cervical microforaminotomy for cervical radiculopathy: Analysis of 105 Patients

Parham Moftakhar, Roham Moftakhar, Nirav J. Patel, Kris Chan

Introduction: Anterior cervical microforaminotomy is a potential disc preserving procedure in patients with cervical radiculopathy from disc herniation or spondylolisthesis. We report the surgical outcomes of our series of patients who have undergone anterior cervical microforaminotomy.

Methods: Between January 1998 and May 2005, 144 consecutive patients underwent anterior cervical microforaminotomy. One-hundred-five patients completed a Cervical Spine Research Society questionnaire and were included in this study. There were 59 men and 46 women. The mean age was 48 years. All patients presented with cervical radiculopathy from either disc herniation and or spondylolisthesis. Of the 105 patients, 83 underwent a single level procedure and the rest had two level microforaminotomy. Patients’ clinical outcome was determined using a modified Cervical Spine Research Society Questionnaire for Cervical Radiculopathy.

Results: The median follow-up period was 45 months. Eighty-three percent of patients were either very satisfied or satisfied with the surgical results. The patients’ mean pain rating decreased from 3.8 (± 1.1) preoperatively to 0.97 (± 1.1) post-operatively (p < 0.0001). The patients’ mean functional status increased from 1.1 (± 0.8) preoperatively to 2.4 (± 0.8) post-operatively (p < 0.0001). The mean number of activities that worsened the patients’ symptoms before surgery decreased from 2.8 (± 1.5) to 0.9 (± 1.5) post-operatively (p < 0.0001).

Conclusion: Controlled vertebral augmentation not possible with balloon kyphoplasty, is now possible when the StaXx® FX Structural Kyphoplasty System. Structural kyphoplasty appears to be a safe and effective procedure that relieves pain, uses less cement volume than published results of vertebroplasty and balloon kyphoplasty and reliably restores vertical height to the fractured vertebra.

Utility of Ceramic Compounds in Spine Surgery
Igor Richard Yusupov, Donald John Blaskiewicz, Mohamed Mudathir Abdulhamid, Ross R. Moquin

Introduction: Autograft harvest-related morbidity has led to the development of alternatives. Ceramic bone graft extenders have been used in spine surgery but clinical data is scarce. Individual ceramic compounds vary in composition and microarchitecture but all pose osteoconductive properties. In this study, the authors evaluated the utility of Vitoss (Orthovita, PA) and Mastergraft (Medtronic, MN) in surgical treatment of spinal disorders.

Methods: The authors performed a retrospective review of surgical cases where ceramic compounds were utilized. The treatment cohort was then compared to control cohort. Medical records and imaging studies were evaluated. All patients were treated by the senior author.

Results: Over a period of 18 months 48 patients had undergone spinal stabilization procedure utilizing hardware and either Vitoss (n = 19) or Mastergraft (n = 29). Primary diagnoses included trauma, degenerative disease and spinal deformity. Twenty-five patients had lumbar procedures, 15 thoracolumbar, 6 thoracic and 2 cervical. Long-term follow-up was available for 38 patients. One patient progressed to hardware failure over four months and required revision surgery (3% failure rate). The rest of the cohort did well and progressed to fusion. The authors then identified case-control cohort. These patients were selected from the same time period while controlling for age, gender, pathology and procedure. None of these patients had ceramic compounds implanted. Of the 38 patients in the control cohort, 7 had hardware failure that led to revision surgery (18% failure rate).

Conclusion: Ceramic compounds utilization in this series significantly reduced failure rate. We speculate that this effect is due to enhanced fusion offered by the intrinsic properties of these compounds.

An Independent, Prospective Assessment of Complications in Spinal Surgery: Initial Report
Arvind Sabesan, Arpan Patel, Bryan Lebude, Mitchell Gil Maltenfort, James S. Harrop, Ashwini Dayal Sharan, John K. Ratliff

Introduction: Prospective studies of complications in spine surgery are wanting. We quantify incidence of perioperative complications through a prospective audit of a complex spine surgery practice.

Methods: An independent prospective assessment of three surgeons’ spine surgery practices was completed from July to September 2008. An auditor experienced in spinal care assessed all post-operative patients. Clinic follow-up was at a single central office, facilitating capture of post-operative events. We included all patients with capacity for adequate follow-up treated during the study period. Operative complications were defined through a survey of spine surgeons and spine surgery patients.
117 patients met inclusion criteria. Demographic data was assessed (male: 66, average age: 54 ± 15 years, average BMI 28 ± 7.2, hospital LOS: 9.7 ± 9 days). Monthst procedures were instrumented fusions (cervical: 57 fusions, average 2.5 segments, thoracic: 30, 2.9 segments and lumbosacral: 30, 2.1 segments). Twenty-six patients underwent decompressions alone. Medical comorbidities were common (cardiovascular, 49 patients, 41.9%, diabetes mellitus, 11 patients, 9.4%, smoking, 24 patients, 20.5%). Minor adverse events or major complications occurred in 58 patients (incidence: 49.6%), 42 major complications occurred in 26 patients (incidence: 22.2%). The most common adverse event was urinary tract infections, common major complications were infections requiring return to OR and pulmonary compromise. Metabolic comorbidities increased the likelihood of complications (p = 0.04). In thoracolumbar procedures, increasing number of levels increased the risk of complications (p = 0.0002). Presence of a complication lengthened hospital stay (p = 0.002).

Conclusion: This is the first independent prospective assessment of perioperative complications in a complex spine surgery practice. Our incidence of perioperative adverse events arises from case complexity and may imply underreporting of complications in retrospective reviews. Improved outcome measures will aid pre-operative decision making and provide foundation for pay-for-performance reimbursement.

504. Is Surgery Effective for Cervical Spondylotic Myelopathy? Results of a Systematic Literature Review Encompassing 26 Articles in 1597 Patients

David Mercier, Babak Arvin, Michael G. Fehlings

Introduction: Although cervical spondylotic myelopathy (CSM) is recognized to cause progressive spinal cord impainment, there is uncertainty in the literature (based on a Cochrane review of only two published studies) as to whether surgery is effective in treating this condition. Given that the Cochrane methodology solely relies on randomized controlled trials, we sought to undertake a systematic review (using the GRADE system) of the entire literature to address the question of which treatments are most effective for CSM.

Methods: A systematic search for articles published from 1966 to 2008 was undertaken with the MeSH terms “cervical myelopathy” using the MEDLINE (1960-June 2008) and EMBASE (1980-June 2008) databases. The papers included were limited to those reporting on prospective clinical studies with a minimum of one-year follow-up and at least 30 patients. Two reviewers independently scrutinized studies for inclusion criteria and quality using the Downs and Black criteria. The GRADE methodology was used to assign strength of recommendations and level of evidence.

Results: 648 studies were identified and scanned for inclusion/exclusion criteria. Twenty-six prospective studies, encompassing 1597 patients and including a broad range of surgical and non-surgical treatments met the pre-determined criteria. The studies reported that surgical treatment was associated with significant improvement in neurological outcomes. However, there was no clear benefit of surgery over conservative treatment in subjects with mild cervical myelopathy based on a RCT. Nonetheless, several case series and cohort studies showed that patients with early myelopathy require close observation due to continued clinical progression.

Conclusion: Our systematic review of literature on CSM supports a strong recommendation based on low to moderate-quality evidence for a benefit of surgery over observation/conservative management in patients with moderate and severe CSM.

505. Cervical Myeloradiculopathy in Patients in a Prospective Randomized Clinical Trial: Outcomes of CTDR vs. ACDF

Michael K. Rosner, Jeanette E. Ahrens, Christopher Chaput

Introduction: The use of cervical arthroplasty devices in patients with myelopathy remains controversial. The US IDE Clinical Trial of the PCM Artificial Cervical Disc is a prospective and randomized study of cervical disc arthroplasty (CTDR) and anterior cervical disectomy and fusion (ACDF) for the treatment of single level cervical radiculopathy or myelopathy.

Methods: This post hoc analysis compares outcomes of the subset of patients with both radiculopathy and signs of myelopathy treated with either CTDR or ACDF. Myelopathy was defined as the presence of one or more of the following: positive Romberg, abnormal heel/toe walk, pathologic hyporeflexia, lower extremity clonus, positive Babinski reflex or positive Hoffman’s sign. Clinical outcome measures, including the Neck Disability Index (NDI), neck and arm VAS scores, Nurick Grading, complications and adverse events were recorded at 6, 12, 26 and 52 weeks post-operatively and compared via one-way ANOVA.

Results: Of 278 PCM patients in the trial, thirty-eight (or 14%) had radiculopathy and signs of myelopathy, while of the 164 ADCF patients with available data, thirty-six (or 22%) had signs of myelopathy. Mean age was 44 years in both groups. Clinical outcomes were similar (Table 1) between groups at all time points (P > 0.08). No patient in either group declined in Nurick’s classification from baseline to last reported follow-up visit. No device removals or revisions occurred. One patient in the PCM group with unrecognized congenital stenosis was treated with a multi-level laminoplasty for persistent L’Hermitte’s symptoms.

