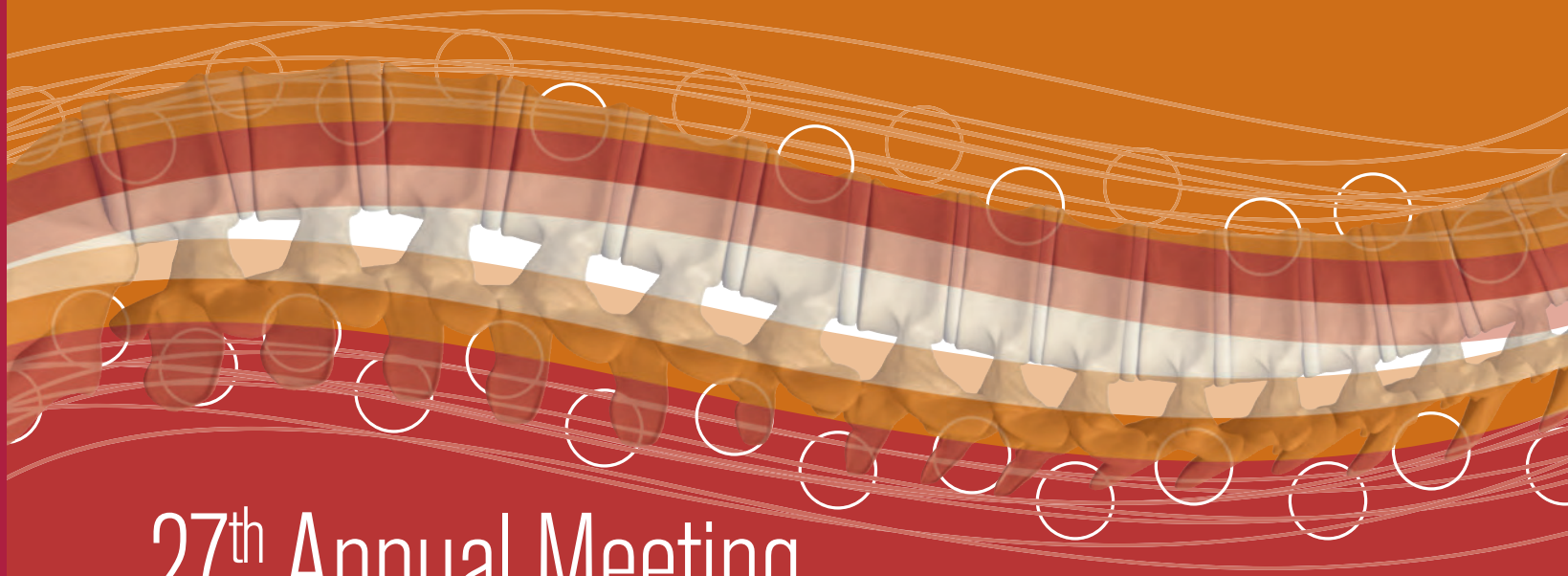
Scientific Program



27th Annual Meeting of the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves

Evidence-Based Spine Surgery in the Real World

March 9-12, 2011
JW Marriott Desert Ridge
Phoenix, Arizona

American Association of Neurological Surgeons
and the American Association of Neurosurgeons

CONGRESS OF NEUROLOGICAL SURGEONS
1951
ERUDITIO OBSERVANTIA SOCIETAS
Education and Innovation

PROGRAM AT-A-GLANCE

WEDNESDAY
MARCH 9, 2011

8:00 AM – 6:00 PM
Registration
Grand Canyon Foyer

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

1:30 – 5:30 PM
Pediatric Craniocervical Society
Desert Conference Suite III

Special Course I – Coding Update and Review
Grand Canyon 9

Special Course II – Masters in Spinal Surgery: What Has Experience Taught Me?
Grand Canyon 10

Special Course III – Spinal Deformity
Grand Canyon 11

Special Course IV – Advanced MIS Techniques/Managing MIS Complications
Desert Conference Suite IV

Special Course V – Management of Perioperative Pain
Grand Canyon 13

Special Course VI – Update on Spinal Surgery in Turkey
Grand Canyon 12

Special Course VII – Cervical Myelopathy
Desert Conference Suite VIII

6:00 – 8:00 PM
Opening Reception
Sage Court

THURSDAY
MARCH 10, 2011

6:00 AM – 6:00 PM
Registration
Grand Canyon Foyer

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

6:30 – 7:00 AM
Continental Breakfast
Grand Saguaro Foyer

6:30 – 6:55 AM
Case Presentations
Grand Saguaro North

7:00 – 9:30 AM
Scientific Session I – Evidence-Based Spine Surgery in the Real World
Grand Saguaro North

9:00 AM – 7:00 PM
Exhibit Hall Open and Poster Viewing
Grand Canyon Ballroom

9:30 – 10:15 AM
Beverage Break and *What's New* Session I
Grand Canyon Ballroom

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

12:30 – 1:25 PM
Lunch and *What's New* Session II
Grand Canyon Ballroom

1:30 – 3:00 PM
Scientific Session II – Spinal Surgery Complication Avoidance and Management
Grand Saguaro North

3:00 – 3:45 PM
Beverage Break and *What's New* Session III
Grand Canyon Ballroom

3:45 – 5:15 PM
Oral Poster Presentations I
Grand Saguaro North

Oral Poster Presentations II
Grand Canyon 9

5:15 – 6:45 PM
Reception in the Exhibit Hall
Grand Canyon Ballroom

FRIDAY
MARCH 11, 2011

6:00 AM – 5:00 PM
Registration
Grand Canyon Foyer

6:00 AM – 5:00 PM
Speaker Ready Room
Pinnacle Peak 3

6:30 – 7:00 AM
Continental Breakfast
Grand Saguaro Foyer

6:30 – 7:00 AM
Case Presentations
Grand Saguaro North

7:00 – 9:00 AM
Scientific Session III – Evolution of Treatment for Metastatic Disease
Grand Saguaro North

9:00 – 9:30 AM
Mayfield Awards and Presentations
Grand Saguaro North

9:00 AM – 12:00 Noon
Exhibit Hall Open and Poster Viewing
Grand Canyon Ballroom

9:30 – 10:15 AM
Beverage Break and *What's New* Session IV
Grand Canyon Ballroom

10:15 AM – 12:15 PM
Oral Platform Presentations II
Grand Saguaro North

12:20 – 12:30 PM
Annual Business Meeting
Grand Saguaro North

12:30 – 2:30 PM
Luncheon Symposium I – Revision Spine Surgery
Grand Canyon 9

Luncheon Symposium II – Neurosurgeon as CEO: Business Aspects of Spinal Surgery
Grand Canyon 10

Luncheon Symposium III – Cranial-Cervical Junction
Grand Canyon 11

Luncheon Symposium IV – Geriatric Spine
Grand Canyon 12

Luncheon Symposium V – Spinal Arthroplasty
Grand Canyon 13

1:30 – 5:30 PM
Special Course VIII – Peripheral Nerve Exposures and Nerve Repair Techniques
Desert Conference Suite III

Special Course IX – Evaluation and Management of the Spine Trauma Patient
Desert Conference Suite IV

SATURDAY
MARCH 12, 2011

6:00 AM – 12:30 PM
Registration
Grand Canyon Foyer

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

6:30 – 7:00 AM
Continental Breakfast
Grand Saguaro Foyer

6:30 – 6:55 AM
Case Presentations
Grand Saguaro North

6:55 – 8:15 AM
Oral Posters Presentations III
Grand Saguaro North

8:20 – 9:40 AM
David Cahill Memorial Controversies Session
Grand Saguaro North

9:00 AM – 12:00 Noon
Exhibit Hall Open and Poster Viewing
Grand Canyon Ballroom

9:40 – 10:25 AM
Beverage Break
Grand Canyon Ballroom

10:25 – 11:05 AM
Fellowship Awards and Updates
Grand Saguaro North

11:05 AM – 12:35 PM
Oral Posters Presentations IV
Grand Saguaro North

PURPOSE OF THE SPINE AND PERIPHERAL NERVES SECTION

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

PREVIOUS MEETINGS

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

YOUR OPINION COUNTS!

A link to the online evaluations will be sent to the e-mail address that you used to register for the meeting. A link to the evaluation system will also be available at www.spinesection.org.

You will be able to login with either:

1. Your last name and the e-mail address where the link was sent.
2. Your Annual Meeting badge number and your last name.

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

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

Dear Colleague:

The AANS/CNS Section on Disorders of the Spine and Peripheral Nerves welcomes you to the 2011 Annual Meeting here at the spectacular JW Marriott Desert Ridge. This year's meeting will deliver maximum educational value as we explore our timely theme, ***Evidence-Based Spine Surgery in the Real World.***

Experts from the United States and across the globe will address several critical and controversial topics within spine and peripheral nerve surgery and examine the impact of each on your practice. This year's Scientific Program Committee has created a truly outstanding program with nine Special Courses highlighting the latest techniques and strategies on many topics including MIS techniques, current issues in spine coding, and spinal deformity; five Luncheon Symposia covering critical business aspects of spinal surgery to the management of the geriatric spine; and more than 240 Oral Platform, Oral Poster and Digital Poster abstracts. Our Scientific Sessions will explore the evolution of treatment for metastatic disease, evidence-based medicine in the real world, and complication avoidance and management in spinal surgery.

Our Exhibit Hall will offer further opportunities for education with more than 60 exhibitors displaying the latest advances and technology in the field! Visit with your corporate partners during daily breaks to learn more about the products and services available to enhance and improve your practice. You won't want to miss our daily *What's New* sessions which will feature new and innovative products and/or technological services.

In addition to the outstanding education, you can also experience valuable networking events throughout the week allowing you to connect with both your colleagues and corporate contacts in a more relaxed atmosphere. Wednesday evening's Opening Reception, and Thursday afternoon's Lunch in the Exhibit Hall and Thursday evening's Reception with the Exhibitors will provide sumptuous hors d'oeuvres and beverages while you network with colleagues from around the globe. Residents will also enjoy connecting with other young neurosurgeons while viewing a special presentation by Dr. Robert F. Heary at the Young Neurosurgeons' Dinner on Friday evening.

Thank you again for joining us in Phoenix for the 2011 Annual Meeting. We hope you will take time to enjoy both the science and the scenery here at the JW Marriott Desert Ridge.

Sincerely,

Ziya L. Gokaslan, MD, FACS
Chairman

Praveen V. Mummaneni, MD
Annual Meeting Chairperson

Daryl R. Fourney, MD
Scientific Program Chairperson

2011 ANNUAL MEETING COMMITTEES

Annual Meeting Chairperson
Praveen V. Mummaneni

Scientific Program Chairperson
Daryl R. Fourney

Exhibit Chairperson
Brian R. Subach

2011 Scientific Abstract Review and Scientific Advisory Committee
Peter D. Angevine
Carlos Bagley
Ali Bydon
John Chi
Dean Chou
Sanjay S. Dhall
Daryl R. Fourney
Oren N. Gottfried
James S. Harrop
Robert F. Heary
Langston T. Holly
Patrick C. Hsieh
Adam S. Kanter
Dean Karahalios
Yevgeniy A. Khavkin
Frank La Marca
Matthew J. McGirt
Praveen V. Mummaneni
Ibrahim Omeis
Daniel M. Sciubba
Justin S. Smith
Robert J. Spinner
Michael P. Steinmetz
Eve C. Tsai
Jamie S. Ullman
Marjorie Wang
Michael Y. Wang
Timothy F. Witham
Jean-Paul Wolinsky
Lynda Jun-San Yang

2011 Poster Awards and Grading Committee
Daryl R. Fourney
Adam S. Kanter
Daniel M. Sciubba
Marjorie C. Wang

Ziya L. Gokaslan, MD, FACS

Donlin M. Long Professor
Professor of Neurosurgery, Oncology, and Orthopaedic Surgery
Vice-Chairman – Department of Neurosurgery
Director – Neurosurgical Spine Program
Johns Hopkins University School of Medicine

ZIYA L. GOKASLAN, MD, FACS, was born on April 7, 1959 in Washington, DC (USA). He later returned to Turkey with his family where he completed his medical education at the Medical Faculty of Istanbul University. In 1984, Dr. Gokaslan returned to the US and worked as the Clinical Director of Sleep Disorders Center of the Department of Psychiatry for 1½ years. He then entered General Surgery Residency under Dr. Michael E. DeBakey in 1985. After one year of internship, he joined the Department of Neurosurgery at Baylor College of Medicine as Clinical Neurotrauma Research Fellow. In 1988, he became a Neurosurgery Resident under Dr. Robert G. Grossman and completed his training in 1993 at the Baylor College of Medicine in Houston. He was then accepted into the Neurosurgery/Orthopaedic Spine Surgery Fellowship Training under Drs. Paul Cooper and Thomas Errico at the New York University Medical Center in New York. After the completion of his Fellowship Training in Spinal Surgery, Dr. Gokaslan returned to Houston and joined the Department of Neurosurgery faculty as Assistant Professor at the University of Texas, MD Anderson Cancer Center under Dr. Raymond Sawaya. This is where Dr. Gokaslan specialized in the surgical treatment of spinal neoplasms, published extensively on the topic and developed novel surgical approaches in managing these tumors.

In 2000, Dr. Gokaslan became the Director of Neurosurgical Spinal Oncology Section and, in 2002, was appointed Deputy Chairman of the Department of Neurosurgery and promoted to Associate Professor. In 2002, Dr. Gokaslan was recruited to Johns Hopkins University, Department of Neurosurgery and became the Director of the Spine Division, Vice-Chairman, and Professor of Neurosurgery, Oncology, and Orthopaedic Surgery under Dr. Henry Brem. Later that year, he was awarded the Donlin M. Long Professorship at Johns Hopkins.

Dr. Gokaslan's clinical practice focuses on the radical surgical treatment of both primary and metastatic spinal tumors, sacral neoplasms and spinal cord tumors. He developed many novel approaches for resection of pancoast tumors, spinal neoplasms, as well as sacral tumors, including total sacrectomy and complex spinal and pelvic reconstruction.

His basic research focuses on the development of new animal models to study the pathophysiology of neoplastic spinal cord compression and to define the roles of proteolytic enzymes in tumor invasion and to devise novel therapeutic approaches to spinal tumors.

He has authored over 200 peer-reviewed papers and has presented over 150 national and international lectures since 1996. He was voted one of the Best Doctors in America in 2005 and garnered *Baltimore Magazine's* Top Doctors recognition in 2007. He serves on the editorial boards of top academic journals, including *Journal of Spinal Disorders & Techniques, The Spine Journal, Journal of Neurosurgery: Spine, The European Spine Journal, Nature Reviews in Neurology, Journal of Surgical Oncology,* and *World Neurosurgery.* He is currently the Chairperson of the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves.

He is a member of numerous prestigious societies, notably the Society of Neurological Surgeons since 2007, Cervical Spine Research Society since 2003, American Society of Clinical Oncology since 2001, American Association of Neurological Surgeons since 1998, Congress of Neurological Surgeons since 1997, and the North American Spine Society since 1994.

PRESIDENTIAL ADDRESS

Evolution of Surgical Treatment

THURSDAY, MARCH 10, 8:50 AM
GRAND SAGUARO NORTH

Paul R. Cooper, MD

2011 Meritorious Service Award Recipient

PAUL R. COOPER, MD, received his BA from Columbia in 1962, completed his MD degree at the University of Virginia in 1966 followed by an internship and a year of residency in general surgery at the University Hospitals of Cleveland. He subsequently served as a Medical Officer in the United States Navy aboard the USS Wright and at the Naval Air Station in Norfolk, Virginia. Following military service he completed a residency in neurosurgery at The New York University Medical Center in 1975.