Conclusion: The treatment of carefully selected patients with radiculopathy and mild myelopathic symptoms with CTDR can result in similar short-term clinical outcomes to ACDF. However, further study and more long-term follow-up is needed.

507. Minimally Invasive Percutaneous Cervical Correclional Correction and Fusion for Adult Spinal Deformity: 1.5-year Clinical and Radiological Results

Neel Anand, Eli M. Baron, Rebecca Rosemann

Introduction: Lumbar degenerative scoliosis is a common condition of the spine that is usually treated nonoperatively. Severely symptomatic cases may warrant surgical intervention. Traditional surgical approaches are associated with significant blood loss and morbidity. In this population, which is often elderly and has coexisting medical comorbidities, this is particularly relevant. We review our experience and report 1.5-year follow-up data.

Methods: Ten patients underwent minimally invasive circumferential deformity correction and fusion using three minimally invasive spine (MIS) surgical techniques: transpoas disectomy/interbody fusion, Trans1 AxialIF transsacral lumbosacral interbody fusion and percutaneous pedicle screw fixation. All interbody fusions were performed with allograft and bone morphogenetic protein (rh-BMP2) 10. Mean age was 73.2 years (SD 9.6). Intraoperative blood loss (EBL) was estimated by the attending anesthesiologist, operative times were recorded by nursing staff. Radiographs, VAS, treatment intensity scores (TIS), ODI and SF-36 were assessed pre-operatively and at last post-operative visit.

Results: Mean levels operated on was 3.6 (SD 1.96). Four patients underwent fusion to the sacrum. Mean EBL for anterior procedures was 181.43 (SD 174.4), for posterior procedures were 162.5 (SD 104.58). Mean surgical time for anterior procedures was 270.6 minutes (SD 141.31 min), for posterior procedures was 258.2 min (SD 99.67). Mean pre-op Cobb was 20.66 (SD 10.7), post-op was 7.15 (SD 7.56). Mean follow-up was 563.8 days (SD 101).
All patients maintained correction of their deformity and were noted to have solid arthrodesis on plain films. Significant reductions in VAS, ODI, SF-36 and treatment intensity scores were noted. There were no blood transfusions or ICU stays, one patient had transient quadriiceps weakness that resolved by 3 months post-op.

**Conclusion:** Three MIS techniques allow correction of lumbar degenerative deformity, with similar operative times and significantly less blood loss than historical controls. MIS techniques may afford older patients with concurrent medical comorbidities surgical options for the treatment of degenerative scoliosis whereas in the past these patients may have not been considered surgical candidates.

### 508. A New Osteoconductive Synthetic Bone Graft as an Alternative for Autograft in Lumbar Spine Fusion: Clinical and Radiological Results after 24–Months Follow-up

Luiz Pimenta, Juliano Lhamby, Juliano Fratezi, Thomas Schaffa, Etevaldo Coutinho, Leonardo Oliveira

**Introduction:** The spinal arthrodesis is the gold standard of treatment in a large number of cases, such as trauma, DDD associated with facet disease, spondylolisthesis, osteoporosis or in the treatment of degenerative canal stenosis which demands interbody fusion and many other indications of fusion. The problems of autologous bone graft associated with the iliac crest donor site include haematoma, persistent pain, increased operation time and blood loss. It is important to develop alternatives to autologous graft, such as allografts and synthetic bone substitutes.

**Methods:** Lumbar interbody fusion through anterior (ALIF: 17 patients) or extreme lateral approach (XLIF: 21 patients) was used in all cases. PEEK interbody cages packed with silicated calcium phosphate mixed with bone marrow aspirate were implanted. Eight cc of silicated calcium phosphate was combined with 8 to 12 cc of bone marrow aspirate per surgical level.

**Results:** The literature reports variable fusion rates with the use of autologous bone. We have an 89% fusion at 12 months using silicated calcium phosphate and 93% solid fusion rate at 24 months. Complications include: non unions - 1 patient (2.6%), delayed unions - 1 patient (2.6%), pain persistence - 4 patients (10.5%). Subsidence was observed in 2 patients (5.3.%). The mean surgical time was 50 minutes in both surgeries ALIF and XLIF techniques with a mean blood loss of 58.7 cc. The mean pre-operative VAS was 8.9, which decreased to 2.4 at 12-months follow-up and 1.8 at 24 months after surgery. The mean pre-operative ODI was 51.6 which decreased to 19.7 at 12-months follow-up and to 15.1 at 24 months after surgery.

**Conclusion:** The use of silicated calcium phosphate is a good alternative to achieve solid lumbar fusion on a high rate of the cases (93%), avoiding complications related with graft donor site such as pain and infection were obtained compared with iliac crest autograft.

### 509. Cervical Hybrid Arthroplasty: Lifestyles Outcomes Scale

Pablo R. Pazmino, Carl Laurysen, Todd Hopkins Lamnan, Azadeh Farin, Osama Qaqi, Shannon Murphy

**Introduction:** Cervical Hybrid Arthroplasty has emerged as a means towards addressing patients with prior fusions or multilevel disc pathology. The present study evaluates our subset of patients through our Lifestyles Outcomes Scale (LOS).

**Methods:** A total of 50 cervical arthroplasties in 41 patients were reviewed. Arthroplasty was performed using either the Prodisc C or Prestige ST prosthesis in concert with fusion in 41 consecutive patients. Twenty-two females and 19 males were evaluated with a mean age of 42 years and a mean followup of 12.64 months. Patients completed NDI, SF-36, VAS measures and completed the Lifestyles Outcomes Scale (LOS). The LOS evaluates patients perceived outcomes, length of stay, weight changes, narcotic use, walking time and distance, return to sex, travel/driving, sport and work.

**Results:** The mean NDI score at baseline was 64.92 which improved to a mean of 33.28. The mean VAS score at baseline was 8.48 which improved to a mean of 3.45. The mean SF36 score at baseline was 43.44 which improved to a mean of 63.25.

**Conclusion:** Our results show that the Charité artificial disc is a very safe and effective option in the treatment of DDD with motion preservation, being an alternative to interbody fusion with clinical improvement in monthst of patients, low rate of revisions and no major complications, with an overall satisfaction rate of 85%.

### 510. Charité 7-Years Follow-up: Clinical and Surgical Experience

Luiz Pimenta, Juliano Lhamby, Carlos Luiz Arias, Juliano Fratezi, Ihab Gharzeddine Gherze, Leonardo Oliveira

**Introduction:** The lumbar degenerative disc disease has been treated over the years with methods of fusion and it has presented good results, but the complete loss of motion in a fused segment leads to an overload in the adjacent segment and disc degeneration, pseudoarthrosis. Looking for reducing the adjacent disc degeneration incidence and the long recovery in post-op period, the artificial discs have been developed as an alternative for fusion to keep the range of motion of the spine and attempt to decrease the adjacent disc degeneration.

**Methods:** We have evaluated 224 cases with 7-years follow-up in 171 patients submitted to Charité total lumbar disc replacement. The protheses were implanted between L2-L3, L3-L4 and L5-S1 levels, with 122 cases of single level and 49 cases of multiple levels. All the patients had been evaluated using the VAS and ODI outcomes assessment with 6 weeks, 3, 6, 12, 24, 36, 42, 60 and 72-months follow-up, images (X-rays AP, lateral in flexion and extension and MRI)

**Results:** The VAS pre-op was 8 and with 60 months was 2.08, ODI pre-op was 54% and with 60 months was 15.72%. Complications: 25% had facet join pain, subsidence 0.44%, bad positioning 11%, polyethylene fracture 0.89%, bilateral pedicle fracture 0.44%, iatrogenic scoliosis 5%, heterotopic ossification 1.33% and we had nine (5.26%) prosthesis retrievals, seven patients using XLIF technique and the other two by ALIF with no major complication and improvement of clinical outcomes after revision.

**Conclusion:** Our results show that the Charité artificial disc is a very safe and effective option in the treatment of DDD with motion preservation, being an alternative to interbody fusion with clinical improvement in monthst of patients, low rate of revisions and no major complications, with an overall satisfaction rate of 85%.

### 511. Complications Associated with Semi-Rigid (PEEK Rod) Stabilization in Lumbar Fusion

Russ P. Nockels, Todd Hopkins Lamnan, Ahmad Khaldi

**Introduction:** Semi-Rigid posterior stabilization is increasingly utilized by spine surgeons in the management of lumbar disease. The theoretical advantages include load sharing of the interbody space, improved screw bone interface tolerance.
and an elastic modulus identical to bone. The material is biologically safe, radiolucent, resilient and has reproducible biomechanics. Additionally, the elliptical PEEK rod has biomechanical stability similar to a 5.5 mm titanium rod. However, the long-term complication rate associated with the use of the PEEK rod in lumbar fusion has not been described.