He began his academic career as Assistant Professor in the Division of Neurosurgery, University of Texas – Southwestern Medical School and was subsequently appointed Associate Professor in the Department of Neurosurgery, State University of New York – Downstate Medical Center. He returned to New York University Medical Center in 1981 as Associate Professor of Neurosurgery and Director of the Neurosurgery Spine Fellowship Program. He was subsequently named the Attilio & Olympia Ricciardi Professor of Neurosurgery at New York University School of Medicine, and Professor of Orthopedic Surgery, positions he held through 2007. As director of the spine fellowship program, the highlight of his academic career was training over fifteen superb spine surgeons, many of whom are attending this meeting.

Dr. Cooper was active in both international and local societies, including the Academy of Neurological Surgeons, Society of Neurological Surgeons, Congress of Neurological Surgeons, the American Association of Neurological Surgeons and the Société de Neurochirurgie de Langue Française. He served as President of the Cervical Spine Research Society from 2002 to 2003. Dr. Cooper has held editorial positions for *NEUROSURGERY*® and *Spine*, and has served as an ad hoc reviewer for the *New England Journal of Medicine*.

In addition to his academic and clinical responsibilities, Dr. Cooper has written over 140 articles and book chapters. He has edited a number of books on head injury, the management of post-traumatic spinal instability, contemporary diagnosis and management of pituitary adenomas, and degenerative disease of the cervical spine. In 1996, he co-authored *The Practice of Neurosurgery* with Drs. George Tindall and Daniel Barrow.

Since retiring from active practice in 2007 he has been able to spend more time with his family, including two daughters and two grandchildren. He took the intensive course in cuisine for culinary professionals at the Cordon Bleu in Paris which sharpened his cooking skills, and spends an hour a day practicing the piano. At his country home in rural Massachusetts he tends a large organic garden, and raises sheep and chickens. He has been able to exercise a long passion for squash and bicycling. Weather permitting, he hikes and skis on the trails adjacent to his home. When the sun goes down, he is not averse to pulling the cork on a bottle from his extensive wine cellar.

Meritorious Service Award Recipients 1990 – 2010

2010	Regis W. Haid, Jr.
2009	Paul C. McCormick
2008	Ronald I. Apfelbaum
2007	David L. Kelly, Jr.
2006	John A. Jane, Sr.
2005	Ulrich Batzdorf
2004	Russell W. Hardy, Jr.
2003	Edward C. Benzel
2002	No Award Presented
2001	Stewart B. Dunsker
2000	Arnold H. Menezes
1999	Volker K. H. Sonntag
1998	Russell L. Travis
1997	David G. Kline
1996	No Award Presented
1995	No Award Presented
1994	Sanford J. Larson
1993	Joseph A. Epstein
1992	Charles A. Fager
1991	Frank H. Mayfield
1990	Ralph B. Cloward

Awards

On pages 5-9 general information regarding section sponsored research and fellowship awards is listed. For more information, visit the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves web site at: www.spinesection.org

Research Funding

The AANS/CNS Section on Disorders of the Spine and Peripheral Nerves has established three Research Grants. Depending upon the quality of the award submissions, there may be one award in each category annually.

RONALD I. APFELBAUM RESEARCH AWARD

Past Ronald I. Apfelbaum Research Award Recipient:
2010 – John H. Shin, MD

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.

ZACHARY ADAM SMITH, MD

Zachary A. Smith, MD, completed his undergraduate degree as a Presidential Scholar from Dartmouth College and received his medical degree from the UCLA School of Medicine. In 2010, he completed neurosurgical training at UCLA. During his neurosurgical training, he developed a specific interest in minimally invasive surgical techniques in the spine while working under the mentorship of Dr. Larry T. Khoo. As a recipient of the Apfelbaum Award, he will work under the guidance of Dr. Richard G. Fessler at Northwestern during his one-year clinical fellowship. His research award will support a biomechanical study titled, "Biomechanical Comparison of Minimally Invasive Spinal Decompression vs. Open Lumbar Laminectomy."

DAVID KLINE RESEARCH AWARD

Past David Kline Research Award Recipient:
2010 – Gerald Tuite, MD

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

JACOB D. ALANT, MBCHB, MMED, FRCS(C)

Jacob D. Alant, MBChB, Mmed, FRCS(C), received his medical degree in 1997 and completed his neurosurgical residency in 2006 at the University of Pretoria in South Africa. He completed a Peripheral Nerve Surgery Fellowship with Dr. Rajiv Midha in Calgary, Canada from 2008-2009 and earned his FRCS(C) in 2009. From 2009-2010, he completed a Combined Spine Surgery Fellowship in Calgary.

Dr. Alant is currently working on his Masters of Science in Neurosciences at the University of Calgary and is working to further characterize and validate their novel experimental traumatic neuroma-in-continuity injury model.

SANFORD LARSON RESEARCH AWARD

Past Sanford Larson Research Award Recipient:
2010 – Matthew J. McGirt, MD

The Larson Award, sponsored by DePuy Spine, is limited to clinical research with funding up to $30,000. This research award is intended to establish funding for clinically relevant research related to the spine and peripheral nerves, and to provide a means of peer review for clinical research projects to help improve the quality of the proposal and therefore, enhance competitiveness for National Institutes of Health (NIH) funding. The award is also meant to create an annual funding mechanism to establish the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves as a known source for quality clinical research aimed at answering questions pertaining to the treatment of disorders of the spine and peripheral nerves.

ERICA F. BISSON, MD

Erica F. Bisson, MD, completed her neurosurgical training at the University of Vermont and is a graduate of the Tufts University School of Medicine. Additionally, she completed a fellowship in spine surgery at the University of Utah under the guidance of Dr. Ronald Apfelbaum. She joined the Department of Neurosurgery at the University of Utah in 2009, specializing in complex spine surgery with a clinical and academic emphasis on occipitocervical disease.

Prior to returning to Utah, Dr. Bisson was Senior Staff in the Department of Neurosurgery at the Lahey Clinic and Department of Surgery at Emerson Hospital. Currently, she is the principal investigator on a multicenter trial evaluating surgical approach in cervical spondylotic myelopathy.

CAHILL FELLOWSHIP

Past Cahill Fellowship Recipient:
2010 – Chandan G. Reddy, MD

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

TIMOTHY DAVID USCHOLD, MD

Timothy David Uschold, MD, is a PGY-5 senior resident at the Barrow Neurological Institute in Phoenix, Arizona. He graduated summa cum laude from Cornell University with an undergraduate degree in biology (concentrating in neurobiology and behavior) in 2002. He obtained his MD from Duke University School of Medicine in 2006. Dr. Uschold's clinical and research interests include occipital-cervical junction injuries, spinal deformity, spinal trauma, minimally invasive techniques, and decision-making in spinal surgery. Under the auspices of the Cahill Fellowship, he will pursue additional clinical training at Frenchay Hospital in Bristol, UK with Mr. Nitin Patel. He plans to integrate his current work at the BNI with a larger multicenter evaluation of anterior vs. posterior cervical approaches. He additionally aims to explore the socioeconomic factors affecting spine care in two different health systems.

CLOWARD FELLOWSHIP

Past Cloward Fellowship Recipient:
2010 – Helene T. Khuong, MD

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

MICHAEL J. DORSI, MD

Michael J. Dorsi, MD, completed his medical degree at Johns Hopkins School of Medicine in Baltimore and will graduate from its neurosurgery program in 2011. Over the past two years he completed a research fellowship at UCLA sponsored by the California Institute for Regenerative Medicine studying intraspinal stem cell transplantation following ventral root avulsion. He will join Dr. Langston Holly for a twelve-month spine surgery fellowship at UCLA. The Cloward Fellowship will support his research work on animal models of cervical myelopathy. Dr. Dorsi plans to establish a future practice focused on complex peripheral nerve and minimally invasive spine surgery.

SONNTAG INTERNATIONAL FELLOWSHIP

Past Sonntag International Fellowship Recipient:
2010 – Payman Vahedi, MD

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.

GURPREET SINGH GANDHOKE, MD

Gurpreet Singh Gandhoke, MD, completed his medical school training at the Pune University in India and completed a three year residency training in general surgery from the Byramjee Jeejeebhoy Medical College. He then went on to complete his neurosurgery residency training at the King George's Medical University in India where he won the gold medal for being the best outgoing student during both his residency training programs. While still in training, Dr. Gandhoke published 11 scientific papers – one, published in the British Journal of Neurosurgery, describes a new technique to treat long segment spinal extradural arachnoid cysts in the pediatric population.

Dr. Gandhoke is currently a research fellow with Dr. Peter Nakaji at the Barrow Neurological Institute in Phoenix, Arizona, and is contributing to two neurosurgical atlases, book chapters and research papers. Dr. Gandhoke is now looking forward to expand his skills in treating spinal disorders by pursuing an observership with Dr. Praveen V. Mummaneni at the University of California, San Francisco.

During his free time, Dr. Gandhoke enjoys playing the guitar.

2011 OUTCOMES COMMITTEE AWARD

Past Outcomes Committee Award Recipient:
2010 – Daniel C. Lu, MD

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

CHEERAG D. UPADHYAYA, MD, MS

Cheerag D. Upadhyaya, MD, MS, graduated from the neurosurgery residency at University of Michigan. Dr. Upadhyaya received his BS degree from Emory University and his MD from the University of Florida College of Medicine. He completed a fellowship with Dr. Praveen V. Mummaneni at the University of California San Francisco.

Friday, March 11, 9:20 – 9:28 AM
Analysis of the Three United States FDA-IDE Cervical Arthroplasty Trials
Cheerag Upadhyaya, Jau-Ching Wu, Regis W. Haid, Jr., Vincent C. Traynelis, Bobby Tay, Domagoj Coric, Gregory R. Trost, Scott A. Meyer, Praveen V. Mummaneni

MAYFIELD 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 the outstanding manuscripts detailing a laboratory or clinical investigation in the area of spinal or peripheral nerve disorders. This award is also applicable to individuals in DO training programs. The manuscript for this award is presented by attaching related information to their abstract during the abstract submission process. Two awards are available, one for clinical research and one for basic science research. Each recipient will receive a $1,000 cash award and an honorarium up to $2,000 to cover the expenses of attendance at the Annual Meeting of the AANS/CNS Section on Disorders of the Spine and Peripheral Nerves. Abstracts to be considered for the Mayfield Award should be identified as such on the Annual Meeting abstract submission form and submitted prior to deadline.

Mayfield Award Recipients 1984 - 2010

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

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

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

2007 Basic Science: *Sharad Rajpal*
Clinical Science: *Florian Roser*

2006 Basic Science: *Toshitaka Seki*
Clinical Science: *Benson Yang*

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

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

2003 No Awards Presented

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

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

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

1999 Basic Science: *Steven Casha*
Clinical Science: *Nicholas Theodore*

1998 *Tord D. Alden*

1997 *Michael A. Morone*

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

1995 *Simcha J. Weller*

1994 *Timothy C. Ryken*

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

1992 *Rajiv Midha*

1991 *Peter G. Gianaris*

1990 *R. John Hurlbert*

1989 *Richard K. Simpson, Jr.*

1988 No Award Presented

1987 *John A. Feldenzer*

1986 No Award Presented

1985 *Abhijit Guha*

1984 *Mark N. Hadley*

2011 MAYFIELD BASIC SCIENCE AWARD

MOHAMMED F. SHAMJI, MD

Mohammed F. Shamji, MD, is the chief resident of neurosurgery at The Ottawa Hospital in Ottawa, Canada. Dr. Shamji completed combined BS/MS degrees in chemistry at Yale University, his MD training at Queen's University, and is finishing his neurosurgical residency at The Ottawa Hospital. Mid-residency, he completed PhD training in Biomedical Engineering at Duke University with projects focusing on animal models of inflammatory radiculopathy and sustained-release drug delivery. He is husband to his devoted wife, father to two lovely daughters, and spends his spare time feeding his endurance running habit. His academic interests include spine surgery and pathomechanisms of low back pain with career aspirations of evolving into a surgeon-scientist.

Friday, March 11, 9:00 – 9:08 AM

Evidence of Descending Supraspinal Control of Nociception and Pain Behavior in Experimental Disc-Herniation Radiculopathy

Mohammed F. Shamji, Priscilla Hwang, Kyle D Allen, Mosfata Gabr, J. Chen, Liufang Jing, William J. Richardson, Lori A. Setton

2011 MAYFIELD CLINICAL SCIENCE AWARD

TYLER J. KENNING, MD

Tyler J. Kenning, MD, is currently a sixth-year neurosurgery resident at Albany Medical Center. After completing his undergraduate degree in biology from Washington and Lee University, Dr. Kenning attended Jefferson Medical College. During residency, he conducted stem cell research for spinal cord injury in conjunction with Sally Temple, PhD, of the New York Neural Stem Cell Institute. In addition to the Mayfield Clinical Science Award, he was recently the recipient of the 2010 CNS/Karl Storz Endoscopy Fellowship. Upon completion of his residency, he will be conducting a fellowship in endoscopic skull base surgery with Dr. James Evans at Thomas Jefferson University Hospital.

Friday, March 11, 9:10 – 9:18 AM

Perioperative Use of Dexamethasone in Multilevel Anterior Cervical Spine Surgery: Preliminary Results of a Prospective, Randomized, Double-Blinded Trial

Tyler J. Kenning, Karen Petronis, John W. German, Doniel Drazin, Darryl J. Dirisio

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The Speaker Ready Room, located in Pinnacle Peak 3, will be available:

Wednesday, March 9	8:00 AM - 6:00 PM
Thursday, March 10	6:00 AM - 6:00 PM
Friday, March 11	6:00 AM - 5:00 PM
Saturday, March 12	6:00 AM - 12:30 PM

All speakers and abstract presenters should visit the Speaker Ready Room prior to their presentation. All Scientific Session Faculty are required to check in at the Speaker Ready Room 24 hours ahead of your presentation.

Exhibit Hall Hours:

The Exhibit Hall is located in the Grand Canyon Ballroom.

Thursday:	9:00 AM - 7:00 PM
Friday:	9:00 AM - 12:00 PM
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Registration Hours:

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Edward J. Gerber
Ownership Interest: NuVasive

Ziya L. Gokaslan
Other Financial or Material Support: NREF; Integra; DePuy; Medtronic; AO North America
Ownership Interest: Spinal Kinetics; U.S. Spine

J. Allan Goodrich
Consulting Agreement: NuVasive

Arnold Graham-Smith
Consulting Agreement: SI-Bone, Inc.

Michael W. Groff
Consulting Agreement: EBI Spine Biomet
Royalty: DePuy Spine

Richard D. Guyer
Consulting Agreement: Spinal Motion

Regis W. Haid
Consulting Agreement: Globus Medical; Piedmont Health Care
Other Financial or Material Support: Globus Medical; Medtronic; NuVasive
Ownership Interest: Spine Universe
Royalty: Medtronic

John Jay Halki
Consulting Agreement: SI-Bone, Inc.