**Methods:** 158 consecutive patients (91 F, 67M) undergoing lumbar fusion with the CD Horizon Legacy PEEK rod (Medtronic, Memphis TN) were prospectively studied for clinical and radiological outcomes. Mean age = 52 years (range 21-87). Follow-up averaged 21 months (6-43 months). Approximately 1/3 of patients had Grade 1-2 spondylolisthesis and 70% had interbody grafts. Implant related complications were defined as adverse events directly related to the use of the PEEK rod with or without the need for re-operation.

**Results:** Four implant related complications were noted (2.5%): 1 infection, 1 broken screw (asymptomatic), 1 displaced bone graft following a significant trauma 3 weeks post-operatively and 1 temporary lumbar radiculopathy. There were no instances of rod breakage, re-operation for pseudoarthrosis or conversion to metal rods.

**Conclusion:** Clinical use of semi-rigid posterior lumbar instrumentation in a diverse group of patient demographics and pathologies has a low rate of complications. The CD Horizon Legacy PEEK rod appears safe in these patients over a lengthy follow-up period.

512. MRI Analysis of Disc Morphology in Post-Microdiscectomy Asymptomatic Patients with Anular Repair
Mark E. Myers, Steven L. Griffith, Jason Snider

**Introduction:** Lumbar microdiscectomy is the most frequent common surgical procedure performed in the spine with over 750,000 microdiscectomies performed worldwide. Although a relatively straight-forward procedure, complications can arise after surgery, such as continued pain or further disc degeneration. Little is known about how the anulus fibrosus and posterior disc margin behaves after being repaired following a microdiscectomy, particularly in asymptomatic patients. In diagnosing such complications, magnetic resonance imaging (MRI) is the favored method. The study purpose is to discuss the post discectomy appearance of the disc anular complex following anular repair.

**Methods:** All patients (33) had a non-contrast sagittal and axial MRI scan performed prior to their microdiscectomy surgery. After a successful microdiscectomy, the anulus fibrosus was repaired using the Xclose Tissue Repair System manufactured by Anulex Technologies. All patients were then scanned 6 months after the index procedure. MRIs were evaluated by an independent radiologist for changes in disc morphology.

**Results:** Disc Height: “Average height at pre-op and 6 months was 7.98 and 7.74 mm, respectively, which was within standard error.” Disc heights studied collapsed 2 mm or more at 6 months.

**Conclusion:** It is necessary to gather a better understanding of the limitations of diagnostic magnetic resonance imaging in post lumbar microdiscectomy patients, particularly in those patients in which the anulus fibrosus was repaired. Documenting the behavior of the repaired anulus fibrosus in asymptomatic patients will provide better understanding of the causes and thus treatments of post microdiscectomy complications.

513. Extreme Lateral Interbody Fusion (XLIF) in the Treatment of Lumbar Stenosis: Indirect Decompression in a Minimally Invasive Way: Clinical and Radiological Results
Luiz Pimenta, Juliano Lhamby, Juliano Fratezi, Everaldo Coutinho, Thomas Schaffa, Leonardo Oliveira

**Introduction:** Symptomatic lumbar stenosis presents as a consequence of different factors that narrow the lumbar spinal canal and the nerve roots. Its most common symptoms are weakness, numbness/tingling, radicular pain and neurogenic claudication in almost equal proportions. Traditional treatment includes laminectomy with spinous processes, laminae and pedicles removal. The purpose of this paper is to present a lateral retroperitoneal minimal invasive approach for the indirect treatment of lumbar central and lateral stenosis without the morbidity of a larger procedure.

**Methods:** The extreme lateral approach was done through the retroperitoneal space and through psoas muscle avoiding vascular lesions. A partial discectomy was done and the end-plate cleaned preserving ALL, keeping the spine more stable than the traditional surgery. Twenty patients with central or lateral stenosis underwent the XLIF Stand Alone procedure. Dynamic X-rays, MRI and clinical outcome assessment using Oswestry and VAS scores were performed pre-operatively, one and 12 weeks after surgery. The measurements were done using medical imaging software. The required measures were disc height (A/P), foraminal height (L/R), foraminal area (L/R), foraminal width (L/R), canal area, canal diameter and subarticular diameter (L/R).

**Results:** We used a t-test to compare the average and standard deviation of the pre-operative and post-operative data. All parameters were statistically significant (p < 0.05), showing the improvement of the disc height, canal area and foraminal space. VAS pain scores improved from an average 8.9 at pre-op to 3.25 at 3 months. Oswestry scores improved from an average 56.40 at pre-op to 32.5 three months after surgery.

**Conclusion:** The XLIF procedure provides the necessary decompression for the treatment of central and/or lateral stenosis in a minimally invasive way, preserving the ALL and all posterior elements of the lumbar canal.

514. Early Clinical and Radiographic Results of the N-Hance Posterior Dynamic Stabilization System
Christopher P. Ames, Jeffrey Coe, Scott Kitchel, Finn Christensen, Tae-Ahn Jahng, Hans Joerg Meisel, Mark Schnorring, Charles H. Wingo

**Introduction:** Posterior pedicle screw/rod-based dynamic stabilization systems aim to reduce the fusion-associated drawbacks of pseudoarthrosis, accelerated adjacent-segment disease, hardware failure and iatrogenic fixed sagittal imbalance. We analyzed the radiographic and clinical outcomes of patients treated with the N-Hance System (Synthes Spine) when used as a dynamic stabilization system. We hypothesized that the N-Hance system provides comparable clinical improvement in pain and function scores compared to rigid rod fusion systems.

**Methods:** Seven sites participated in a retrospective assessment of 80 consecutive patients who underwent lumbar dynamic stabilization at one level with or without rigid fusion at a contiguous level. Patients were included based on the presence of degenerative disc disease (DDD) in 34 patients, spondylolisthesis in 16 patients, fusion-related complications in 9 patients, lumbar stenosis in 15 patients, degenerative scoliosis in 3 patients and recurrent disc herniation in 3 patients. Participants were evaluated pre-operatively and post-operatively. The primary clinical outcome measures at each assessment were VAS and ODI scores. Radiographic measurements included evidence of instrumentation failure and the presence of motion at 3, 6, 12 and 24 months.

**Results:** Eighty patients (34M:46F) with a mean age of 53.4 years (range 19-86) were included. Average follow-up was 16.7 months (range 14-24). The mean VAS score
improved from 8.1 pre-operatively to 3.5 post-operatively (p < 0.001) and the ODI score from 45.6 to 26.3 (p < 0.001). There was no statistically significant difference in outcomes based on the indication for posterior instrumentation. Motion on i/e films was visible in some patients at 12 and 18 months, however this varied widely and was impacted by pre-operative motion at the dynamically treated level.  

**Conclusion:** Dynamic stabilization with the N-Hance System produces significant improvements in pain and function at midterm follow-up, comparable to rigid fusion systems and, with appropriate patient selection, is not associated with an increased risk of instrumentation failure.

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**515. A Simple Technique to Avoid Percutaneous Electrode Migration**

Richard B. North, Violette M. Renard  

**Introduction:** The strength of percutaneous spinal cord stimulation electrodes is also their weakness. Because they are cylindrical catheters that can be advanced and withdrawn through a needle, they are inserted during a screening trial to test multiple spinal levels and then easily withdrawn. When used for permanent implantation, however, they have a propensity to migrate, which can eliminate pain relief unless reprogramming of contacts or surgical revision is successful. A literature review reported that approximately 13% of patients undergo surgical revision to correct electrode migration. We devised a simple method to avoid this problem and have conducted a study to determine its efficacy.  

**Methods:** From July 1998 through December 2006, we implanted permanent percutaneous electrodes in 287 patients. In each case, we glued the inner surface of the anchoring sleeve to the outer surface of the electrode with < 0.1 cc of silicone elastomer adhesive. We reviewed these cases to determine the incidence of electrode migration.  

**Results:** In follow-up through July 2007 (range 0.5 to 9 years), four patients experienced migration that required revision. In two cases, the catheter or lead body remained fixed to the silicone elastomer anchor the longitudinal migration involved only the electrode at the tip of the lead, which ratcheted downward, one intercontact distance at a time (the same electrode design in each case). In the third case, lateral migration followed erosion of the sutures through the supraspinous ligament. The fourth case involved longitudinal migration of only the lead (not the electrode) through the anchor.  

**Conclusion:** Our simple, inexpensive technique all but eliminated longitudinal migration of percutaneous electrodes.

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**516. Early Decompressive Surgery in Symptomatic Idiopathic Spinal Epidural Lipomatosis**

Theofilos Machinis, Chris Zacko, Rodney Mark Samuelson, Harold F. Young, Robert Scott Graham  

**Introduction:** Spinal epidural lipomatosis is a relatively rare clinical entity, consisting of excessive deposition of adipose tissue in the epidural space leading to symptomatic spinal stenosis. Our study aims to provide further insight into this disease and its treatment options.  