Arik Hanannel
Salary: InSightec

J. Frederick Harrington
Consulting Agreement: Zimmer Spine

James S. Harrop
Consulting Agreement: DePuy Spine; Ethicon; Neural Stem
Other Financial or Material Support: Geron; Ascubio; Axiomed

David J. Hart
Consulting Agreement: Aesculap Spine; Integra; Depuy Spine; TranS1

Charles A. Hartjen
Consulting Agreement: Facet Solutions; Medtronic
Intellectual Fees: Facet Solutions
Ownership Interest: K2M

Roger Hartl
Other Financial or Material Support: Apatech; Spine Wave; Brainlab; Synthes

Robert F. Heary
Other Financial or Material Support: DePuy Spine; Biomet Spine
Royalty: Depuy Spine; Thieme Medical Publishers; Zimmer Spine

John G. Heller
Consulting Agreement: Medtronic

Jason M. Highsmith
Consulting Agreement: Boston Scientific

Patrick W. Hitchon
Other Financial or Material Support: DePuy Spine

Langston T. Holly
Consulting Agreement: Medtronic

John K. Houten
Honoraria: Medtronic
Other Financial or Material Support: Stryker Spine

Patrick C. Hsieh
Consulting Agreement: Medtronic; DePuy Spine

Jonathan Hyde
Consulting Agreement: NuVasive

Cary Idler
Consulting Agreement: NuVasive

Robert E. Isaacs
Consulting Agreement: NuVasive

R. Patrick Jacob
Consulting Agreement: Synthes Spine

George I. Jallo
Consulting Agreement: Codman; Medtronic

Michael Janssen
Other Financial or Material Support: AOSNA

J. Patrick Johnson
Consulting Agreement: Alphatec; Pioneer Medical; SpineWave; Johnson & Johnson; Biomet; DePuy; FlexUspine
Stockholder: Alphatec; Pioneer Medical; FlexUspine; SpineWave

Terrence D. Julien
Consulting Agreement: Orthovita; Globus Medical; Trinity Orthopedics; Stryker Spine
Honoraria: Medtronic
Stockholder: Orthovita

Iain H. Kalfas
Royalty: Mako

Adam S. Kanter
Consulting Agreement: Lanx, NuVasive

Dean Karahalios
Consulting Agreement: Anulax, Lanx, Medtronic
Ownership Interest: Lanx
Royalty: Medtronic; Anulax; Lanx

Hans S. Keirstead
Ownership Interest: California Stem Cell

Larry T. Khoo
Consulting Agreement: DePuy Spine; Globus Medical; TranS1; Zimmer Spine

Kee Duk Kim
Consulting Agreement: Covidien

Branko Kopjar
Consulting Agreement: Vertiflex; SpineMark; Scient'X; Lanx, Inc.; Johnson & Johnson; Cerepedics, Inc.

Tyler R. Koski
Consulting Agreement: Medtronic
Honoraria: DePuy; Stryker

Ryan M. Kretzer
Consulting Agreement: Chestnut Medical; eV3

Charles Kuntz, IV
Consulting Agreement: Synthes
Grants: Synthes; Stryker; AOSpine
Ownership Interest: Mayfield Clinic; Precision Radiotherapy; Priority Consult; CKIV Alignment; The Christ Hospital Spine Surgery Center
Other Financial or Material Support: AOSpine; Synthes; Stryker

Frank La Marca
Consulting Agreement: Biomet; Globus; DePuy; Medtronic

Lawrence Lenke
Other Financial or Material Support: DePuy Spine
Royalty: Quality Medical Publishing; Medtronic

Kyle Malone
Salary: NuVasive

Mark R. McLaughlin
Consulting Agreement: Spine Wave;
Ownership Interest: Spine Wave

Ehud Mendel
Honoraria: Stryker Spine; Baxter; Synthes

Rajiv Midha
Other Financial or Material Support: CIHR

Charles Joseph Miller
Consulting Agreement: Medical Designs, LLC

Praveen V. Mummaneni
Consulting Agreement: DePuy Spine; Medtronic
Ownership Interest: 2N LLC

Rania Nasis
Salary: California Stem Cell

Ewell Lee Nelson
Consulting Agreement: Medtronic

Pierce D. Nunley
Consulting Agreement: Spinal Motion

David O. Okonkwo
Consulting Agreement: Lanx; Synthes
Honoraria: Medtronic

Brian A. O'Shaughnessy
Consulting Agreement: DePuy

Paul Park
Consulting Agreement: DePuy Spine
Grants: Orthofix

Naresh P. Patel
Consulting Agreement: Orthofix; Medtronic; Stryker Spine

Mick J. Perez-Cruet
Consulting Agreement: Aesculap; Stryker; Zimmer Spine
Ownership Interest: Thompson MIS; MI4 Spine

Kenneth Pettine
Royalty: Medtronic

Frank M. Phillips
Consulting Agreement: NuVasive, Inc.
Royalty: NuVasive, Inc.

Eric A. Potts
Consulting Agreement: Lanx; Medtronic
Ownership Interest: Lanx
Royalty: Medtronic

Srinivas K. Prasad
Honoraria: Stryker Spine

Christopher D. Pritchard
Board Trustee or Officer Position: InVivo Therapeutics

Alfredo Quinones-Hinojosa
Other Financial or Material Support: Leica; Stryker; Porex; Eisai; Vycor

Kevin A. Rahn
Consulting Agreement: NuVasive
Ownership Interest: Titan Spine

John Rasmussen
Salary: AnyBody Technology

W. Carlton Reckling
Consulting Agreement: SI-Bone, Inc.

John J. Regan
Consulting Agreement: Facet Solutions
Intellectual Fees: Integra Life Sciences
Ownership Interest: Pioneer Surgical

Mark Reiley
Ownership Interest: SI-Bone, Inc.
Stockholder: SI-Bone, Inc.

Francis M. Reynolds
Ownership Interest: InVivo Therapeutics

Laurence D. Rhines
Honoraria: Medtronic; Biomet

Lee H. Riley
Other Financial or Material Support: Lifenet Health; CSRS

Bruce Robie
Ownership Interest: ARO Medical, LLC

Jody A. Rodgers
Ownership Interest: NuVasive

W.B. Rodgers
Consulting Agreement: TranS1; NuVasive; Exactech
Ownership Interest: NuVasive
Royalty: NuVasive

Gerald E. Rodts, Jr.
Consulting Agreement: Globus Medical, Inc.; Orthofix, Inc.
Other Financial or Material Support: SpineUniverse.com
Royalty: Globus Medical, Inc.

Leonard M. Rudolf
Ownership Interest: SI-Bone, Inc.

Timothy C. Ryken
Consulting Agreement: Medtronic Inc; Merck Inc / Schering-Plough Inc; Eisai

Amer F. Samdani
Consulting Agreement: DePuy Spine; SpineVision; Synthes Spine

Rick Sasso
Other Financial or Material Support: Cerapedics
Royalty: Medtronic

Christopher I. Shaffrey
Consulting Agreement: Biomet Spine; DePuy; Medtronic
Grants: AO; Department of Defense; National Institutes of Health; NACTN
Other Financial or Material Support: Medtronic

Mark Edwin Shaffrey
Other Financial or Material Support: DePuy Spine

A. Nick Shamie
Consulting Agreement: SI-Bone, Inc.

Ashwini Dayal Sharan
Consulting Agreement: NLT; St. Jude; Medtronic
Honoraria: Integra
Ownership Interest: ICVRX; Intellect
Royalty: Zimmer

Lilach Shay
Salary: Shira Nehemia Bio-Medical Engineering

Jonathan D. Sherman
Consulting Agreement: DePuy; Medtronic

Jonathan R. Slotkin
Consulting Agreement: Stryker Spine; InVivo Therapeutics, Inc.
Honoraria: Synthes Spine

Justin S. Smith
Consulting Agreement: Axial Biotech; Biomet; Medtronic
Honoraria: Biomet; DePuy
Other Financial or Material Support: DePuy; Medtronic

Solas Degenerative Study Group
Consulting Agreement: NuVasive
Other Financial or Material Support: NuVasive

Matthew Songer
Ownership Interest: Pioneer Surgical

Volker K. H. Sonntag
Royalty: Medtronic

Leo R. Spector
Intellectual Fees: Synthes

John G. Stark
Consulting Agreement: Signus Medical
Ownership Interest: Ilion Medical

Michael P. Steinmetz
Consulting Agreement: Biomet Spine

William R. Taylor
Intellectual Fees: NuVasive

John M. Tew
Consulting Agreement: KLS Martin; Cosman Medical

Antoine Tohmeh
Consulting Agreement: NuVasive

Soren Torholm
Salary: AnyBody Technology

Jeffrey M. Toth
Consulting Agreement: Medtronic
Other Financial or Material Support: Lanx, Inc.; Osteotech, Inc.; Medtronic

Vincent C. Traynelis
Consulting Agreement: United HealthCare; Medtronic
Royalty: Medtronic

Gregory R. Trost
Honoraria: Medtronic

Eve C. Tsai
Other Financial or Material Support: Brainlab; Stryker Spine; Synthes

Joseph Turner
Consulting Agreement: Medtronic

Jamie Sue Ullman
Consulting Agreement: Oxygen Biotherapeutics
Honoraria: Brain Trauma Foundation

Juan S. Uribe
Consulting Agreement: NuVasive; Medtronic; Orthofix

Antonio Valdevit
Consulting Agreement: Medtronic

Brent Vanconia
Salary: St. Mary's Health Center

Melvin Wahl
Consulting Agreement: NuVasive

Jeffrey Wang
Royalty: Zimmer; Seaspine; Biomet; Stryker; Osprey; Aesculap; Amedica; Medtronic; Alphatech

Marjorie C. Wang
Salary: Robert Wood Johnson Physician Faculty Scholars Program

Michael Y. Wang
Consulting Agreement: Aesculap Spine; Biomet; DePuy Spine
Ownership Interest: NeuroConsulting, LLC; NeuroConsulting Specialists, LLC

William Charles Welch
Board Trustee or Officer Position: Pittsburgh Standard Spine
Consulting Agreement: Zimmer Spine
Grants: Synthes Spine
Other Financial or Material Support: Lanx, Inc.

Bryan J. Wellman
Consulting Agreement: Medical Designs, LLC

Donald M. Whiting
Consulting Agreement: Medtronic; Alphatec Spine
Ownership Interest: Applied Science Technologies

Beth A. Winkelstein
Other Financial or Material Support: Synthes

Eric J. Woodard
Ownership Interest: InVivo Therapeutics Corporation
Royalty: Stryker Spine
Honoraria: DePuy Spine

Lynda Jun-San Yang
Other Financial or Material Support: Sparton Corp.

Sangwook Yoon
Other Financial or Material Support: Biomet; Phygen; OMEGA; AOSNA; OREF
Royalty: Stryker; Nexgen

Jim A. Youssef
Consulting Agreement: Aesculap/B. Braun; DePuy; NuVasive; SeaSpine
Other Financial or Material Support: DePuy; Stryker; NuVasive; Stryker Biotech; BioSurface Engineering Technologies; Facet Solutions; Advanced Technologies in Regenerative Medicine; Axial Biotech
Ownership Interest: Amedica
Royalty: Osprey; Aesculap/B. Braun; DePuy; NuVasive; Seaspine

As of February 11, 2011

NOTHING TO DISCLOSE

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

Oran Aaronson
Tuychiboy Abdullaev
Amir Abtahi
Frank L. Acosta
Owoicho Adogwa
Basheal M. Agrawal
Antonio Aguilera
Henry Ahn
George Al Shamy
Dunbar S. Alcindor
Ronald Alkalay
Fahad A. Alkherayf
Kyle D. Allen
Anubhav Amin
Neel Anand
Vijay K. Anand
Aditya Ancha
Bill Anderson
Daniel G. Anderson
Karen K. Anderson
Richard C. E. Anderson
Peter D. Angevine
Rein Anton
Colette Ap Rhys
Kristen Archer-Swygert
Vincent Arlet
Iñaki Arrotegui
Dimitrios Arvanitakis
Basar Atalay
Ola Awad
Yunus Aydin
Ali A. Baaj
Jason Babuska
Bradley T. Bagan
Carlos A. Bagley
Mirza N. Baig
Robert J. Banco
Marco Barbero
Michal Barna
Daniel L. Barrow
Jack Barrow
Benjamin Baskin
Tracey Bastrom
Ulrich Batzdorf
Joel A. Bauman
Nrupen Baxi
Yasar Bayri
Robert Bazzano
Andrew Becker
Deniz Belen
Thomas W. Belknap
Allan J. Belzberg
Randal Betz
Karin S. Bierbrauer
Barry D. Birch
Allen T. Bishop
Erica Bisson
Bennett Blumenkopf
Margaret Boltes
Stefano Boriani
Orland K. Boucher
Hakan Bozkus
Thomas B. Briggs
Douglas L. Brockmeyer
Darrel S. Brodke
Nathaniel P. Brooks
Justin M. Brown
Kelli Bunton
James Burgess
Clinton Judson Burkett
Sigita Burneikiene
Mohamad Bydon
Sedat Cagli
Patrick Cahill
Blair Calancie
Eliezer Calo
Philippe Campeaux
Hakan H. Caner
Arturo Cardenas-Blanco
Cameron Carmody
Frances A. Carr
Israel Caspi
Halit Çavusoglu
Suleyman Cayli
Wade Ceola
Kaisorn L. Chaichana
Chen-Kuei Chang
Christopher Chaput
Budong Chen
J. Chen
Chun-Yu Cheng
Henrich Cheng
Daniel R. Chernavvsky
Brandon G. Chew
Wen-Ta Chiu
Kyoung Suok Cho

Haroon F. Choudhri
Tanvir Choudhri
Don Chow
Finn Christensen
Susan Christopher
Chu-Hsiang Chu
Megan Clark
Michelle J. Clarke
Brenton R. Coger
Anthony G. Conte
Daniel Cook
David M. Cook
David Cooley
Paul R. Cooper
Chase Corn
Garth Rees Cosgrove
Jean-Valery Coumans
Daniel Edward Couture
Catharine Craven
Colin Crosby
Bryan W. Cunningham
Jill Curran
Bradford Curt
David Del Curto
Ergun Daglioglu
Elias Dakwar
Ali Dalgic
Colin Dalton
Margot Damaser
David J. Daniels
Maureen A. Darwal
Hormuzdiyar H. Dasenbrock
Aileen Davis
Brandon J. Davis
Raphael P. Davis
Antonella De Carlo
Enrico De Micheli
Kevin J. DeLuzio
Stacie DeMent
Gulden Demirci
Clint Devin
Clinton J. Devin
Sundeep Dhaliwal
Sanjay S. Dhall
Roberto Jose Diaz
Marine Dididze
Thomas Dimmig
Darryl J. Dirisio
Denizhan Divanlioglu
Michael J. Dorsi
Eric J. Dozois
Doniel Drazin
Brian Drew
Jack H. Dunn
Brett C. Ebeling
Paul K. Edwards
Kelly Egan
Kurt M. Eichholz
Gregg Elbert
Enayatkhater Omar Elkelany
Eric H. Elowitz
Luella Engelhart
Jack Engsberg
Sang Soo Eun
Jesse Even
J. E. Evin
Anthony P. Fabrizi
Asdrubal Falavigna
Igor Faquini
Chad W. Farley
Daniel Robert Fassett
Nathan Faulkner
Li-Yu Fay
John F. Ferguson
Joel Finkelstein
Michael A. Finn
Charles Fisher
Phyllis Flomenberg
Matthew Foote
Michael Ford
Daryl R. Fourney
John France
Colin Franz
Juliano Fratezi
Allan H. Friedman
Kai-Ming G. Fu
Erin Fulchiero
Mosfata Gabr
Robert M. Galler
Laura Ganau
Mario Ganau
Sarah T. Garber
Mark P. Garrett
Angelina N. Garvin
Christian Geannette
Harry H. Gebhard
Zachariah Maliakal George
John W. German
Massimo Gerosa
Zoher Ghogawala
Samer Ghostine
Caterina Giannini
Federico Girardi
Dave Gladowski
Wayne Gluf
Shankar Prakash Gopinath
Charley Gordon
Tessa Gordon
Oded Goren
Cristian Gragnianiello
R. Scott Graham
Richard Gray
Mark Greenberg
Joey Kevin Grochmal
Marshall L. Grode
Jonathan A. Grossberg
Benjamin B. Guarino
Barton L. Guthrie
Sergio Gutiérrez
Robert J. Hacker
Mark N. Hadley
Ryan J. Halpin
D. Kojo Hamilton
Shannon Hann
Carolyn Hardin
Ran Harel
Sagi Harnof
Kyle M. Healy
Marie-Noelle Hebert-Blouin
Samantha Hemingway
Theresa Hernandez
Shawn Hervey-Jumper
Girish K. Hiremath
Robert A. Hirschl
Joseph Kyle Hobbs
Christoph Hofstetter
Daniel J. Hoh
Jeffrey R. Holtz
Brian James Hood
Wesley Hsu
Nianbin Hu
Wen-Cheng Huang
Pil Woo Huh
Craig S. Humphreys
R. John Hurlbert
Priscilla Hwang
Roy Hwang
Steven Wei-Hung Hwang
Allison Hyngstrom
Christopher A. Iannotti
Chris Idemmili
Yael Inbar
Line Jacques
William E. Janes
Nicolas V. Jaumard
Mohammed Ali Jazayeri
Mithulan Jegapragasan
Arthur L. Jenkins
Diana Jho
Hai-Hong Jiang
Ismael Jimenez-Estrada
Liufang Jing
Michael Jirgis
Michael Jirjis
Garth Johnson
Lakesha Johnson
Clinton Jung
Okan Kahyaoglu
Michael G. Kaiser
Udaya K. Kakarla
Frank Kandziora
Takahisa Kaneko
Tuncay Kaner
Erkan Kaptanoglu
Chris S. Karas
Isaac Karikari
Alina Karpova
Manish K. Kasliwal
Bettina Keller
Elizabeth Kenney
Tyler J. Kenning
Safdar Khan
Yevgeniy Anatoliy Khavkin
Cumhur Kilincer
Insoo Kim
Jin-Sung Kim
Terrence T. Kim
Zdenek Klezl
John J. Knightly
Kemal Koc
Ricardo Jorge Komotar
Deniz Konya
Andreas Korge
Murat Korkmaz
Thomas Kosztowski
Kadir Kotil
Izabela Kowalczyk
Izumi Koyanagi
William E. Krauss
Ajit A. Krishnaney
Jan Kryl
Abhaya Vivek Kulkarni
David Kung
Shekar N. Kurpad
Sun Kwon
John J. Labiak
Fred Chiu-lai Lam
Robert Langer
Sophia Lang-Perez
Darryl Lau
Ilya Laufer
Bruno C.R. Lazaro
Tien V. Le
Richard L. Lebow
Darko Ledic
Brendan Lee
Ho-Yeon Lee
JY Lee
Ming-Hsueh Lee
Sang Bok Lee
Sang-Ho Lee
Tae Gyu Lee
Michael Lemole
Daniel Leonard
Jason Lerner
Jim Lesko
Allan D. Levi
Khai Lham
Chien-Min Lin
Chun-Hsien Lin
Mao-Tsun Lin
Martin Lin
David Loeb
Baron Lonner
David C. LoPresti
Daniel C. Lu
John Lucio
Neal Luther
Mark K. Lyons
Samuel J. Mackenzie

Marcella Madera
Raffaella Maina
Mitchell Gil Maltenfort
Jacinto Manon
Frances Mao
Petra Margetic
Michelle Marks
Robert A. Marsh
Jonathan Martin
Joseph J. Marzluff
Alexander Mason
Eric M. Massicotte
Paul C. McAfee
Edward McCarthy
Jamal McClendon
Paul C. McCormick
Kirk McCullough
Matthew McGirt
Ankit Indravadan Mehta
Gregory A. Mencio
Arnold H. Menezes
Scott A. Meyer
James Mills
Agrawal Basheal Mohan
Ahmed Mohyeldin
Bahram Mokri
Camilo A. Molina
Chad J. Morgan
Thomas Mroz
Ryan D. Muchow
Debraj Mukherjee
Tomohiro Murakami
Daniel B. Murrey
Ahmet Murat Müslüman
S. Terence Myles
Osman Nacar
Sait Naderi
Robert Partlow Naftel
Rani Nasser
Petr Nesnidal
Benjamin Newman
Peter Newton
Shahid Mehdi Nimjee
Ko-Chi Niu
Eric W. Nottmeier
Miriam Nuno
Donna D. Ohnmeiss
Onder Okay
Tunc Oktenoglu
Shaun T. O'Leary
Stephen L. Ondra
Joseph O'Neil
Kevin O'Neill
Timothy M. O'Shea
Lauren Rose Ostling
Adetokunbo A. Oyelese
Cagatay Ozdol
Memet Ozek
Ali Fahir Ozer
Fahir Ozer
Selcuk Omer Palaoglu
Hung-Chuan Pan
Guergana Panayotova
Chun Kun Park
Jon Park
Scott L. Parker
Scott Parker
Robert S. Pashman
Alexandra Paul
Ramiro Perez de la Torre
Karen Petronis
David B. Pettigrew
Mark A. Pichelmann
Maurizio Pintucci
Ersin Polat
Glen Pollock
David W. Polly
Ryan Ponton
Randall W. Porter
Joshua E. Preiss
Ross Puffer
Sharad Rajpal
Edwin Ramos
Shilpa Rao
Daniel M. S. Raper
Davis Reames
Pablo F. Recinos
Violette Renard Recinos
Rajesh Reddy
Alexa Lynne Reeves
Adam S. Reig
Daniel K. Resnick
William J. Richardson
Orlando Righesso
Eva Ritzl
Dennis Allen Roberts
Jack P. Rock
Darren Roffey
Peter Rose
Michael K. Rosner
Andrew L. Ross
Enis Saban
Abraham E. Sabersky
Arjun Sahgal
Tatianna Olivia Saleh
Srinath Samudrala
Charles A. Sansur
Rachel Sarabia-Estrada
Mehdi Sasani
Dwight Saulle
Luigi Schiabello
Michael Schiraldi
Christian Schlicht
Meic H. Schmidt
Brian Schmit
Werner Schmolz
Joseph Schreiber
Albert Jesse Schuette
James M. Schuster
Theodore H. Schwartz
Daniel M. Sciubba
Cara Sedney
Neda I. Sedora-Roman
Howard B. Seim, III
Lori A. Setton
Sagar R. Shah
Mohammed F. Shamji
Adrija Sharma
Brian Shender
Patrick Shih
Alexander Y. Shin
Benjamin Shin
John H. Shin
Robert Shugart
Daniel J. Siegwart
Ibet Marie Sih
Pedro Guaresi Silva
Nathan E. Simmons
Oliver P. Simmons
Anoushka Singh
Bhagat Singh
Harshpal Singh
Terra Slaton
John M. Small
Igor Smirnov
Jason S. Smith
Timothy R. Smith
William D. Smith
William Douglas Smith
Zachary Adam Smith
Heather Spader
Robert J. Spinner
Marin F. Stancic
Robert M. Starke
Jeffrey A. Steinberg
Brian D. Stemper
Edwin Andrew Stevens
David Stidd
Andrea L. Strayer
Jan Stulik
Brian R. Subach
Patrick Alexander Sugrue
Ian Suk
Karin R. Swartz
Thomas A. Sweasey
Nikolaos Syrmos
Po-An Tai
Adesh Tandon
Bobby Tay
Alisson Teles
Amy Theiler
Nicholas Theodore
John A. Thomas
Jorge Torres
P. Justin Tortolani
Apostolos Tsiouris
Luis M. Tumialan
Cengiz Tuncer
Osman Nuri Türkmenoglu
A. Simon Turner
Michael Scott Turner
Ozhan Uckun
John L. Ulmer
Hidemasa Umekoji
Cheerag Upadhyaya
Alexander R. Vaccaro
Fernando L. Vale
Nico van Rooijen
Shoshanna S. Vaynman
Milorad Vilendecic
Alan T. Villavicencio
Eugene Wai
Beverly C. Walters
Anthony C. Wang
Jeffrey C. Wang
Mei Wang
Brittany Weeks
Philip R. Weinstein
Christine L. Weisshaar
Robert Gray Whitmore
Jack E. Wilberger
Brian Jeremy Williams
Seth Williams
Jefferson Wilson
Timothy F. Witham
Christopher E. Wolfla
Jean-Paul Wolinsky
Cyrus Chi-Ho Wong
Kamal Ronald Woods
Jodie B. Woznica
Neill Marshall Wright
Zachary G. Wright
Jau-Ching Wu
Qing Gui Xu
Risheng Xu
Jen-Tsung Yang
Wei-Hsun Yang
Reza Yassari
Donald Y. Ye
Ulas Yener
Gayane Yenokyan
Raymond Yerly
Ali Yildirim
Narayan Yoganandan
Do Sung Yoo
Daryl Young
Alexander Kwong-Tak Yu
Kemal Yucesoy
Kasim Zafer Yuksel
Eric L. Zager
Mehmet Zileli
Richard S. Zimmerman
Doug Zochodne

As of February 11, 2011

NON-FDA APPROVED LISTING

Faculty Presentations Including Non-FDA Approved Investigational Drugs or Devices

Scientific Session I: Evidence Based Spine Surgery in the Real World
Daryl R. Fourney

Scientific Session II: Spinal Surgery Complication Avoidance and Management
James S. Harrop
Patrick C. Hsieh
Srinivas K. Prasad

Scientific Session III: Evolution of Treatment for Metastatic Disease
Daryl R. Fourney

David Cahill Memorial Controversies: Spine and Peripheral Nerves
Burst Fracture Intact
James S. Harrop
Charles Kuntz, IV

Pediatric Craniocervical Society
Richard C.E. Anderson

Special Course II: Masters in Spinal Surgery: What Has Experience Taught Me?
Regis W. Haid

Special Course III: Spinal Deformity
Peter D. Angevine
James S. Harrop
Charles Kuntz, IV
Praveen V. Mummaneni
Juan S. Uribe

Special Course IV: Advanced MIS Techniques/Managing MIS Complications
Mick J. Perez-Cruet

Special Course V: Management of Perioperative Pain
Sanjay S. Dhall

Special Course VI: Update on Spinal Surgery in Turkey
Basar Atalay
Sedat Cagli
Suleyman Cayli
Kadir Kotil
Fahir Ozer

Special Course VII: Cervical Myelopathy (co-sponsored by CSRS)
Lee H. Riley
Rick Sasso

Special Course IX: Evaluation and Management of the Spine Trauma Patient
Sanjay S. Dhall
Eve C. Tsai

Luncheon Symposium IV: Geriatric Spine
James S. Harrop

Luncheon Symposium V: Spinal Arthroplasty
Regis W. Haid

Case Presentations
David J. Hart
Patrick C. Hsieh

Oral Platform Presentations II
Paul M. Arnold
Charles Kuntz, IV

What's New Session II
John Chi

What's New Session III
Sanjay S. Dhall

Mayfield and Outcomes Awards
119: *Darryl J. Dirisio*

Oral Platform Presentations I
Ali Bydon
104: *Roberto Jose Diaz*
Oral Platform Presentations II
113: *Domagoj Coric*

Oral Poster Presentations I
203: *D. Kojo Hamilton*
204: *Domagoj Coric*

Oral Poster Presentations II
John Chi
228: *Dwight Saulle*
229: *Jamal McClendon*
241: *Jan Stulik*

Digital Posters
306: *Christoph Hofstetter*
307: *Kenneth Pettine*
320: *Sanjay S. Dhall*
321: *Hung-Chuan Pan*
349: *Fred Chiu-lai Lam*
354: *Ali Bydon*
355: *Ryan M. Kretzer*
370: *Kasim Zafer Yuksel*
384: *Ali Dalgic*
392: *Samer Ghostine*
393: *John G. Stark*
395: *Sharad Rajpal*
401: *Kasim Zafer Yuksel*
404: *Brian James Hood*
417: *Kenneth Pettine*
427: *Bruce Robie*
438: *Iñaki Arrotegui*
439: *Iñaki Arrotegui*
450: *Luis M. Tumialan*
458: *Li-Yu Fay*
461: *Kenneth Pettine*

As of February 11, 2011

WEDNESDAY
MARCH 9

1:30 – 5:30 PM
Desert Conference Suite III

PEDIATRIC CRANIOCERVICAL SOCIETY

$200 includes lunch
Course Director: *Douglas L. Brockmeyer*
Faculty: *Richard C.E. Anderson, Daniel Edward Couture, Jonathan Martin*
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:
- Apply appropriate management of complex pediatric craniospinal disorders.
- Utilize appropriate research strategies to further the care of patients with craniospinal disorders.
- Apply 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
Break

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

1:30 – 5:30 PM
Grand Canyon 9

SPECIAL COURSE I

Coding Update and Review

$200 includes lunch
Course Directors: *Joseph S. Cheng, John J. Knightly*
Faculty: *Peter D. Angevine, Domagoj Coric, R. Patrick Jacob, Karin R. Swartz*
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:
- Integrate the newest changes in CPT coding for spine.
- Apply the methodology for correct spine coding.
- Identify specific difficult coding scenarios and bring clarity to the coding process.

1:30 – 1:45 PM
Introduction and Future Issues for Coding (ICD-10)
Joseph S. Cheng, John J. Knightly

1:45 – 2:15 PM
Updates and Issues in the CPT/RUC Process
R. Patrick Jacob

2:15 – 2:45 PM
Surgical Modifiers – With 2011 Updates
Domagoj Coric

2:45 – 3:30 PM
22000 Series – With 2011 Updates
John J. Knightly

3:30 – 4:15 PM
63000 Series – With 2011 Updates
Peter D. Angevine

4:15 – 4:45 PM
Peripheral Nerve Coding
Karin R. Swartz

4:45 – 5:30 PM
Discussion

1:30 – 5:30 PM
Grand Canyon 10

SPECIAL COURSE II

Masters in Spinal Surgery: What Has Experience Taught Me?

$200 includes lunch
Course Director: *Regis W. Haid*
Faculty: *Richard G. Fessler, Ziya L. Gokaslan, Robert F. Heary, Paul C. McCormick, Christopher I. Shaffrey, Vincent C. Traynelis*
Course Description: This course will discuss the evolution in diagnosis and treatment of spinal disorders and surgery from the perspective of those that have extensively contributed to that evolution. Attendees will serve to gain wisdom through historical knowledge and experiential narration.
Learning Objectives: Upon completion of this course, participants should be able to:
- Synthesize the evolution of spinal surgery principles and techniques.
- Differentiate and apply the treatment algorithms learned via durable experience and outcomes analysis.

1:30 – 1:50 PM
Point: Grade I Spondylolisthesis with Stenosis: Open or Mini-open Is the "Way to Go"
Robert F. Heary

1:50 – 2:10 PM
Counterpoint: Grade I Spondylolisthesis with Stenosis: MIS Is the "Way to Go"
Richard G. Fessler

2:10 – 2:25 PM
Debate and Discussion

2:25 – 2:50 PM
How Do I Decide on Total Tumor Removal vs. Debulking?
Ziya L. Gokaslan

2:50 – 3:10 PM
Intradural Extramedullary Dumbbell Tumors: Techniques of Resection (Bone, Intra and Extraforaminal, Dural Closure, etc.)
Paul C. McCormick

3:10 – 3:30 PM
Cervical Deformity: How Do I Decide Among Anterior, Posterior, Anterior Post Combo (i.e., What Can I Now Do from the Front that I Used to Do Front – Back)
Vincent C. Traynelis

3:30 – 3:45 PM
Break

3:45 – 4:15 PM
"How High To Go and Where To Stop" in Degenerative Lumbar Scoliosis with Stenosis
Christopher I. Shaffrey

4:15 – 5:30 PM
Discussion

1:30 – 5:30 PM
Grand Canyon 11

SPECIAL COURSE III

Spinal Deformity

$200 includes lunch

Course Directors: *Praveen V. Mummaneni, Christopher I. Shaffrey*

Faculty: *Peter D. Angevine, James S. Harrop, Robert F. Heary, Tyler R. Koski, Charles Kuntz, IV, Frank La Marca, David O. Okonkwo, Michael K. Rosner, Amer F. Samdani, Justin S. Smith, Juan Uribe*

Course Description: This course will discuss adult spinal deformity with a focus on the evaluation, classification, and treatment options available to this patient population. Non-surgical management options will be noted but emphasis will be placed on surgical correction principles and techniques. Complication management and operative outcomes will be emphasized.