**Methods:** In our current communication, we present our experience with eight patients with epidural lipomatosis treated at our institution during a period of 12 months (7 men/1 woman, age 44-58). Diagnosis was established with MRI. All of our patients experienced significant back and/or leg pain pre-operatively, 3/8 patients were non-ambulatory due to neurological involvement on presentation at our institution. All patients underwent surgical decompression of the affected area within 3 weeks of establishing the diagnosis. 6/8 patients were treated with decompressive laminectomies and resection of epidural adipose tissue, whereas in two cases fusion was employed along with decompression.  

**Results:** One patient was lost to follow-up. Six out of the remaining seven patients experienced pain alleviation post-operatively. Additionally, five out of seven patients showed neurological improvement after surgery. Our three patients that were non-ambulatory pre-operatively regained ability to ambulate (2 independently and 1 with a walker). Post-operative complications included one wound infection.  

**Conclusion:** Symptomatic spinal epidural lipomatosis is a disease that can be associated with severe neurological impairment. Surgical decompression and resection of the adipose component performed in a timely fashion seems to improve neurological and functional outcome significantly. Increased awareness of this disorder is imperative for early diagnosis and management.

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**517. Satisfaction with Indirect Decompression in Lumbar Stenosis with the XLIF Procedure**

Daniel S. Yanni, Eric H. Elowitz, Noel I. Perin  

**Introduction:** The purpose of this review is to examine the utility of the extreme lateral interbody fusion (XLIF) for treating patients with lumbar stenosis and segmental instability without direct decompression. Restoration of disc height with the XLIF procedure opens the neural foramina and indirectly decompresses the lateral recesses and central canal. We have identified a subset of patients with lumbar stenosis and segmental instability who may be treated with an XLIF and posterior stabilization without direct decompression.  

**Methods:** We reviewed our past two-year experience performing the XLIF procedure. Twenty-two of the 78 patients underwent XLIF procedures without direct posterior decompression of the neural elements. All patients had varying severity of lumbar stenosis and presented with back pain, leg pain and/or claudication symptoms. Patients who had significant weakness were excluded and underwent direct decompression. Post-operatively, patients were followed clinically and radiographically to assess outcomes, canal dimensions and fusion.  

**Results:** There were 22 patients in the study, mean age 61 years. Fourteen patients had Grade I spondylolisthesis and 9 patients had degenerative disk disease with segmental instability and discogenic back pain. Nine patients had severe central, lateral recess and/or foraminal stenosis. Thirteen had mild to moderate stenosis. Post-operative improvement in imaging, symptoms, VAS scores and satisfaction were assessed. 67% of the severe group and 92% of the mild/moderate group had significant clinical improvement. Overall, average VAS scores improved from 7 to 2 for back pain and from 8 to 3 for leg pain. Satisfaction with surgery as assessed by independent reviewer was greater than 90%.  

**Conclusion:** The use of the XLIF procedure, without direct decompression of the neural elements, is effective for treating patients with moderate stenosis and segmental instability.

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**518. Combined Anterior and Posterior Approach for Cervical Spondylotic Myelopathy**

Marina Abramova, Erich O. Richter, John C. Steck  

**Introduction:** The selection of an anterior versus a posterior approach for cervical spondylotic myelopathy (CSM) remains controversial. Details of the anatomic features and clinical presentation are critical to this decision. We reviewed our surgical series of combined anterior-posterior fusions for CSM.  

**Methods:** The medical records of 50 patients with an established diagnosis of CSM were retrospectively reviewed. All individuals had surgical intervention via a combined anterior (corpectomy or discectomy) and posterior (laminecetomy with fusion) approach. Clinical outcome, complications and total hospital length of stay were analyzed.  

**Results:** From 2004 to 2008, 48 patients (29 males and 19 females) with CSM underwent combined anterior-posterior fusion. The patients’ ages ranged from 25 to
82 years (mean 58.9). Total hospital stay ranged from 3 to 35 days (mean 7.4). All but one showed improvement in neurologic symptoms. Complications included post-operative infection in three cases (6%) and neck abscess and hematoma in one case (2%). There was no hardware failure or graft failure.

**Conclusion:** Circumferential decompression and fusion may have an advantage over stand alone multilevel anterior surgery. Combined anterior-posterior cervical decompression and fusion is not associated with an increased complication rate compared to anterior surgery alone and may be associated with a lower rate of graft failure and instrumentation failure. The surgery can be performed on the same day without the need for staging. We believe that in selected patients for whom neither anterior nor posterior approach is ideal by itself, the combined anterior-posterior approach may yield a better biomechanical result and prevent long-term deterioration. Further follow-up will clarify this.

**519. The Impact of Pre-operative DEXA Scores Following Arthroplasty on Long-term Clinical and Radiographic Outcomes: A 5-Year Follow-up Study**


**Introduction:** Osteoporosis and osteopenia are clear contraindications for arthroplasty. The goal of this study was to evaluate clinical and radiographic outcomes of patients with DEXA T scores < -1.0 and nevertheless included in the CHARITÉ IDE study. This study only analyzed patients with a mild osteopenia and provides no information on more severe osteopenia or osteoporotic patients, as they were not entered into the study.

**Methods:** Randomized and Training CHARITÉ cases from the 5-yr CHARITÉ IDE study with complete pre-operative and post-operative DEXA scan data were included herein. Two groups were compared herein: 1) the Large Disc Group (LDG) 5mm difference between index- and superior-level disc space, 2) Fusion Group (FUS). The correlation between ODI and worker’s compensation was only significant for the control group. Total surgery time was comparable for both, however there was a statistically significant difference in blood loss between groups (ASG 179.9 ± 157.0cc, LDG 371.0 ± 410.5cc, p = 0.0005). A trend of shorter hospitalization was also found for ASG vs. LDG (ASG 3.8 ± 0.94 days, LDG 3.5 ± 0.68 days, p = 0.0717). No differences in VAS and ODI improvements between groups were observed. Mean ROM showed non-statistical trends towards reduced motion in the LDG vs. the ASG group.

**Results:** There were 81 subjects in the ASG group vs. 31 in the LDG group. Average disc height was 12.4 ± 1.79mm in the ASG vs. 14.2 ± 1.37mm in the LDG. Demographics between groups were similar for gender, race, age, weight and body mass index.

**Conclusion:** Large disc implantation resulted in increased blood loss and hospital stay but did not affect the long-term pain and disability outcomes.

**520. FlexiCore® Total Disc Replacement vs. 360° Fusion for Lumbar Degenerative Disc Disease: Does Lower Clinical Improvement Correlate with Unemployment, Worker’s Compensation and Narcotics?**

Eric J. Woodard, Charles S. Theofilos, Rick C. Sasso, James Zucherman

**Introduction:** The aim of this abstract is to determine whether changes in back pain or functionality after total disc replacement or fusion are associated with changes in employment status, worker’s compensation status and/or use of narcotic medication.

**Methods:** Back pain was measured with VAS and functionality was assessed with ODI. Employment status, worker’s compensation and use of narcotic medication at 2-year follow-up were each binary coded in this analysis. Pearson’s correlation coefficient was used to assess the correlation between level of improvement of VAS or ODI and the employment status, receipt of worker’s compensation, or use of narcotics at the 2-year follow-up. Data was available for 50 FlexiCore® subjects vs. 24 fusion subjects.

**Results:** Significantly (p = 0.0016) more patients went from unemployed to employed in the FlexiCore group vs. the fusion group. The correlation between lower VAS as well as lower ODI and employment at 2-year follow-up was significant for both groups. The correlation between VAS and worker’s compensation was only significant for the control group. The correlation between ODI and worker’s compensation was significant in both groups. The correlation between VAS and narcotic use was r = 0.31 p = 0.03 for FlexiCore® and r = 0.52 p = 0.01 for fusion. Lower ODI and narcotic use correlated highly in both groups.

**Conclusion:** These results suggest that greater improvement in back pain and functionality is associated with a higher rate of employment, reduced use of worker’s compensation and/or lower narcotic use at the 2-year follow-up.
522. Preliminary Experience with Anterior Cervical Micro-Discectomy Only (ACMO), at a Tertiary Care Institute in North India
Krishan K. Bansal, Deepak Goel, Sanjay Agrawal, Veena Asthana, Shailendra Raghuvanshi

Introduction: The interbody fusion following anterior cervical discectomy for degenerative disc disease (DDD) is a traditional and conventional teaching. The design of this prospective study was to evaluate long-term clinical outcomes in patients of cervical disc herniation operated upon for anterior cervical micro-discectomy only (ACMO).