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

- Synthesize and apply the evaluation and classification of adult spinal deformity.
- Identify the various treatment indications and options for adult spinal deformity.
- Utilize the unique complication avoidance strategies employed during spinal deformity surgery.

1:30 – 1:45 PM
Correction of Cervical Kyphosis
Frank La Marca

1:45 – 2:00 PM
Lumbo-Sacro-Pelvic Parameters and Fixation
Praveen V. Mummaneni

2:00 – 2:15 PM
Pedicle Subtraction Osteotomy and Smith Petersen Osteotomy: When and How
Robert F. Heary

2:15 – 2:30 PM
Direct Lateral Approaches for Lumbar Spine Deformity (Lessons Learned)
Juan Uribe

2:30 – 2:45 PM
When To Do Major Reconstruction Surgery vs. Limited Surgery for Spinal Deformity
Christopher I. Shaffrey

2:45 – 3:00 PM
Parkinson's Disease and Spinal Deformity
Peter D. Angevine

3:00 – 3:15 PM
My Worst Spinal Deformity Complications and Complication Avoidance
Charles Kuntz, IV

3:15 – 3:30 PM
Post-Traumatic Spinal Deformity: Prevention and Treatment
James S. Harrop

3:30 – 3:45 PM
Break

3:45 – 5:30 PM
Cases with Complications
Praveen V. Mummaneni
Discussants: *Tyler R. Koski, David O. Okonkwo, Michael K. Rosner, Amer F. Samdani, Justin S. Smith*

1:30 – 5:30 PM
Desert Conference Suite IV

SPECIAL COURSE IV

Advanced MIS Techniques/Managing MIS Complications

$200 includes lunch

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

Faculty: *Asdrubal Falavigna, Kevin T. Foley, Anthony Frempong-Boadu, Adam S. Kanter, Paul Park, Mick J. Perez-Cruet, Daniel M. Sciubba, Justin S. Smith*

Course Description: This course will discuss contemporary data and experience through MIS case-based, interactive, didactic presentations. Faculty will discuss their evaluations and treatment algorithms regarding minimally invasive vs. open surgical options to maximize complication avoidance. Focus will be given to cases initially treated minimally invasively with immediate or subsequent necessity for open conversion.

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

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

Introduction
Langston Holly

1:30 – 1:50 PM
Open vs. Tubular Microdiscectomy: What the Data Shows
Asdrubal Falavigna

1:50 – 2:10 PM
Nuances of MIS Cervical Decompression

2:10 – 2:30 PM
MIS TLIF: New Technologies for Safe Surgery
Mick J. Perez-Cruet

2:30 – 2:50 PM
MIS Cervical Fusion and Instrumentation
Anthony Frempong-Boadu

2:50 – 3:10 PM
XLIF/MIS Lateral Approaches and Its Complications
Adam S. Kanter

3:10 – 3:30 PM
Discussion

3:30 – 3:45 PM
Break

3:45 – 4:15 PM
MIS: What the Past Has Taught Us and What the Future Holds
Kevin T. Foley

4:15 – 4:30 PM
Case Presentation #1
Justin S. Smith

4:30 – 4:45 PM
Case Presentation #2
Paul Park

4:45 – 5:00 PM
Case Presentation #3
Daniel M. Sciubba

5:00 – 5:30 PM
Questions and Answers
Michael Y. Wang

1:30 – 5:30 PM
Grand Canyon 13

SPECIAL COURSE V

Management of Perioperative Pain

Special Course for Nurses, Nurse Practitioners and Physician Extenders.
$110 includes lunch
Course Directors: *Michael P. Steinmetz, Andrea L. Strayer, MSN, CNRN, ACNP*
Faculty: *Sanjay S. Dhall, Daniel J. Hoh, Ajit A. Krishnaney, Gregory R. Trost, Luis M. Tumialan*
Course Description: This course will discuss perioperative pain issues with emphasis on up-to-date practical bedside and outpatient management strategies, with a target audience of nurses, nurse practitioners and physician extenders. Expert practice nurses, physician assistants, and neurosurgeon faculty will explore the challenges of caring for our increasingly complex patient population.
Learning Objectives: Upon completion of this course, participants will be able to:

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

Physician attendees will not be awarded CME credit for this course. Nursing contact hours may 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 need to contact their individual membership association and certification board to determine the requirements for accepting credits. All attendees will receive a confirmation of attendance.

1:30 – 2:00 PM
Pain Pathophysiology, Postoperative Pain, Spine Pain
Sanjay S. Dhall

2:00 – 2:20 PM
Mechanisms of Action for Various Analgesics Including Voiding Issues, Constipation Prevention
Daniel J. Hoh

2:20 – 2:40 PM
NSAIDS, Review, Contraindictions, Options
Ajit A. Krishnaney

2:40 – 3:05 PM
IV vs. Epidular PCA
Luis M. Tumialan

3:05 – 3:30 PM
Do Minimal Access Surgical Patients Have Less Pain?
Michael P. Steinmetz

3:30 – 3:45 PM
Break

3:45 – 4:30 PM
Red Flags What Studies, When
Gregory R. Trost

4:30 – 5:00 PM
Multimodal Therapy
Andrea Strayer, MSN, CNRN, ACNP

5:00 – 5:30 PM
Practice Gap Discussion

1:30 – 5:30 PM
Grand Canyon 12

SPECIAL COURSE VI

Update on Spinal Surgery in Turkey

$200 includes lunch
Course Directors: *Selcuk Omer Palaoglu, Mehmet Zileli*
Faculty: *Basar Atalay, Hakan Bozkus, Sedat Cagli, Hakan Caner, Süleyman Çayli, Patrick C. Hsieh, Erkan Kaptanoglu, Cumhur Kilincer, Kemal Koc, Kadir Kotil, Sait Naderi, Fahir Ozer, Timothy F. Witham*
Course Description: This course will discuss the diagnosis and management of spinal disorders and surgical solutions in Turkey from the perspective of leading Turkish spine surgeons. The topics range from surgical approaches and stabilization techniques to motion preservation surgery and complication management.
Learning Objectives: Following completion of this course, participants should be able to:

- Analyze the evolution of spinal surgery principles and techniques in Turkey.
- Distinguish some technical nuances of spinal surgery practiced in Turkey for a variety of spinal conditions

1:30 – 1:40 PM
Complication Avoidance and Management with Sacral Insufficiency Fractures Following Lumbosacral Fusion
Case Presentation: *Timothy F. Witham, Mehmet Zileli*

1:40 – 1:50 PM
Complication Avoidance and Management of C5 Palsy
Case Presentation: *Patrick C. Hsieh, Selcuk Palaoglu*

1:50 – 2:10 PM
Spine Surgery in Turkey: From Past to Present
Sait Naderi

2:10 – 2:30 PM
Oblique Corpectomy for Cervical Spondylotic Myelopathy
Kemal Koc

2:30 – 2:50 PM
Pedicle Based Dynamic Fixation
Fahir Ozer

2:50 – 3:10 PM
Cervical Anterior Foraminotomy
Cumhur Kilincer

3:10 – 3:30 PM
Surgical Techniques for Upper Cervical Spine Injuries
Sedat Cagli

3:30 – 3:45 PM
Break

3:45 – 4:03 PM
Anterolateral Retroperitoneal Transiliac (ART) Screw Placement to the Fifth Lumbar Vertebra: Anatomical Study and a Novel Surgical Approach
Erkan Kaptanoglu

4:03 – 4:20 PM
Unilateral Pedicle Screw Fixation for Minimally Invasive Transforaminal Lumbar Interbody Fusion
Hakan Caner

4:20 – 4:38 PM
Surgical Techniques for Posterior Craniovertebral Junction Pathologies
Basar Atalay

4:38 – 4:55 PM
Transpedicular Screw Fixation in Cervical Fractures
Kadir Kotil

4:55 – 5:12 PM
Lumbar Facet Arthroplasty: Techniques, Biomechanics and Clinical Experiences
Hakan Bozkus

5:12 – 5:30 PM
Management of Congenital Scoliosis
Süleyman Çayli

1:30 – 5:30 PM
Desert Conference Suite VIII

SPECIAL COURSE VII

Cervical Myelopathy (co-sponsored by CSRS)

$200 includes lunch

Course Directors: *James S. Harrop, Robert F. Heary*

Faculty: *Michael G. Fehlings, John G. Heller, Lee H. Riley, Rick Sasso, Vincent C. Traynelis, Jeffrey C. Wang, Timothy F. Witham*

Course Description: This course will discuss contemporary data and experience through case-based, interactive, didactic presentations. Faculty will discuss the evaluation and treatment algorithms regarding cervical myelopathy and specifically discuss surgical approaches. Etiology, pathogenesis and diagnosis through contemporary imaging modalities will be explored.

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

- Synthesize appropriate anatomy and biomechanics of the cervical spine.
- Differentiate the methods for diagnosis of neck disorders.
- Apply operative and non-operative treatment options for cervical spine disorders.
- Recognize and respond to complications of surgical treatment.
- Synthesize and apply information on cervical spine research, diagnosis and treatment.

1:30 – 1:31 PM
Introduction and Welcome
James S. Harrop, Robert F. Heary

1:31 – 1:40 PM
Pathophysiology of Myelopathy
James S. Harrop

1:40 – 1:50 PM
Myelopathy at the CVJ
Rick C. Sasso

1:50 – 2:00 PM
Subaxial Myelopathy: Anterior Treatment Strategies
Michael G. Fehlings

2:00 – 2:10 PM
Subaxial Myelopathy: Posterior Treatment Strategies
John G. Heller

2:10 – 2:20 PM
Myelopathy and CT Junction
Timothy F. Witham

2:20 – 2:30 PM
Why OPLL is Special
Vincent C. Traynelis

2:30 – 2:40 PM
Imaging and Myelopathy
Lee H. Riley

2:40 – 2:50 PM
When Is a Second Procedure Indicated?
Jeffrey C. Wang

2:50 – 3:30 PM
Case Presentations and Discussion

3:30 – 3:45 PM
Break

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

Opening Reception

6:00 – 8:00 PM **Sage Court**

Take in spectacular views of the mountains and watch the sunset while enjoying a lavish array of food and beverages as you network with old friends and new colleagues at the Opening Reception. Please note this event is held outdoors. Resort casual attire is recommended.

THURSDAY
MARCH 10

6:30 – 6:55 AM
Grand Saguaro North
Case Presentations
Moderators: *Patrick C. Hsieh, Eve C. Tsai*

6:55 – 7:00 AM
Grand Saguaro North
Introductory Remarks/Meeting Announcements
Daryl R. Fourney

7:00 – 9:30 AM
Grand Saguaro North

SCIENTIFIC SESSION I

Evidence-Based Spine Surgery in the Real World

Moderators: *Peter D. Angevine, Michael Y. Wang*

Session Description: This session will explore how spine surgery has been affected by the application of evidence-based medicine, with particular focus on cost-utility analysis and comparative effectiveness. Speakers will discuss how this data can be applied to practice. Additionally, the session will explore how practice is affected by conflicting or limited outcomes data.

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

- Appraise what evidence-based medicine is and how the concept has evolved.
- Relate what cost-utility and comparative effectiveness analyses are and list some examples in spine surgery.
- Analyze how conflicting or limited evidence may be evaluated in a systematic fashion to determine best practice.

7:00 – 7:14 AM
Cost-Utility Analysis
Matthew J. McGirt

7:14 – 7:27 AM
Comparative Effectiveness
Zoher Ghogawala

7:27 – 7:40 AM
Applying Base Evidence to Practice
Daniel K. Resnick

7:40 – 7:53 AM
How To Resolve Clinical Problems with Lack of Data
Michael G. Kaiser

7:53 – 8:06 AM
How To Resolve Conflicting Data (e.g., Vertebroplasty)
Daryl R. Fourney

8:06 – 8:19 AM
Evidence-Based Recommendations for Spine Surgery: How Has the Process Changed?
Paul C. McCormick

8:19 – 8:32 AM
How To Resolve Cost Conflicts with "Best Evidence"
R. Patrick Jacob

8:32 – 8:45 AM
How To Resolve Reimbursement Conflicts with "Best Evidence"
Joseph S. Cheng

8:45 – 8:50 AM
Introduction of Section Chairperson
Daryl R. Fourney

8:50 – 9:05 AM
PRESIDENTIAL ADDRESS
Evolution of Surgical Treatment

Ziya L. Gokaslan

9:05 – 9:10 AM
Introduction of Meritorious Service Award Recipient
Michael G. Fehlings

9:10 – 9:30 AM
MERITORIOUS SERVICE AWARD PRESENTATION
Question Authority or a Critical Look at Things We Take for Granted

Paul R. Cooper

9:30 – 10:15 AM
Grand Canyon Ballroom
BEVERAGE BREAK WITH EXHIBITORS

***What's New* Session I**
Moderators: *Dean Karahalios, Daniel M. Sciubba*

10:15 AM – 12:30 PM
Grand Saguaro North
ORAL PLATFORM PRESENTATIONS I

Moderators: *Ali Bydon, Praveen V. Mummaneni*
Discussants: *Joseph T. Alexander, Michael W. Groff, R. John Hurlbert, Iain H. Kalfas, Mark R. McLaughlin, Daniel K. Resnick, Gregory R. Trost, Christopher E. Wolfla, Eric L. Zager*

10:15 – 10:24 AM
100. In Situ Placement of High-dose rhBMP-2 within Spine Tumors Slows Tumor Growth and Decreases Onset to Paralysis in a Rat Model of Metastatic Breast Cancer
Camilo A. Molina, Rachel Sarabia-Estrada, Guergana Panayotova, Antonio Aguilera, Ziya L. Gokaslan, Jean-Paul Wolinksy, Ali Bydon, Daniel M. Sciubba

10:24 – 10:27 AM
Discussant: *Eric L. Zager*

10:27 – 10:36 AM
101. The Effect of Surgery on Health Related Quality of Life and Functional Outcome in Patients with Metastatic Epidural Spinal Cord Compression Initial Results of the AOSpine North America Prospective Multicenter Study
Michael G. Fehlings, Branko Kopjar, Alexander R. Vaccaro, Paul M. Arnold, Charles Fisher, Ziya L. Gokaslan, James M. Schuster, Mark B. Dekutoski, Joel Finkelstein, Laurence D. Rhines

10:36 – 10:39 AM
Discussant: *Iain H. Kalfas*

10:39 – 10:48 AM
102. Survival of Patients with Malignant Primary Osseous Spinal Neoplasms from the Surveillance, Epidemiology, and End Results (SEER) Database from 1973-2005
Kaisorn L. Chaichana, Scott Parker, Owoicho Adogwa, Debraj Mukherjee, Oran Aaronson, Joseph S. Cheng, Ziya L. Gokaslan, Matthew J. McGirt

10:48 – 10:51 AM
Discussant: *Christopher E. Wolfla*

10:51 – 11:00 AM
103. Electrical Stimulation Enhances Axon and Nerve Regeneration
Rajiv Midha, Bhagat Singh, Qing Gui Xu, Colin Franz, Colin Dalton, Tessa Gordon, Doug Zochodne