Methods: Patients with radiological evidence of one/two level cervical disc disease were enrolled in the study, from January 2004 to March 2007 and were followed for minimum 6 months to maximum 46 months. All patients were subjected to anterior cervical microdiscectomy only by a single surgeon using Leica microscope. Patients were evaluated for improvement in clinical symptoms, work status and signs using Nurick’s grading and Odom’s criteria.

Results: Of the 33 patients operated on during the study period, 28 were males and their age ranged from 28 years to 65 years with a mean age of 45.72 years. C5-6 disc herniation was the most commonly affected level. Five patients have two levels of disc herniation and were operated for two levels at same sitting. Month’s common presentation was radiculo myelopathy followed by root pain and myelopathy. Root pain was the earliest symptoms to disappear after surgery followed by myelopathy symptoms.

Conclusion: This technique is an adequate surgical treatment for the majority of cases of cervical disc prolapse, it does not require a fusion and avoids specific problems and complications associated with instrumentation and fusion. We are still continuing the following study of these patients, but to date, no considerable delayed problems have become evident. We think the best answer to this question can be obtained only with a prospective randomized double blind multi-center study.

523. Relationship Between Obesity and Major Complications after Cervical Spine Surgery
Cheerag Dipakkumar Upadhaya, Jayson Sack, Samuel Kaufman, Wajd Al-Holou, Frank LaMarca, Paul Park

Introduction: Spine surgery in the obese is frequently technically more difficult. In addition, there is a perception that obesity is associated with increased complications after spine surgery. In our review of the literature, there have been no previous studies evaluating the relationship of obesity with major complications occurring after cervical spine surgery.

Methods: After Institutional Review Board approval, we retrospectively evaluated 711 consecutive patients who underwent cervical spine surgery from 2000 - 2006. We identified any major condition that occurred after surgery requiring further intervention including death, myocardial infarction, pulmonary embolus, stroke, reoperation within 30 days and pneumonia. For statistical analysis, we utilized multiple logistic regression to determine if a relationship existed between BMI and the occurrence of major complications.

Results: Of the 711 patients, 55% were male and the mean age was 50 years (range, 18 - 88). The mean BMI was 28 (range, 11 - 65). There were 407 (57%) anterior cervical procedures, 259 (36%) posterior cervical procedures and 44 (6%) circumferential procedures. There were a total of 68 (9.6%) major medical complications. There was no statistically significant relationship between BMI (p = 0.127) and occurrence of a major adverse event.

Conclusion: There does not appear to be an increased risk for a major complication occurring after cervical spine surgery in obese patients.

525. Lumbar Spine Canal Augmentation Using the New Percutaneous Interspinous Device “In Space”: A Prospective 15-Months Clinical and Radiological Follow-up Study to Treat Single Level Degenerative Lumbar Spinal Stenosis
Roberto C. Diaz, Miguel E. Berbero, Ernesto Esteban, Manuel Vergara

Introduction: Symptoms of spinal stenosis are often postural with standing and lumbar extension exacerbating and flexion relieving leg pain, tingling and weakness. The treatment options may vary from activity modification, NSAIDs drugs, physiotherapy, epidural injection and surgical decompression with or without fusion in patients who fail to respond to conservative measures. Surgical decompression is the standard surgical treatment, it has the potential for significant complications, especially when a fusion is performed. In contrast with other rigid IPD devices, placement of the ‘In Space’ does not violate the supraspinous/interspinous ligamentous complex, which was found to be the largest contributor to resisting applied flexion moments in the lumbar spine in the animal model, also use a percutaneous approach avoids significant morbidity of the traditional approach.

Methods: Data will be collected pre-operatively and from the O.R. record to obtain operating times, blood loss and lengths of the hospital stay. In addition, the VAS score Oswestry (ODI), Zurich Claudication Questionaire (ZCQ) and Odom scores were collected on all patients enrolled in the study. X-ray image follow-up will be recorded pre-operatively and at 1, 3, 6 and 12 months post-operatively. Adverse events and surgical related complications will also be recorded.

Results: Twenty patients (66 y/o mean age) with lumbar canal stenosis and 1 patient with degenerative lumbar disc disease were enrolled. Operated levels were L3-L4 (n = 2), L4-L5 (n = 18). There were no intra-operative and post-operative complications. Blood loss was less than 20 cc. Mean surgical time 12 minutes. All patients (100%) recovered uneventfully and recovery of the pre-operative symptoms. Patients experienced minimal post-operative pain and were discharged before 23 hours. VAS, SF-36 and ZCQ scores improved post-operatively. 100% Excellent-Good results using Odom scale.

Conclusion: Current study demonstrates that In Space device a percutaneous minimal invasive interspinous system was safe and feasible for the treatment of neurological claudication due to single level lumbar canal stenosis, there are numerous potential applications for this less invasive new technique and may be a new therapeutic option for minimally invasive spinal surgeons.

526. Intraoperative Multiplanar Fluoroscopy and Image Guidance for Anterior Thoracic and Lumbar Vertebractomy and Reconstruction
Charles J. Riedel

Introduction: Image guidance increases the accuracy of instrumentation placement for pedicle screws of the cervical, thoracic and lumbar spines as demonstrated in laboratory studies and clinically. The application of image guidance to anterior approaches to the thoracic and lumbar spine has been more limited, however, because of increased difficulty with reference marker placement and registration. We describe a novel approach to image guidance of the anterior thoracic and lumbar spine that facilitates surgery, may eliminate errors that require instrumentation revision (which may become a never event) and may improve patient safety.

Methods: Seven patients underwent thoracotomy or retroperitoneal approaches for vertebractomy and anterior reconstruction. In each case a reference frame was placed through a separate 1 cm incision and attached to a spinous process within 1-2 levels of the primary pathology after the initial anterior exposure was carried out and self retaining retractors
placed. O-arm multiplanar fluoroscopy was used in conjunction with a computerized guidance system. Because all images are obtained intraoperatively, manual registration is not required. At the completion of surgery a final imaging series is conducted. All patients underwent systematic evaluation of radiographic results as well as clinical outcome and complications.**

**Results:** Image guidance eliminated the need for standard intraoperative x-rays while improving the determination of anatomical levels. No instrumentation violated the spinal canal. There were no instances of instrumentation placement requiring revision surgery. In cases with difficult trajectories, image guidance assured accurate trajectory in all planes. No neurological complications occurred. One patient developed a superficial wound infection at the reference marker insertion site which responded to local wound care and oral antibiotics.**

**Conclusion:** Image guidance utilizing multiplanar fluoroscopy is readily applied to anterior approaches to the thoracic and lumbar spine. Implant placement is accurate even under adverse conditions. Decompression is facilitated and confirmed prior to leaving the OR. Patient safety is enhanced.

**527. Is Pre-operative Disc Height a Contributing Factor in 5-Year Success Rate with Arthrodesis and Arthroplasty?**

**Introduction:** Pain, disability and ROM in the CHARITÉ IDE patient population treated either with CHARITÉ or BAK with autograft was evaluated, based on pre-operative disc height.**

**Methods:** Pre-operative disc height for all patients (randomized and training cases) was analyzed and subjects within the lowest 25 percentile of all disc heights (LDH) were compared to those in the higher 75 percentile (HDH). The subgroups were compared for pain (VAS), disability (ODI) as well as ROM and disc height, at 5 years. A receiver operating characteristic (ROC) curve was constructed to evaluate if pre-operative disc height was predictive of successful outcome. The AUC (area under the curve) and associated statistical test were calculated for the ROC curve.**

**Results:** Pre-operative disc heights and corresponding VAS and ODI changes from pre-operative to 5-year post-operative are shown in Table 1 below. At L5-S1, Between LDH and HDH arthroplasty groups, changes in ODI and VAS were greater in the LDH vs. HDH groups (ODI: p = 0.0335, VAS: p = 0.0520). No significant differences in 5-year disc height, ROM and translation were observed between groups. ROC analyses indicated that pre-operative disc height might not be a strong predictor for clinical success (AUC = 0.5550, p = 0.2641).**

**Conclusion:** Despite decreased pain and disability scores in the arthroplasty LDH vs. HDH group at L5-S1, pre-operative disc height was not found to be a strong predictor of clinical success.

**528. Lifestyle Outcomes Analysis after Minimally Invasive Microscopic Decompression for Lumbar Spinal Stenosis**
Pablo R. Pazmino, Carl Laurysen, Brandon Cohen, Azadeh Farin, Ryan Gordon

**Introduction:** Microscopic minimally invasive surgical decompression provides an effective option when symptoms associated with degenerative lumbar stenosis persist despite conservative management. Nevertheless, the extent of function and quality of life following decompression are still somewhat undefined with more minimally invasive procedures. The aim of this study was to explore patient lifestyle and outcomes after surgical decompression for lumbar stenosis.**

**Methods:** A total of 174 consecutive patients were reviewed. 63% men and 37% women, mean age 69, underwent single or multilevel decompression for lumbar stenosis. The average duration of symptoms prior to having surgery was 5.77 years. The average duration of symptoms prior to having surgery was 5.77 years. Using the modified Stauffer-Coventry classification the mean outcome was 3.44, with 55% of patients reporting excellent, 29% good, 14% fair and 2% poor results. Eighty-four percent would have the surgery again. The mean ZCQ score in the Symptom Severity domain was 2.27, 1.77 in Physical Function and 1.90 in Satisfaction. The mean interval from surgery for the 111 patients who returned to driving was 22.6 days. The mean interval from surgery for the 20 patients who returned to sex was 3.58 months. The mean interval from surgery for the 123 patients who returned to driving was 22.6 days.**

**Conclusion:** The rate of improvement is rapid and sustained through 4 years. This study observes outcomes and times to return to work, sport and sex which may serve as a guide for patient education and post-operative expectations.

**530. Minimally Invasive Posterior Trans Muscular C1-C2 Screw Fixation through an Anatomical Corridor to Preserve Occipital-Cervical Tension Band: Prospective 18-Months Clinical and Radiological Study**
Miguel E. Berbeo, Roberto C. Diaz, Manuel Vergara, Victor Alfonso Morera Porras

**Introduction:** The C1-C2 joint is affected by multiple entities that may produce biomechanical instability. Optimal management for atlanto-axial instability has been searched by ways of different surgical techniques with different results, generating discussion between second effects of a particular treatment. In the following study, we propose a minimally invasive (MIS) C1-C2 fusion technique through the anatomical corridor between the posterior major rectus capitis and the inferior obliquus capitis. We performed a C1 lateral-mass screws and C2 pedicular screws instrumentation. The use of a MIS technique to perform posterior C1-C2 fixation, reducing muscle devascularization and denervation would preserve the medial tension band. This means less intraoperative blood loss, less post-operative pain and shorter hospital stay, also better post-operative cervical spine stability.**

**Methods:** Prospective study, nine patients with C1-C2 instability due to dense fracture and/or rheumatoid arthritis atlanto axial subluxation were enrolled. Operative time, blood loss and hospitalization time were recorded. Subjects were evaluated pre-operatively and post-operatively at 1, 3, 6, 12 and 24 months. Analysis consists of clinical outcomes and radiological assessment.**

**Results:** We performed in all cases a minimally invasive trans-muscular approach through a 25 mm bilateral paramedian skin incision, using the access MIS platform Maxcess II® and subsequent placing screws according to the modified Harm’s technique. This approach uses a progressive tubular dilators system through the superficial nucal musculature (trapezius and semispinalis capitis) and then through the anatomical corridor. A 4.0 mm diameter poliaxial screws are inserted using Harm’s technique. The articular surfaces of C1 and C2 are decorticated using curettes and demineralized bone matrix mixed with bone marrow aspirated is placed inside the joint. The same procedure is made in the contra lateral side in the same way. There were no intra-operative or post-operative complications. All patients (100%)
recovered uneventfully and recovery of the pre-operative symptoms. Patients experienced minimal post-operative pain and were discharged before 46.8 hours mean time.

Conclusion: As our experience in minimally invasive techniques improves, we can offer our patients less morbid treatment options with similar or better results to those achieved with conventional procedures.

### 531. Contouring Index (CI) for Evaluation of Spinal Cord Contouring for Patients with Cervical Spondylotic Myelopathy
Chelsea Meskunas, Steve McNany, Nancy Montero-Barletta, Tanvir Choudhri

**Introduction:** Spinal cord contouring is a well-recognized finding associated with cervical spondylotic myelopathy. However, to date, there has been few efforts to qualitatively or quantitatively characterize this phenomena. Prior studies have utilized the AP compression ratio to analyze the degree of cord deformation. In this study, we introduce two rating scales (Compression Scale, Contouring Index) and use them to evaluate patients with cervical spondylotic myelopathy.

**Methods:** This IRB-approved retrospective study analyzed patients undergoing evaluation/treatment for cervical spondylotic myelopathy between October 2001 and October 2006. For a randomly selected subset of these patients a detailed radiographic analysis was performed on axial T2-weighted images (6 levels per patient, n = 40). For each analyzed level the following were determined: AP compression ratio (AP), Compression Scale (CS) and Contouring Index (CI). The data were analyzed using standard statistics.

**Results:** Levels with the least amount of spondylotic compression (CS = 0) showed significantly less cord contouring compared with levels with more significant compression (p < 0.001 for both CS = 3 and CS = 4). Additionally, both CI (r-squared = 0.59) and AP (r-squared = 0.73) showed moderate correlation with respect to CS.

**Conclusion:** This study provides an introduction to a 5 point Compression Scale (based on degree of canal compromise) and a measured/calculated Contouring Index that can be used to characterize the effects of cervical spondylotic on the spinal cord in patients with myelopathy. These preliminary data show that there appears to be a moderate correlation of the CI with degree of compression. Additional analysis is required to better characterize the utility of these rating scales.

### 532. Multilevel Cervical Arthroplasty: Lifestyles Outcomes Scale
Pablo R. Pazmino, Todd Hopkins Lanman, Carl Laurysen, Azadeh Farin, Osama Qaqi, Shannon Murphy

**Introduction:** Cervical arthroplasty has been approved as a means towards addressing patients with single level disc pathology. However a subset of patients with multilevel cervical disc pathology may benefit from arthroplasty as well. The present study evaluates our subset of patients treated with multilevel cervical arthroplasty through our Lifestyles Outcomes Scale.

**Methods:** A total of 64 cervical arthroplasties in 32 patients were reviewed. Arthroplasty was performed using either the Prodisc C or Prestige prosthesis in 32 consecutive patients. Eighteen females and 14 males were evaluated with a mean age of 38 years and a mean followup of 11.56 months. Patients completed NDI, SF-36, VAS measures and completed the Lifestyles Outcomes Scale (LOS). The LOS evaluates patients perceived outcomes, length of stay, weight changes, narcotic use, walking time and distance, return to sex, travel, driving, sport and work.

**Results:** The mean NDI score at baseline was 66.86 which improved to a mean of 31.53. The mean VAS score at baseline was 8.72 which improved to a mean of 3.79. The mean SF36 score at baseline was 48.98 which improved to a mean of 67.52. Improvement at each interval and overall was statistically significant (p < 0.05) using the Wilcoxon Rank Sum Test. The mean interval from surgery for return to work for the 25 patients in employment was 26 days. The mean interval from surgery for return to sporting activities was 18.3 days. The mean weight loss for the 14 patients that lost weight was 7.7 pounds. The mean weight gain for the 3 patients that gained weight was 4.8 pounds. The mean interval to return to driving was 21.43 days.

**Conclusion:** Multilevel cervical arthroplasty appears to be a safe and effective treatment for painful discogenic disease and radiculopathy. The rate of improvement is rapid and sustained.

### 533. Spinal Process Reconstruction of the Cervicothoracic Spine to Eliminate Post-surgical Defect
Huy The Duong, Kee Duk Kim

**Introduction:** Symptomatic multilevel cervical spondylisis is often treated with multilevel laminectomy for decompression and posterior instrumented fusion to prevent post-laminectomy kyphosis. After surgery most patients have a crater-like defect in their neck, especially if C7 laminectomy is performed. In this paper we present a new approach in rebuilding the posterior elements of the spine using custom titanium mesh to reconstruct the cervicothoracic lamina and spinous processes and avoid any problematic defect.

**Methods:** We surgically treated three patients with multilevel cervical spondylisis extending down to the cervicothoracic junction. After decompressive laminectomy including removal of the C7 spinous process, posterior instrumented fusion down to upper thoracic spine is performed. Titanium mesh measuring 10 x 10 cm is cut and molded to the appropriate size and shape to simulate the missing spinous processes and lamina. The superior, inferior and lateral edges of the titanium mesh are then secured to the corresponding vertebrae using titanium self-drilling/self-tapping screws. Paraspinal muscles are loosely reapproximated and the surgical wound is closed in the usual fashion.

**Results:** Six months post-operatively, all three patients demonstrate improvement in their pre-operative symptoms. All report improvement or elimination of neck pain with no wound infection or delayed wound healing. Surgical incisions appear well-healed with good soft tissue filling and without visible defect as with standard decompressive surgery. In fact, patients report they are unable to detect the surgical site with palpation of their cervical spine.

**Conclusion:** Cervical multilevel decompressive laminectomy involving C7 spinous process is associated with an unsightly cosmetic defect which may be associated with chronic neck pain. We describe a novel technique reconstructing the spinous processes from intraoperatively formed, readily available titanium mesh. From our limited experience, this technique is associated with high patient satisfaction without new complication.