11:00 – 11:03 AM
Discussant: *Michael W. Groff*

11:03 – 11:16 AM
Discussion

11:16 – 11:25 AM
104. Efficacy and Active Ingredients in an Epidural Analgesic Paste after Lumbar Decompression: A Prospective Randomized Double-Blind Controlled Trial.
Roberto Jose Diaz, S. Terence Myles, R. John Hurlbert

11:25 – 11:28 AM
Discussant: *Mark R. McLaughlin*

11:28 – 11:37 AM
105. Radiographic Same-level Recurrent Disc Herniation After Lumbar Discectomy: Prospective Longitudinal Study with Two-year Follow-up
Scott Parker, Richard L. Lebow, Owoicho Adogwa, Adrija Sharma, Oran Aaronson, Joseph S. Cheng, Matthew J. McGirt

11:37 – 11:40 AM
Discussant: *Joseph T. Alexander*

11:40 – 11:49 AM
106. Cost Effectiveness of Multilevel Hemilaminectomy for Lumbar Stenosis Associated Radiculopathy
Erin Fulchiero, Brandon J. Davis, Owoicho Adogwa, Oran Aaronson, Joseph S. Cheng, Clint Devin, Matthew J. McGirt

11:49 – 11:52 AM
Discussant: *Daniel K. Resnick*

11:52 AM – 12:01 PM
107. Provocative Discography Screening Improves Surgical Outcome
Petra Margetic, Marin F. Stancic

12:01 – 12:04 PM
Discussant: *R. John Hurlbert*

12:04 – 12:13 PM
108. The Impact of Surgeon Professional Fees to the National Cost of Healthcare
Camilo A. Molina, Ziya L. Gokaslan, Timothy F. Witham, Ali Bydon, Jean-Paul Wolinsky, Daniel M. Sciubba

12:13 – 12:16 PM
Discussant: *Gregory R. Trost*

12:16 – 12:30 PM
Discussion

12:30 – 1:25 PM
Grand Canyon Ballroom
LUNCH WITH EXHIBITORS

***What's New* Session II**
Moderators: *Michael P. Steinmetz, John Chi*

1:25 – 1:30 PM
Grand Saguaro North
Meeting Announcements
Praveen V. Mummaneni

1:30 – 3:00 PM
Grand Saguaro North
SCIENTIFIC SESSION II

Spinal Surgery Complication Avoidance and Management

Moderators: *R. John Hurlbert, Eve C. Tsai*
Course Description: This course will address the complications encountered in a case-based format with attention to management techniques and learned avoidance strategies. Cases will specifically address complications encountered during minimally invasive procedures, vertebral artery injury, intradural tumors, lumbar fusion, transpsoas approaches and anterior cervical approaches.
Learning Objectives: Upon completion of this course, participants should be able to:

- Identify risk factors associated with spinal surgery complications.
- Create surgery planning strategies to avoid complications.
- Develop intraoperative strategies to avoid complications.
- Incorporate postoperative strategies to avoid complications.

1:30 – 1:33 PM
MIS Complication Case – Introduction
Daniel M. Sciubba

1:33 – 1:43 PM
MIS Complication Case – Discussion
Michael Y. Wang

1:43 – 1:46 PM
Complication Avoidance and Management with Vertebral Artery Injury – Introduction
Dean Karahalios

1:46 – 1:56 PM
Complication Avoidance and Management with Vertebral Artery Injury – Discussion
Volker K.H. Sonntag

1:56 – 1:59 PM
Complication Avoidance and Management with BMP Interbody in the Lumbar Spine – Introduction
Srinivas K. Prasad

1:59 – 2:09 PM
Complication Avoidance and Management with BMP Interbody in the Lumbar Spine – Discussion
James S. Harrop

2:09 – 2:12 PM
Complication Avoidance and Management with Intraoperative Monitoring Changes with Intradural Tumors – Introduction
George I. Jallo

2:12 – 2:22 PM
Complication Avoidance and Management with Intraoperative Monitoring Changes with Intradural Tumors – Discussion
R. John Hurlbert

2:22 – 2:25 PM
Complication Avoidance and Management with Sacral Insufficiency Fractures Following LS Fusion – Introduction
Timothy F. Witham

2:25 – 2:35 PM
Complication Avoidance and Management with Sacral Insufficiency Fractures Following LS Fusion – Discussion
Mehmet Zileli

2:35 – 2:38 PM
Complication Avoidance and Management with Transpoas Approaches (Nerve Injury) – Introduction
Adam S. Kanter

2:38 – 2:48 PM
Complication Avoidance and Management with Transpoas Approaches (Nerve Injury) – Discussion
Allan J. Belzberg

2:48 – 2:51 PM
Complication Avoidance and Management with C5 Palsy – Introduction
Patrick C. Hsieh

2:51 – 3:00 PM
Complication Avoidance and Management with C5 Palsy – Discussion
Selcuk Omer Palaoglu

3:00 – 3:45 PM
Grand Canyon Ballroom
BEVERAGE BREAK WITH EXHIBITORS

***What's New* Session III**
Moderators: *Sanjay S. Dhall, Matthew J. McGirt*

3:45 – 5:15 PM
Grand Saguaro North
ORAL POSTER PRESENTATIONS I
(Concurrent Sessions)
Moderators: *Dean Chou, Justin S. Smith*

3:45 – 3:50 PM
200. Pulsed Electromagnetic Field Bone Growth Stimulation for High Risk Fusion Patients: An Analysis of 452 Consecutive Cases
Naresh P. Patel, Barry D. Birch, Mark K. Lyons, Richard S. Zimmerman, Stacie DeMent, Gregg Elbert, Orland K. Boucher, Amy Theiler

3:50 – 3:55 PM
201. Preservation of Segmental Motion with Anterior Contralateral Cervical Microdiskektomy and Interbody Fat Graft: Prospective Study
Yunus Aydin, Halit Çavusoglu, Cengiz Tuncer, Osman Nuri Türkmenoglu, Ahmet Murat Müslüman

3:55 – 4:00 PM
202. Radiographic Outcomes in Two-level ACDFs: Comparison of PEEK and Allograft Interbody Devices at 1 and 2 Year Follow-up
Jody A. Rodgers, W.B. Rodgers, Edward J. Gerber

4:00 – 4:05 PM
203. Safety, Efficacy, and Dosing of Recombinant Human Bone Morphogenetic Protein-2 (rhBMP-2) for Posterior Cervical and Cervico-thoracic Instrumented Fusion with a Minimum Two-year Follow-up
D. Kojo Hamilton, Justin S. Smith, Davis Reames, Brian Jeremy Williams, Daniel R. Chernavvsky, Christopher I. Shaffrey

4:05 – 4:10 PM
204. Prospective Results from the US IDE Feasibility Study of a Novel Peek-On-Peek Nucleus Replacement Device with Minimum Two-Year Follow-up
Domagoj Coric, Matthew Songer, John J. Regan

4:10 – 4:15 PM
Discussion

4:15 – 4:20 PM
205. Preoperative Grading Scale to Predict Survival in Patients Undergoing Resection of Malignant Primary Osseous Spinal Neoplasms
Scott Parker, Kaisorn L. Chaichana, Oran Aaronson, Joseph S. Cheng, Ziya L. Gokaslan, Matthew J. McGirt

4:20 – 4:25 PM
206. Clinical Outcomes Following En Bloc Sacrectomies via Posterior Approach
Michelle J. Clarke, Daniel M. Sciubba, Matthew J. McGirt, Timothy F. Witham, Ali Bydon, Patrick C. Hsieh, Ziya L. Gokaslan, Jean-Paul Wolinsky

4:25 – 4:30 PM
207. Generation of Chordoma Cell Line, JHC7, and the Identification of Brachyury as a Novel Molecular Target
Wesley Hsu, Ahmed Mohyeldin, Sagar R. Shah, Lakesha Johson, Neda I. Sedora-Roman, Thomas Kosztowski, Colette Ap Rhys, Ola Awad, Edward McCarthy, David Loeb, Jean-Paul Wolinsky, Ziya L. Gokaslan, Alfredo Quinones-Hinojosa

4:30 – 4:35 PM
208. Reconstruction of Extensive Defects from Posterior En Bloc Resection of Sacral Tumors Using Human Acellular Dermal Matrix and Gluteus Maximus Myocutaneous Flaps
Hormuzdiyar H. Dasenbrock, Michelle J. Clarke, Ali Bydon, Timothy F. Witham, Daniel M. Sciubba, Oliver P. Simmons, Ziya L. Gokaslan, Jean-Paul Wolinsky

4:35 – 4:40 PM
243. Clinical Outcome and Risk of Reoperation for Recurrent TCS in 99 Consecutive Children Operated for Tight or Fatty Filum
Lauren Rose Ostling, Karin S. Bierbrauer, Charles Kuntz, IV

4:40 – 4:45 PM
Discussion

4:45 – 4:50 PM
210. Identification of Cancer Stem Cells in Human Chordoma
Wesley Hsu, Ahmed Mohyeldin, Sagar R. Shah, Thomas Kosztowski, Lakesha Johnson, Ola Awad, Neda I. Sedora-Roman, David Loeb, Edward McCarthy, Jean-Paul Wolinsky, Ziya L. Gokaslan, Alfredo Quinones-Hinojosa

4:50 – 4:55 PM
211. Sacral Laminoplasty for the Treatment of Symptomatic Sacral Perineural (Tarlov) Cysts, Clinical Outcomes and Surgical Observations
Zachary Adam Smith, Larry T. Khoo

4:55 – 5:00 PM
212. Hydrostatic Strength Dural Patch Repair Materials
Michael A. Finn, Paul Anderson, Nathan Faulkner

5:00 – 5:05 PM
213. Hydrostatic Comparison of Titanium Clip and Suture Repair of Durotomy
Michael A. Finn, Paul Anderson, Nathan Faulkner

5:05 – 5:10 PM
214. Prospective Randomized Controlled Trial in Spine Patients to Compare Low Swell Formulation of a Polyethylene Glycol Hydrogel Spinal Sealant with Other Methods of Dural Sealing
Kee Duk Kim, Joseph S. Cheng, Randall Matthew Chesnut, Dean Chou, Haroon F. Choudhri, Garth Rees Cosgrove, Shankar Prakash Gopinath, R. Scott Graham, Richard Gray, Ajit A. Krishnaney, Paul C. McCormick, Ehud Mendel, Jon Park, Mark Edwin Shaffrey, Nathan E. Simmons, John M. Tew, Jr., Jack E. Wilberger, Jr., Neill Marshall Wright

5:10 – 5:15 PM
Discussion

3:45 – 5:15 PM
Grand Canyon 9

ORAL POSTER PRESENTATIONS II
(Concurrent Sessions)
Moderators: *John Chi, Marjorie C. Wang*

3:45 – 3:50 PM
215. Assessment of Thoracic Laminar Dimensions in a Pediatric Population: A CT-Based Feasibility Study for Pediatric Thoracic Translaminar Screw Placement
Camilo A. Molina, Christopher Chaput, Daniel M. Sciubba, P. Justin Tortolani, George I. Jallo, Ryan M. Kretzer

3:50 – 3:55 PM
216. CT Hounsfield Units for Assessing Bone Mineral Density: A Tool For Osteoporosis Management
Paul A. Anderson, Joseph Schreiber

3:55 – 4:00 PM
217. Effects of Epidural Steroid Injections on Blood Glucose Levels in Patients with Diabetes Mellitus
Owoicho Adogwa, Jesse Even, Kirk McCullough, Clint Devin, Matthew J. McGirt

4:00 – 4:05 PM
218. The Prognostic Value of a Cervical Selective Nerve Root Block: A Correlation with Surgical Outcomes
Luis M. Tumialan, David C. LoPresti, Angelina N. Garvin, Wayne Gluf

4:05 – 4:10 PM
219. The Prognostic Value of a Lumbar Selective Nerve Root Block: A Correlation with Surgical Outcomes
Luis M. Tumialan, David C. LoPresti, Angelina N. Garvin, Wayne Gluf

4:10 – 4:15 PM
Discussion

4:15 – 4:20 PM
220. Proximal Junctional Kyphosis in Adult Thoracolumbar Instrumented Fusion: Time to Development, Clinical and Radiographic Characteristics, and Management Approach in 32 Consecutive Cases
Davis Reames, Justin S. Smith, D. Kojo Hamilton, Vincent Arlet, Christopher I. Shaffrey

4:20 – 4:25 PM
221. Direct Vertebral Body Derotation: A Comparison of Different Techniques
Amer F. Samdani, Steven Wei-Hung Hwang, Michelle Marks, Tracey Bastrom, Randal Betz, Patrick Cahill

4:25 – 4:30 PM
222. Direct Vertebral Body Derotation, Thoracoplasty or Both: Which is Better with Respect to Inclinometer and SRS-22 Scores?
Amer F. Samdani, Steven Wei-Hung Hwang, Peter Newton, Baron Lonner, Michelle Marks, Tracey Bastrom, Patrick Cahill, Randal Betz

4:30 – 4:35 PM
223. Differences in Treatment and Inpatient Outcomes for Hospitalized Scoliosis Patients in the United States from 1998 to 2007
Doniel Drazin, Miriam Nuno, Frank L. Acosta, Jr.

4:35 – 4:40 PM
224. The Safety and Efficacy of Transforaminal Lumbar Interbody Fusion for Deformity Correction in Degenerative Scoliosis with Spinal Stenosis
Alan T. Villavicencio, Ewell Lee Nelson, Alexander Mason, Sharad Rajpal, Frances A. Carr, Sigita Burneikiene

4:40 – 4:45 PM
Discussion

4:45 – 4:50 PM
225. Biomechanical Analysis of Iliac Screws vs. S2 Alar-Iliac Screws
Cyrus Chi-Ho Wong, Chase Corn, Colin Crosby, Jesse Even, Gregory A. Mencio, Clinton J. Devin, Matthew J. McGirt

4:50 – 4:55 PM
226. Reduced Surgical Site Infections in Patients Undergoing Posterior Spinal Stabilization of Traumatic Injuries Using Vancomycin Powder
Owoicho Adogwa, Kevin O'Neill, Jason S. Smith, Amir Abtahi, Kristen Archer-Swygert, Clint Devin, Matthew J. McGirt

4:55 – 5:00 PM
227. Intraoperative Glucose Levels and its Association with Developing Postoperative Surgical Site Infections Following Spine Surgeries
Frances Mao, Ajit A. Krishnaney

5:00 – 5:05 PM
228. Multiple-day Drainage when Using BMP for Long Segment Thoraco-lumbar Instrumented Fusions Results in Low Reoperation Rates for Infection and Seroma
Dwight Saulle, Kai-Ming G. Fu, Justin S. Smith, Christopher I. Shaffrey

5:05 – 5:10 PM
229. Efficacy of Prophylactic Preoperative Inferior Vena Cava Filters for Major Spinal Surgery in Adults: A Review of 219 Patients at a Single Institution
Jamal McClendon, Jr., Brian A. O'Shaughnessy, Timothy R. Smith, Patrick Alexander Sugrue, Ryan J. Halpin, Tyler R. Koski, Stephen L. Ondra

5:10 – 5:15 PM
Discussion

Reception with the Exhibitors

5:15 – 6:45 PM
Grand Canyon Ballroom

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

FRIDAY
MARCH 11

6:30 – 7:00 AM
Grand Saguaro North
Case Presentations
Moderator: *David J. Hart, Daniel C. Lu*

7:00 – 9:00 AM
Grand Saguaro North
SCIENTIFIC SESSION III

Evolution of Treatment for Metastatic Disease

Moderators: *Daryl R. Fourney, Laurence D. Rhines*
Session Description: This session will review the natural history and management of metastatic spinal tumors. Clinical and radiographic assessment as well as current treatments including MIS and radiosurgery will be discussed. The costs of care for this complex patient population will also be discussed.
Learning Objectives: Upon completion of this session, participants should be able to:

- Assimilate the significance of tumor biology, neurology, patient fitness and mechanical stability in considering management options.
- Analyze the indications and techniques for metastatic spine tumors.
- Relate costs of care and how treatment impacts the quality of life.