### 534. Operative Management of Pediatric Spinal Deformity: A Neurosurgical Experience
Sumon Bhattacharjee

**Introduction:** The management of pediatric spinal deformity has undergone substantial progress in the last decade. The neurosurgical experience has been mostly limited to the management of cranio cervical deformities. Recently, more neurosurgeons have been involved in the management of the full range of pediatric spinal deformities. We present our initial surgical experience in the management of multilevel of pediatric spinal deformities. This also illustrates the neurological surgeon’s involvement in managing complex pediatric spinal pathology.

**Methods:** Fifty consecutive pediatric patients were evaluated and managed under...
our care with complex spinal pathologies. There were eighteen patients who underwent surgical intervention for their spinal pathologies with minimum of one-year follow-up who were included in our current study. All data was collected in a prospective fashion, including SRS scores, Oswestry Disability Index and perioperative radiographs.

**Results:** The results include a wide range of pediatric spinal pathologies. There were four patients with neuromuscular scoliosis, two congenital spinal deformities, one Grade IV spondylolisthesis and 11 patients with adolescent idiopathic scoliosis. There were 50% or greater curve correction in each category, with associated improvement of SRS and Oswestry Disability Index. There was one perioperative instrumentation failure requiring return to the operative room for correction. There were no neurological deficits or other major perioperative complications.

**Conclusion:** Neurosurgical surgeon’s experience with the management of pediatric spinal pathology was limited predominantly to the craniocebral junction and intradural lesions. Our early experience is able to produce results that are comparable with other large series that have been reported in the literature. This provides an impetus to encourage the neurosurgical community to be further involved and be involved in managing these complex pediatric spinal pathologies.

**535. Cervical Cages for ACDF as a Standalone Device: The Ultimate in Dynamism**

Michael W. Groff, Efstatios Papavassiliou

**Introduction:** Dynamic plates and thinner plates have both generated enthusiasm as adjuncts to anterior cervical fusion. In the context of degenerative disease in the cervical spine of one and two levels it may be the case that no plate is required at all. Certainly, the original description of anterior cervical arthrodesis by Smith and Robinson in 1958 did not utilize plate fixation for the tricortical iliac crest graft. Avoiding a plate has significant advantages including removing any degree of graft shielding, simplifying re-operation at adjacent levels if that becomes necessary and limiting slightly the exposure needed for the index operation.

**Methods:** We retrospectively reviewed 37 cases of one and two level ACDFs in which a carbon fiber cage was used as a standalone device without any plating. The graft chamber was filled with a combination of Healos and local bone. The Healos, a cellulose sponge of hydroxyappitite was admixed with bone marrow aspirate taken from the anterior iliac crest. All cases were followed for a minimum of one year. In addition to clinical success and Odom’s criteria, flexion/extension x-rays were obtained in each case to assess fusion.

**Results:** All patients experience clinical improvement. There were no cases of pseudoarthrosis. Importantly, there were no cases of graft extrusion or post-operative infection.

**Conclusion:** This is the only US series of Smith-Robinson type cages used as stand-alone devices. Carbon fiber cages can be used safely as stand-alone devices in ACDF constructs. This preliminary data suggest that they perform on a level that is similar to the current standard of care allograft and an anterior plate.

**536. Does Cervical Laminectomy and Lateral Mass Instrumentation and Fusion Cause Less Neck Pain Compared to Laminoplasty for Cervical Spondylotic Myelopathy?**

Daniel C. Lu, Dean Chou, Praveen V. Mummaneni

**Introduction:** Treatment options for cervical myelopathy include laminoplasty and laminectomy with fusion. However scarce data exists in comparing these two treatment options.

**Methods:** We retrospectively reviewed 50 patients who underwent either cervical laminectomy with instrumented fusion (25) or laminoplasty (25) for cervical spondylotic myelopathy. Clinical outcomes were assessed using pre- and post-operative Nurick grades, modified Prolo score and visual analogue scale for neck pain. Radiographic outcomes were assessed using dynamic radiographs and computed tomography (CT) scans.

**Results:** The mean follow-up period was 27 months for laminoplasty vs. 25 months for laminectomy with fusion. There were no pre- or post-surgical differences in Nurick grades between the two group (p > 0.05). However, there was a trend toward significance in modified Prolo score favoring laminectomy with fusion (8.2 vs. 7.5, respectively, p = 0.08). All patients in the laminectomy and fusion group achieved solid radiographic fusion. One patient (4%) in the cervical laminectomy with fusion group required revision surgery while no patients in the laminoplasty group were revised (p < 0.0001). There was one case (4%) of C5 palsy that completely recovered in the laminectomy with fusion group and no neurologic deficits in the laminoplasty group (p < 0.001). Lastly, there were no differences seen in both pre-operative and post-operative visual analogue scale for neck pain in laminectomy and lateral mass fusion vs. laminoplasty (p > 0.05).

**Conclusion:** With proper patient selection, the outcome of laminoplasty in the treatment of cervical spondylotic myelopathy can be satisfactory. The implant cost is lower in laminoplasty cases.

**537. Spontaneous Autofusion of Dorsal Elements Following Hemilaminotomy for Lumbar Microdiscectomy**

Steve McAnany, Chelsea Meskunas, Nancy Montero-Barletta, Tanvir Choudhri

**Introduction:** Although achieving successful lumbar fusion following arthrodesis surgery can be challenging, spontaneous fusion following lumbar decompression surgery is known to occur but is relatively rare and has not been formally reported to our knowledge.

**Methods:** This case report describes a middle-age woman who underwent standard left L4-5 microdiscectomy surgery with hemilaminotomy and partial facetectomy for primarily left-sided symptoms. Several years later, the patient presented again with recurrent lumbar symptoms.

**Results:** The patient underwent lumbosacral MRI and CT scan. An initial review of the axial CT scan images suggested that the hemilaminotomy defect was on the opposite (right) side of the patient’s prior symptoms raising the question if the surgery had been performed on the incorrect side. The incorrect assessment of which side the patient had prior surgery was reflected in the radiology report. However, further analysis with multiplanar reconstruction views clearly demonstrated that the patient had received surgery on the proper (left) side but that a spontaneous fusion had occurred. On the axial images, the fusion at the prior hemilaminotomy site next to the contralateral natural intralaminar space created the misimpression of which side had the prior surgery. Earlier post-operative imaging (prior to the spontaneous fusion) had also confirmed the proper side of the surgery.

**Conclusion:** This case report provides clear radiographic evidence of an example of spontaneous fusion which developed in the site of hemilaminectomy for standard microdiscectomy. This possibility should be considered by surgeons and radiologists as they review post-operative imaging following decompressive surgery even if a formal arthrodesis had not been performed. This case demonstrates how a unilateral spontaneous fusion in the unilateral hemilaminectomy defect and intralaminar space can lead to confusion on what side had the prior surgery. Multiplanar reconstruction views are very helpful to correctly interpret the imaging.
538. Classification of Sacropelvic Resection for Primary Malignant Tumors
Amgad S. Hanna, Michael J. Yaszemski
Introduction: Primary malignant sacral and pelvic tumors represent a considerable challenge for surgeons both from the resection as well as the reconstruction standpoint. They affect a younger population of patients with high impact on their families and the society. Complete resection with negative margins is the only hope for cure for this group of patients.
Methods: We present a new anatomical classification based on our long experience with these tumors at the Mayo Clinic. These tumors include osteosarcomas, chondrosarcomas, malignant peripheral nerve sheath tumors, chordomas, etc. They can be primary or radiation-induced.
Results: Type 1: Total sacrectomy with implantation of carbon fiber. The patients the carbon fiber can be primary or radiation-induced. Nerve sheath tumors, chordomas, etc. They can be primary or radiation-induced. Genito-femoral (GF) nerve function. Two Resume (Medtronic, Minneapolis, MN) leads were placed using a ‘sandwich technique’.
Conclusion: These complex cases of sacropelvic tumors require a team approach involving spine, colorectal, vascular, orthopedic tumor and plastic surgeons. Understanding the normal anatomy as well as the patient’s pathological anatomy is very important for pre-operative planning. With good surgical technique for resection and reconstruction, the patients can have a reasonable cancer-free survival.

539. Radiographic Comparison of Subsidence in Anterior Cervical Spinal Fusion: Allograft vs. Carbon Fiber Cage System
Fangxiang Chen, Kelly B. Mahaney, Patrick W. Hitchon
Introduction: Implantation of carbon fiber cages for anterior cervical discectomy and fusion has in recent years become an alternative to the traditional methods of allograft and autograft implantation for cervical fusion. The authors sought to determine whether rates of settling in anterior cervical fusion utilizing carbon fiber cage implantation were similar to rates observed with fusion utilizing allograft or autograft (iliac crest). The purpose of this study is to establish whether a difference in rates of settling can be detected radiographically.
Methods: A retrospective review was undertaken of recent cases of anterior cervical discectomy and fusion conducted since the carbon fiber cage system was introduced. Twenty-one cases of anterior cervical discectomy and fusion utilizing carbon fiber cage system were compared with 17 cases using allograft or autograft from the iliac crest. X-rays from follow-up at 6 months (actual follow-up times ranged from 4 to 7 months) and 12 months (11-12 months) were compared with x-rays obtained at the time of surgery to determine change in lordosis.
Results: The patients in the allograft group had an average lordotic angle of 2.5 degrees (per level fused) at time of surgery and 5.1 and 2.2 degrees respectively at 6 and 12-month follow-up. The patients in the allograft group had an average lordotic angle of 3.6 degrees at time of surgery and 4.1 and 3.5 degrees at 6 and 12-month follow-up. There was a significant difference in lordotic angle between groups (carbon fiber group more lordotic, p=0.001, one way repeated measures ANOVA).
Conclusion: There was a difference in average lordotic angulation between the allograft and carbon fiber groups and in lordotic angulation between the follow-ups in both groups.
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<td>NeuroSpine PC 287 Healthcare Dr. Dothan, AL 36303000</td>
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<td>Name</td>
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<td>1065 Valparaiso Ave.</td>
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<td>Harold F. Young, MD</td>
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<td>Kemal Yucesoys, MD</td>
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<td>Lloyd Zucker, MD</td>
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</tbody>
</table>
**GENERAL INFORMATION**

**Speaker Ready Room**
The Speaker Ready Room will be available Wednesday, March 11 from 8:00 AM – 6:00 PM, Thursday, March 12 and Friday, March 13, from 6:00 AM – 6:00 PM and Saturday, March 14 from 8:00 AM – 12:30 PM in the Pinnacle Peak Parlor 3 Room. All speakers and abstract presenters should visit the Speaker Ready Room prior to their presentation.

**Evaluation Forms**
The evaluation process is critical to providing cutting edge programming at the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves Annual Meeting. Medical registrant feedback on the quality and diversity of the entire program helps to determine future annual meeting programming. Your views and opinions are valued!

**No Smoking Policy**
Smoking is not permitted at any official AANS/CNS Section on Disorders of the Spine and Peripheral Nerves Annual Meeting event.

**Disclaimer**
The material presented at the 25th 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 on 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.

**CME CREDIT**
This activity has been planned and implemented in accordance with the Essentials and Standards 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 Accreditation Council for Continuing Medical Education (ACCME) accredits the CNS to sponsor continuing medical education for physicians.

**US Physicians**
The CNS designates this educational activity for a maximum of 26.50 AMA PRA Category 1 Credits™. Physicians should only claim credit commensurate with the extent of their participation in the activity.

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

* A maximum of 18.50 AMA PRA Category 1 Credits™ may be earned for Scientific Sessions only.

**Physician Assistant/Physician Extender CME Credit**
Physician Assistants/Physician Extenders will receive credits for attendance at the general Scientific Program and for any optional events attended. Each physician assistant/physician extender should contact his or her individual membership association and certification board to determine the requirements for accepting credits. All attendees will receive a Confirmation 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. CME credit for optional Special Courses and Luncheon Symposia will be issued based on tickets turned in at the time of the course. CME will not be issued unless a ticket is received. An additional 8 optional hours are available.

**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 2 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 2 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.

**DON’T FORGET TO TURN IN YOUR CME TRACKING FORM**
All Medical Registrants must complete the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves CME Tracking Form included in this Scientific Program.

**FOLLOW THESE STEPS TO RECEIVE YOUR CME CERTIFICATE**
- Indicate the number of hours actually spent in attendance at CME activities.
- Return the completed and signed form either onsite or post–meeting.
- Onsite – look for the Evaluation/CME drop boxes conveniently located in registration to submit the completed form.
- Post–Meeting – Mail or fax the completed form to:

  **Congress of Neurological Surgeons**
  10 North Martingale Road, Suite 190
  Schaumburg, IL 60173–2294
  Fax: 847–240–0804

Attendees who submit the CME Tracking form by the April 3, 2009 deadline will receive their CME Certificate by April 27, 2009.

No CME certificates will be issued unless a CME tracking form is returned.
## DIRECTIONS

**STEP 1**
Indicate how many hours you spent in attendance at EACH session.

**STEP 2**
Indicate the total hours you attended for all of the sessions.

**STEP 3**
Check your contact information shown above or fill in your name. Sign the form below.

**STEP 4-RETURN THIS FORM TO THE CNS:**
1. Deposit in drop boxes marked CME Tracking Form throughout the hotel.
2. Fax to the CNS at 847 240 0804 by April 3, 2009.
3. Mail to the CNS at 10 North Martingale Road, Suite 190, Schaumburg, IL 60173-2294 by April 3, 2009.

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### THIS FORM MUST BE COMPLETED

<table>
<thead>
<tr>
<th>Date</th>
<th>Scientific Session I</th>
<th>CME Hours Available</th>
<th>CME Hours Attended</th>
<th>Write Hours Below</th>
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<tr>
<td>Thursday, March 12, 2009</td>
<td>Scientific Session I – Past Evidence: Lessons Learned, Dealing with the Aging Spine</td>
<td>5.25</td>
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<tr>
<td>(Max CME Thursday Hours = 8.25)</td>
<td>Scientific Session II – Present Appraisal: New Trials and Their Implications</td>
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<tr>
<td>Friday, March 13, 2009</td>
<td>Scientific Session III (Part 1): Present Appraisal: The Tethered Cord from Child to Adult from Asymptomatic to Symptomatic</td>
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<tr>
<td>Saturday, March 14, 2009</td>
<td>Scientific Session IV – Future Advocacy: CMS, the Spine, and Spine Care in Alternative Health Systems</td>
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<td>(Max CME Thursday Hours = 5.25)</td>
<td>TOTAL Maximum hours available</td>
<td>18.50</td>
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I verify that I have attended all of the sessions as indicated above.

SIGNATURE (required)

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**SPECIAL COURSE AND LUNCHEON SYMPOSIA CREDIT:** Special Course and Lunch Symposia credit is issued based on tickets that are turned in at the time of the course/symposia. CME will not be issued unless a ticket is received. An additional 8 optional hours are available.

**ACCREDITATION STATEMENT:** The Congress of Neurological Surgeons is accredited by the Accreditation Council for Continuing Medical Education. CNS designates this educational activity, jointly sponsored by the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves, for a maximum of 18.50 hours the *AMA Physician Recognition Award Category I credit(s)*. Each physician should claim only those credits actually spent completing the educational activity.
The AANS/CNS Section on Disorders of the Spine and Peripheral Nerves is pleased to announce that evaluation forms for all General Scientific Sessions, Special Courses and Luncheon Symposia will be sent out via e-mail post-meeting! In an effort to increase convenience and conserve resources, we have determined that this simple change will enhance expediency and clarity in how evaluations are received and reviewed.

Evaluations will be sent to the e-mail address that you registered for the meeting with. Simply follow the provided links and answer all pertinent questions honestly. Your feedback is critical in helping the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves plan future education and Annual Meetings.

You can also visit us online at www.spinesection.org to link directly to each evaluation.

All Medical Registrants must complete the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves CME Tracking Form included in this Scientific Program.

FOLLOW THESE STEPS TO RECEIVE YOUR CME CERTIFICATE

- Indicate the number of hours actually spent in attendance at CME activities.
- Return the completed and signed form either onsite or post-meeting.
- Onsite – look for the CME drop boxes conveniently located in registration to submit the completed form.
- Post-Meeting – Mail or fax the completed form to:

  **Congress of Neurological Surgeons**
  10 North Martingale Road, Suite 190
  Schaumburg, IL 60173–2294
  Fax: 847–240–0804

Attendees who submit the CME Tracking form by the April 3, 2009 deadline will receive their CME Certificate by April 27, 2009. No CME certificates will be issued unless a CME tracking form is returned.
The Congress of Neurological Surgeons is pleased to announce the release of our improved SANS Lifelong Learning. Enjoy new features with superior interface, more user-friendly options and better performance analysis.

My Notebook
The Tools panel allows you to highlight, bookmark and add notes to various questions. With the ability to edit as necessary this feature allows for continuous learning. Bookmark questions you want to come back to, highlight useful information and keep notes for further review.

Score Summary & Analysis
Review your score and see how you compare with others who have taken the test. The analysis tool gives you the option of a quick overview of your overall SANS performance or a specific analysis by category. With expanded learning links and in-depth critique of each question, you maintain and improve your proficiency in surgical decision making. This new version of SANS Lifelong Learning also affords tracking of resident performance and downloadable, ACGME compatible reports.

Content
SANS content is updated to allow you to stay informed and up-to-date with the latest advancements in the field!

SANS Lifelong Learning is still the best tool to build your knowledge base through instant learner feedback, peer-reviewed expert critiques and web-based resources for further study. The improved features and enhanced functionality make SANS all the more valuable.