7:00 – 7:15 AM
MIS/Vertebroplasty/Hybrid Techniques
Ehud Mendel

7:15 – 7:30 AM
Radiosurgery
Jack P. Rock

7:30 – 7:45 AM
Questions for the Panel

7:45 – 8:00 AM
Role of En Bloc vs. Piecemeal for Metastatic Tumors of the Spine
Stefano Boriani

8:00 – 8:15 AM
Evolution of Surgery for Metastatic Disease
Ziya L. Gokaslan

8:15 – 8:30 AM
Cost Utility Analysis and the Role of Surgery for Metastatic Spine Disease in the Elderly
Dean Chou

8:30 – 8:45 AM
The Future: Animal Models/Technology/Biologic Strategies
Daniel M. Sciubba

8:45 – 9:00 AM
Questions for the Panel

9:00 – 9:30 AM
Grand Saguaro North
MAYFIELD AWARDS AND PRESENTATIONS
Moderators: *Adam S. Kanter, Marjorie C. Wang*
Discussants: *Adam S. Kanter, Daniel M. Sciubba, Marjorie C. Wang*

9:00 – 9:08 AM
MAYFIELD BASIC SCIENCE AWARD
Evidence of Descending Supraspinal Control of Nociception and Pain Behavior in Experimental Disc-Herniation Radiculopathy
Mohammed F. Shamji, Priscilla Hwang, Kyle D. Allen, Mosfata Gabr, J. Chen, Liufang Jing, William J. Richardson, Lori A. Setton

9:08 – 9:10 AM
Discussant: *Daniel M. Sciubba*

9:10 – 9:18 AM
MAYFIELD CLINICAL SCIENCE AWARD
Perioperative Use of Dexamethasone in Multilevel Anterior Cervical Spine Surgery: Preliminary Results of a Prospective, Randomized, Double-Blinded Trial
Tyler J. Kenning, Karen Petronis, John W. German, Doniel Drazin, Darryl J. Dirisio

9:18 – 9:20 AM
Discussant: *Adam S. Kanter*

9:20 – 9:28 AM
OUTCOMES COMMITTEE AWARD
Analysis of the Three United States FDA-IDE Cervical Arthroplasty Trials
Cheerag Upadhyaya, Jau-Ching Wu, Regis W. Haid, Jr., Vincent C. Traynelis, Bobby Tay, Domagoj Coric, Gregory R. Trost, Scott A. Meyer, Praveen V. Mummaneni

9:28 – 9:30 AM
Discussant: *Marjorie C. Wang*

9:30 – 10:15 AM
Grand Canyon Ballroom
BEVERAGE BREAK WITH EXHIBITORS

***What's New* Session IV**
Moderators: *Dean Chou, Justin S. Smith*

10:15 AM – 12:15 PM
Grand Saguaro North
ORAL PLATFORM PRESENTATIONS II

Moderators: *Langston T. Holly, Frank La Marca*
Discussants: *Paul M. Arnold, Charles L. Branch, Mark N. Hadley, Charles Kuntz, IV, David O. Okonkwo, Gerald E. Rodts, Jr., Michael K. Rosner, Brian R. Subach, Eric J. Woodard*

10:15 – 10:24 AM
109. Effect of Patient Pain Expectations and Preoperative SF-36 Mental Component Summary Scores on Clinical Outcomes Following Anterior Cervical Discectomy and Fusion
Frances A. Carr, Theresa Hernandez, Kyle M. Healy, Ewell Lee Nelson, Alexander Mason, Sigita Burneikiene, Alan T. Villavicencio

10:24 – 10:27 AM
Discussant: *Charles L. Branch*

10:27 – 10:36 AM
110. Factors Associated with the Occurrence of Perioperative Complications in the Treatment of Cervical Spondylotic Myelopathy Based on 302 Patients from the AOSpine North America Cervical Spondylotic Myelopathy Study
Justin S. Smith, Christopher I. Shaffrey, Branko Kopjar, Paul M. Arnold, Sangwook Yoon, Alexander R. Vaccaro, Darrel S. Brodke, Michael Janssen, Jens Chapman, Rick Sasso, Eric J. Woodard, Robert J. Banco, Eric M. Massicotte, Mark Dekutowski, Ziya L. Gokaslan, Christopher Bono, Michael G. Fehlings

10:36 – 10:39 AM
Discussant: *Mark N. Hadley*

10:39 – 10:48 AM
111. Comparative Economic Analysis of Ventral vs. Dorsal Surgery for Cervical Spondylotic Myelopathy
Andrew Becker, Robert Gray Whitmore, Susan Christopher, Jill Curran, Benjamin Baskin, Zoher Ghogawala

10:48 – 10:51 AM
Discussant: *Gerald E. Rodts, Jr.*

10:51 – 11:00 AM
112. Functional and Quality of Life Outcomes in Geriatric Patients with Type II Odontoid Fracture: One-Year Results from the AOSpine North America Multi-Center GOF Prospective Study
Michael G. Fehlings, Alexander R. Vaccaro, Branko Kopjar, Jens Chapman, Christopher I. Shaffrey, Paul M. Arnold, Ziya L. Gokaslan, Roger Hartl, Darrel S. Brodke, John France, Sangwook Yoon, Mark B. Dekutoski, Rick Sasso, Christopher Bono

11:00 – 11:03 AM
Discussant: *Eric J. Woodard*

11:03 – 11:09 AM
Discussion

11:09 – 11:18 AM
113. Prospective, Randomized, Multicenter Study of Cervical Arthroplasty: 269 Patients from the Kineflex/C Metal-on-Metal Artificial Disc IDE Study with Minimum Two-Year Follow-up
Domagoj Coric, Richard D. Guyer, Pierce D. Nunley, Charley Gordon, Thomas Dimmig, Cameron Carmody, Donna D. Ohnmeiss, Margaret Boltes

11:18 – 11:21 AM
Discussant: *Paul M. Arnold*

11:21 – 11:30 AM
114. Cervical Disc Replacement: Interim Five-year Follow-up Results from the United States Prospective Randomized Bryan Clinical Trial
Richard G. Fessler, Rick Sasso, Paul Anderson, John Heller

11:30 – 11:33 AM
Discussant: *Brian R. Subach*

11:33 – 11:42 AM
115. Are Closed Suction Drains in Posterior Spinal Surgery "The Devil's Highway" for Infection?
James S. Harrop, Srinivas K. Prasad, John Kevin Ratliff, Mitchell Gil Maltenfort, Phyllis Flomenberg, Ashwini Dayal Sharan, Alex Vaccaro, Shilpa Rao

11:42 – 11:45 AM
Discussant: *Michael K. Rosner*

11:45 – 11:54 AM
116. Clinical and Radiographic Factors Driving the Transition from Nonoperative to Operative Treatment in Elderly Adults with Degenerative Scoliosis
Kai-Ming G. Fu, Justin S. Smith, Christopher I. Shaffrey

11:54 – 11:57 AM
Discussant: *Charles Kuntz, IV*

11:57 AM – 12:06 PM
117. Incidence of Vascular Encroachment Resulting from Free Hand Placement of Pedicle Screws in the Thoracic and Lumbar Spine: Analysis of 6,816 Consecutive Screws
Scott L. Parker, Anubhav Amin, Ali Bydon, Daniel M. Sciubba, Jean-Paul Wolinsky, Ziya L. Gokaslan, Timothy F. Witham

12:06 – 12:09 PM
Discussant: *David O. Okonkwo*

12:09 – 12:15 PM
Discussion

12:15 – 12:20 PM
Meeting Announcements
Daryl R. Fourney, Praveen V. Mummaneni

12:20 – 12:30 PM
Grand Saguaro North
ANNUAL BUSINESS MEETING
Presiding Officer: *Ziya L. Gokaslan*
Moderator: *Michael W. Groff*

12:30 – 2:30 PM
Grand Canyon 9

LUNCHEON SYMPOSIUM I

Revision Spine Surgery

$200 includes lunch

Course Directors: *Michael W. Groff, Iain H. Kalfas*

Faculty: *David O. Okonkwo, Timothy C. Ryken*

Course Description: This course will provide state-of-the-art information on complication avoidance during revision spine surgery. Faculty will review their clinical experience and lessons learned via interactive case discussions.

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

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

12:30 – 12:50 PM
Biomechanics of Spinal Instrumentation
Timothy C. Ryken

12:50 – 1:10 PM
Management of Recurrent Lumbar Stenosis and/or Disc Herniation
David O. Okonkwo

1:10 – 1:30 PM
Management of Adjacent Segment Failure
Michael W. Groff

1:30 – 1:45 PM
Break

1:45 – 2:05 PM
Management of Iatrogenic Cervical Deformity
Iain H. Kalfas

2:05 – 2:30 PM
Case Presentations and Discussion

12:30 – 2:30 PM
Grand Canyon 10

LUNCHEON SYMPOSIUM II

Neurosurgeon as CEO: Business Aspects of Spinal Surgery

$200 includes lunch

Course Directors: *Domagoj Coric, John J. Knightly*

Faculty: *E. Hunter Dyer, Mark R. McLaughlin*

Course Description: This course will examine neurosurgery from the philosophy of the small business operation. It will review the basics of revenue generation, transactions with third-party payors, marketing, and operations including management of expenses and personnel.

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

- Differentiate the mechanisms of revenue generation as well as critically examine future scenarios to change in revenue generation.
- Critically examine operations including costs, personnel and efficiency.
- Distinguish and apply different management paradigms for small business.

12:30 – 12:50 PM
Revenue Generation: Ancillary Income-Surgicenter/Imaging Center
Domagoj Coric

12:50 – 1:00 PM
Discussion

1:00 – 1:20 PM
Marketing Your Practice
Mark R. McLaughlin

1:20 – 1:30 PM
Discussion

1:30 – 1:45 PM
Break

1:45 – 2:05 PM
Efficiency in Operations: Personnel/Expenses
E. Hunter Dyer

2:05 – 2:25 PM
Third Party Payors - Negotiations
John J. Knightly

2:25 – 2:30 PM
Discussion

12:30 – 2:30 PM
Grand Canyon 11

LUNCHEON SYMPOSIUM III

Cranial-Cervical Junction

$200 includes lunch

Course Directors: *Curtis A. Dickman, Jean-Paul Wolinsky*

Faculty: *Christopher P. Ames, Dean Chou, Arnold H. Menezes, Volker K.H. Sonntag*

Course Description: This course will discuss contemporary data and experience in treating pathology of the cranial-cervical junction. This course will be in a case-based interactive format with didactic presentations. Faculty will discuss their evaluation and treatment algorithms surrounding pathology of the CCJ. The focus will be on understanding the pathophysiology of various conditions and how treatment strategies have evolved with better understanding of this region.

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

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

12:30 – 12:45 PM
Pathology of the Craniocervical Junction and Closed and Open Reduction Techniques
Dean Chou

12:45 – 1:00 PM
Transoral and Extended Transoral Procedures
Arnold H. Menezes

1:00 – 1:15 PM
Transnasal Approach
Christopher P. Ames

1:15 – 1:30 PM
Transcervical Approach
Jean-Paul Wolinsky

1:30 – 1:45 PM
Break

1:45 – 2:00 PM
Traumatic Dislocations of the Craniocervical Junction
Volker K.H. Sonntag

2:00 – 2:15 PM
Occipital Cervical Instrumentation
Curtis A. Dickman

2:15 – 2:30 PM
Discussion

12:30 – 2:30 PM
Grand Canyon 12
LUNCHEON SYMPOSIUM IV

Geriatric Spine
$200 includes lunch
Course Directors: *James S. Harrop, Gregory R. Trost*
Faculty: *Daniel Robert Fassett, Shaun T. O'Leary, Srinivas K. Prasad, Daniel M. Sciubba, Michael P. Steinmetz*
Course Description: This course will review degenerative disease from the perspective of the aging spine. It will examine basic spinal pathology and determine what effects these processes will have in regards to surgical and non-surgical management in the elderly, as well as their societal and economic impact.
Learning Objectives: Upon completion of this course, participants should be able to:
- Appraise the complexities when dealing with geriatric patients with spinal disorders, specifically focusing on osteoporosis, odontoid fractures, and traumatic central cord injuries.
- Determine how diseases of the aging shift treatment protocols and the modification that may be employed for the surgical and non-surgical management of the aging spine.

12:30 – 12:35 PM
Introduction
Gregory R. Trost

12:35 – 12:45 PM
Osteoporosis and Surgery
James S. Harrop

12:45 – 12:55 PM
Degenerative
Srinivas K. Prasad

12:55 – 1:10 PM
Degenerative Deformity
Daniel Robert Fassett

1:10 – 1:20 PM
Trauma - Odontoid Fractures Type II vs. Type III
Daniel M. Sciubba

1:20 – 1:30 PM
Trauma - Central Cord Injuries
Shaun T. O'Leary

1:30 – 1:40 PM
Trauma – VCF
Michael P. Steinmetz

1:40 – 2:30 PM
Case Presentations

12:30 – 2:30 PM
Grand Canyon 13
LUNCHEON SYMPOSIUM V

Spinal Arthroplasty
$200 includes lunch
Course Directors: *Regis W. Haid, Praveen V. Mummaneni*
Faculty: *Domagoj Coric, Robert J. Hacker, Brian R. Subach*
Course Description: Participants in this course will review outcome data of cervical and lumbar arthroplasty. Pearls and pitfalls of experienced surgeons will be discussed. Complications and their avoidance will be outlined. A comparison between arthroplasty and arthrodesis will be elucidated.
Learning Objectives: Upon completion of this course, participants should be able to:
- Appraise the indications and contraindications for arthroplasty.
- Assimilate the associated complications and management strategies for them.

12:30 – 12:50 PM
Current Status and Outcomes of Lumbar Arthroplasty
Brian R. Subach

12:50 – 1:10 PM
Current Status and Outcomes of Cervical Arthroplasty
Domagoj Coric

1:10 – 1:30 PM
Lessons Learned in Cervical Arthroplasty
Robert J. Hacker

1:30 – 1:45 PM
Break

1:45 – 2:00 PM
Update on Cervical Arthoplasty Studies
Praveen V. Mummaneni

2:00 – 2:30 PM
Case Discussion

1:30 – 5:30 PM
Desert Conference Suite III
SPECIAL COURSE VIII

Peripheral Nerve Exposures and Nerve Repair Techniques
Complimentary for Resident Members
$200 includes lunch
Course Directors: *Robert J. Spinner, Lynda Jun-San Yang*
Faculty: *Allan J. Belzberg, Marie-Noëlle Hébert-Blouin, Line Jacques, Rajiv Midha, Shaun T. O'Leary, Eric L. Zager*
Course Description: This course will demonstrate the common exposures to peripheral nerves in the upper extremity and common techniques used for peripheral nerve reconstruction. It is targeted to practicing surgeons, senior residents and fellows.
Learning Objectives: Upon completion of this course, participants should be able to:
- Synthesize the pertinent and practical surgical anatomy of the brachial plexus and peripheral nerves in the upper limb as related to common nerve injuries, nerve entrapments, and other nerve disorders.
- Distinguish common techniques utilized in the reconstruction of peripheral nerves (direct repair, grafting, nerve transfers, and nerve conduits).

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

1:30 – 1:45 PM
Exposure to the Supraclavicular Brachial Plexus
Robert J. Spinner

1:45 – 1:50 PM
Discussion

1:50 – 2:05 PM
Exposure to the Infraclavicular Brachial Plexus
Lynda Jun-San Yang

2:05 – 2:10 PM
Discussion

2:10 – 2:40 PM
Radial and Ulnar Nerve Exposures
Eric L. Zager

2:40 – 2:45 PM
Discussion

2:45 – 3:00 PM
Median Nerve Exposures
Line Jacques

3:00 – 3:20 PM
Approaches to the Axillary and Suprascapular Nerves
Marie-Noëlle Hébert-Blouin

3:20 – 3:30 PM
Discussion

3:30 – 3:45 PM
Break

3:45 – 4:10 PM
Lower Extremity Exposures
Shaun T. O'Leary

4:10 – 4:15 PM
Discussion

4:15 – 4:40 PM
Techniques for Nerve Repair/Reconstruction
Rajiv Midha

4:40 – 5:10 PM
Techniques for Common Nerve Transfers
Allan J. Belzberg

5:10 – 5:30 PM
Cases

1:30 – 5:30 PM
Desert Conference Suite IV

SPECIAL COURSE IX

Evaluation and Management of the Spine Trauma Patient

Special Course for Nurses, Nurse Practitioners and Physician Extenders.
$110 includes lunch
Course Directors: *Mark Edwin Shaffrey, Andrea L. Strayer, MSN, CNRN, ACNP*
Faculty: *Sanjay S. Dhall, Jeffrey R. Holtz, PA, Adam S. Kanter, David O. Okonkwo, Charles A. Sansur, Justin S. Smith, Eve C. Tsai*
Course Description: This course will provide practical, current didactic information on spine trauma with particular emphasis on an update on medical therapies and intensive care after a complete injury; radiographic interpretation and classification schemes of cervical as well as thoracolumbar fractures. Interactive case presentations will illustrate treatment and care considerations. Expert faculty will explore the challenges of caring for this complex patient population.
Learning Objectives: Upon completion of this course, participants will be able to:

- Analyze current evidence regarding steroid therapy and hypothermia after SCI.
- Evaluate radiographic evaluation following spinal trauma and classification of fracture types.
- Distinguish radiographic evidence as well as care considerations for facet fractures, ligamentous injury, and upper cervical spine including odontoid fractures.
- Develop and apply ICU care considerations following a complete SCI.

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 extenders 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.

1:30 – 2:00 PM
Steroid Therapy and Hypothermia
David O. Okonkwo

2:00 – 2:35 PM
0 – C2: Radiographs, Classification, Nonoperative vs. Operative
Charles A. Sansur

2:35 – 3:05 PM
Subaxial: Radiographs, Classification, Nonoperative vs. Operative
Justin S. Smith

3:05 – 3:30 PM
Complete SCI – ICU Evidence and Pearls
Sanjay S. Dhall

3:30 – 3:45 PM
Break

3:45 – 4:30 PM
T/L Trauma Management
Adam S. Kanter

4:30 – 4:50 PM
Care Consideration of the T/L Junction; Including Neuro/B/B/Postoperative
Jeffrey R. Holtz, PA

4:50 – 5:30 PM
SCI – What Does the Future Hold?
Eve C. Tsai

YOUNG NEUROSURGEONS' DINNER

6:30 PM
Wildflower A/B

Special Presentation by Dr. Robert F. Heary

All residents, fellows and young neurosurgeons are welcome. Please RSVP to DePuy Spine, a Johnson & Johnson Company, Booth #505.

SATURDAY
MARCH 12

6:30 – 6:55 AM
Grand Saguaro North
Case Presentations
Moderators: *Meic H. Schmidt, Jau-Ching Wu*

6:55 – 8:15 AM
Grand Saguaro North

ORAL POSTER SESSION III

Moderators: *Yevgeniy Khavkin, Justin S. Smith*

6:55 – 7:00 AM
230. Defining the Role of Early Surgical Decompression After Traumatic Spinal Cord Injury: Results of a Canadian Multicenter Study
Michael G. Fehlings, Jefferson Wilson, Anoushka Singh, Catharine Craven, Henry Ahn, Brian Drew, Michael Ford

7:00 – 7:05 AM
231. Age-Related Changes in Neurologically Intact Human Spinal Cords Assessed Using Diffusion Tensor MR Imaging
Shekar N. Kurpad, Marjorie C. Wang, Michael Jirgis, Brian Schmit, John L. Ulmer, Brian Shender, Brian D. Stemper, Narayan Yoganandan, Allison Hyngstrom

7:05 – 7:10 AM
232. A Combined Neuroprotective Immuno-modulatory Therapy Mitigates Early Bladder Dysfunction After Experimental Spinal Cord Injury
Daniel J. Hoh, John H. Shin, Megan Clark, Christopher A. Iannotti, Ran Harel, Nico van Rooijen, Hai-Hong Jiang, Margot Damaser, Michael P. Steinmetz

7:10 – 7:15 AM
233. The Role of Nitric Oxide in Secondary Spinal Cord Injury: Insights from a New Transgenic Model
George Al Shamy, Bettina Keller, Philippe Campeaux, Brendan Lee

7:15 – 7:20 AM
234. The Impact of Weekend Hospital Admission on the Timing of Intervention and Outcomes After Surgery for Acute Spinal Cord Injury in the United States, 2005-2008
Hormuzdiyar H. Dasenbrock, Timothy F. Witham, Daniel M. Sciubba, Ziya L. Gokaslan, Ali Bydon

7:20 – 7:23 AM
Discussion

7:23 – 7:28 AM
235. Long-term Outcomes of Patients with Multilevel Ossification of the Posterior Longitudinal Ligament After Laminectomy, Laminoplasty and Laminectomy & Fusion: A Meta-Analysis of Observational Studies
Hormuzdiyar H. Dasenbrock, Mohamad Bydon, Gayane Yenokyan, Timothy F. Witham, Ziya L. Gokaslan, Ali Bydon

7:28 – 7:33 AM
236. Assessment of Potential Predictors of Long Term Outcomes of Surgery for Cervical Spondylotic Myelopathy: Clinical, Demographics and MR Imaging Factors
Michael G. Fehlings, Alina Karpova, Abhaya Vivek Kulkarni, Aileen Davis, Eric M. Massicotte

7:33 – 7:38 AM
237. The AOSpine North America Cervical Spondylotic Myelopathy Study: Perioperative Complication Rates Associated with Surgical Treatment Based on a Prospective Multicenter Study of 302 Patients
Justin S. Smith, Christopher I. Shaffrey, Branko Kopjar, Paul M. Arnold, Sangwook Yoon, Alexander R. Vaccaro, Darrel S. Brodke, Michael Janssen, Jens Chapman, Rick Sasso, Eric J. Woodard, Robert J. Banco, Eric M. Massicotte, Mark B. Dekutoski, Ziya L. Gokaslan, Christopher Bono, Michael G. Fehlings

7:38 – 7:43 AM
238. Spinal Injuries in Children and Adolescents
Jan Stulik, Jan Kryl, Michal Barna, Petr Nesnidal

7:43 – 7:48 AM
239. Diffusion Tensor MR Imaging in Rats with Varying Spinal Contusion Severity
Shekar N. Kurpad, Brian Schmit, Michael Jirjis, Mohammed Ali Jazayeri, John L. Ulmer

7:48 – 7:52 AM
Discussion

7:52 – 7:57 AM
240. CTA Screening for Vertebral Artery Injury in Transverse Foramen Fractures in 320 Patients
Sanjay S. Dhall, Albert Jesse Schuette, Jack Barrow, Gerald E. Rodts, Jr., Daniel L. Barrow

7:57 – 8:02 AM
241. Dens Fractures in Patients over 65 Years of Age: Anterior Screw Fixation of the Dens Versus Posterior Fixation of C1-C2
Jan Stulik, Jan Kryl, Petr Nesnidal

8:02 – 8:07 AM
242. A Pilot Evaluation of the Role of Bracing in Stable Thoracolumbar Burst Fractures
Mohammed F. Shamji, Darren Roffey, Don Chow, Joseph O'Neil, Garth Johnson, Daryl Young, Eugene Wai

8:07 – 8:12 AM
209. En Bloc Resection of Cervical Chordomas: Series of 12 Patients and Clinical Outcomes
Daniel M. Sciubba, Camilo A. Molina, Ziya L. Gokaslan, Dean Chou, Jean-Paul Wolinsky, Timothy F. Witham, Ali Bydon, Christopher P. Ames

8:12 – 8:15 AM
Discussion

8:15 – 8:20 AM
Meeting Announcements
Moderators: *Daryl R. Fourney, Praveen V. Mummaneni*

8:20 – 9:40 AM
Grand Saguaro North
David Cahill Memorial Controversies – Spine and Peripheral Nerves
Moderators: *Charles Kuntz, IV, Praveen V. Mummaneni*
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:
- Analyze the treatment options for synovial cysts.
- Distinguish risks and benefits of surgery vs. nonsurgical care for thoracolumbar burst fractures.
- Evaluate the role of fusion after lumbar discectomy.
- Identify the indications for surgery in degenerative scoliosis.

8:20 – 8:40 AM
Synovial Cyst - Decompression vs. Fusion
Faculty: *Robert F. Heary vs. Philip R. Weinstein*

8:40 – 9:00 AM
Burst Fracture Intact
Faculty: *Eric J. Woodard vs. James S. Harrop*

9:00 – 9:20 AM
Recurrent Lumbar Disc – Fuse or Not
Faculty: *Gerald E. Rodts, Jr. vs. R. John Hurlbert*

9:20 – 9:40 AM
Degenerative Scoliosis Presenting with Radiculopathy - Simple Decompression vs. Multilevel Fusion
Faculty: *Iain H. Kalfas vs. Christopher I. Shaffrey*

9:40 – 10:25 AM
Grand Canyon Ballroom
BEVERAGE BREAK WITH EXHIBITORS

10:25 – 11:05 AM
Grand Saguaro North
FELLOWSHIP AWARDS AND UPDATES

Adam S. Kanter, Daniel M. Sciubba, Marjorie C. Wang

10:25 – 10:30 AM
Award Presentations

SPINE CLINICAL TRIALS FELLOWSHIP PRESENTATIONS

10:30 – 10:42 AM
Miminally Invasive vs. Open TLIF for Spondylolisthesis
Khalid M. Abbed

10:42 – 10:54 AM
CSM – Can Outcome Be Predicted by Diffusion Tensor Imaging?
Marjorie C. Wang

10:54 – 11:05 AM
A Web-based Registry for Comparative Effectiveness Research for Back Pain in the Wisconsin Population
Basheal M. Agrawal

11:05 AM – 12:35 PM
Grand Saguaro North
ORAL POSTER PRESENTATIONS IV

Moderators: *Tanvir Choudhri, Paul Park*

11:05 – 11:10 AM
244. Determination of the Minimum Improvement in Pain, Disability, and Health State Associated with Cost-Effectiveness: Introduction of the Concept of Minimum Cost Effective Difference (MCED)
Scott Parker, Owoicho Adogwa, Brandon J. Davis, Clint Devin, Matthew J. McGirt

11:10 – 11:15 AM
245. Comparative Effectiveness of Minimally Invasive vs. Open Transforaminal Lumbar Interbody Fusion: Two-year Assessment of Narcotic Use, Return to Work, Disability, and Quality of Life
Owoicho Adogwa, Scott Parker, Oran Aaronson, Joseph S. Cheng, Matthew J. McGirt

11:15 – 11:20 AM
246. Comparative Analysis of Surgical Site Infection After Minimally Invasive vs. Open Posterior/Transforaminal Lumbar Interbody Fusion: Analysis of Hospital Billing and Discharge Data from 5,328 Patients
Matthew J. McGirt, Scott Parker, Jason Lerner, Luella Engelhart, Michael Y. Wang

11:20 – 11:25 AM
247. Endoscopic Image-Guided Transcervical Odontoidecomy: Long-Term Outcomes of 15 Patients with Basilar Invagination
Hormuzdiyar H. Dasenbrock, Michelle J. Clarke, Ali Bydon, Daniel M. Sciubba, Timothy F. Witham, Ziya L. Gokaslan, Jean-Paul Wolinsky

11:25 – 11:30 AM
248. Minimally Invasive Treatment of Adjacent Segment Degeneration via XLIF
Jody A. Rodgers, W.B. Rodgers, Edward J. Gerber

11:30 – 11:35 AM
Discussion

11:35 – 11:40 AM
249. Comparative Clinical Outcomes Following Minimally Invasive L5-S1 Interbody Fusion, Comparison of TLIF, ALIF, and AxiaLif for Single-level Arthrodesis
Zachary Adam Smith, Larry T. Khoo

11:40 – 11:45 AM
250. Cost-utility Analysis of Minimally Invasive vs. Open Multilevel Decompression for Lumbar Stenosis
Owoicho Adogwa, Brandon J. Davis, Erin Fulchiero, Oran Aaronson, Joseph S. Cheng, Clint Devin, Matthew J. McGirt

11:45 – 11:50 AM
251. Minimally Invasive Lateral Access Surgery for Symptomatic Thoracic Disc Herniation: Initial Clinical Experience with Clinical and Radiographic Outcomes
Glen Pollock, Elias Dakwar, Mark Greenberg, Fernando L. Vale, William D. Smith, Juan S. Uribe

11:50 – 11:55 AM
252. Early Radiographic Outcomes of XLIF in the Minimally Invasive Treatment of Adult Scoliosis: Results from a Prospective Multicenter Non-randomized Study of 107 Patients
Frank M. Phillips, Safdar Khan, Solas Degenerative Study Group

11:55 AM – 12:00 PM
253. Economic Impact of Minimally Invasive Spine Surgery Open vs. MIS Spinal Fusion Costs in the Perioperative Period (First 45 Days)
Jody A. Rodgers, W.B. Rodgers, John Lucio, Brent Vanconia, Kevin J. DeLuzio

12:00 – 12:05 PM
Discussion

12:05 – 12:10 PM
254. Perioperative Outcomes and Complications Following XLIF for the Treatment of Adult Scoliosis: Results of a Prospective, Non-randomized, Multicenter Evaluation
Robert E. Isaacs, Jonathan Hyde, J. Allan Goodrich, W.B. Rodgers, Frank M. Phillips, Solas Degenerative Study Group

12:10 – 12:15 PM
255. Correlation of Preoperative Depression and Somatic Perception Scales with Postoperative Disability and Quality of Life After Lumbar Discectomy
Scott Parker, Kaisorn L. Chaichana, Owoicho Adogwa, Joseph S. Cheng, Matthew J. McGirt

12:15 – 12:20 PM
256. Microdiscectomy Improves Pain-associated Depression, Somatic Anxiety, and Mental Well-being in Patients with Herniated Lumbar Disc
Scott Parker, Richard L. Lebow, Owoicho Adogwa, Adam S. Reig, Joseph S. Cheng, Matthew J. McGirt

12:20 – 12:25 PM
257. Management of Degenerative Lumbar Stenosis Related to Meyerding Grade I Spondylolisthesis: The Reappraisal of Unilateral Laminotomy
Mario Ganau, Enrico De Micheli, Massimo Gerosa

12:25 – 12:30 PM
258. Determination of Minimum Clinically Important Difference (MCID) in Pain, Disability, and Health State Utility After Transforaminal Lumbar Interbody Fusion (TLIF) for Degenerative Lumbar Spondylolithesis
Scott Parker, Owoicho Adogwa, Alexandra Paul, Bill Anderson, Oran Aaronson, Joseph S. Cheng, Matthew J. McGirt

12:30 – 12:35 PM
Discussion

EXHIBIT HALL – GRAND CANYON BALLROOM

The Exhibit Hall, located in the Grand Canyon Ballroom, will feature: More than 60 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* presentations.

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

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

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

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

Exhibit Hall Hours

Thursday, March 10
9:00 AM – 7:00 PM

Friday, March 11
9:00 AM – 12:00 Noon

Saturday, March 12
9:00 AM – 12:00 Noon

Beverage Break and *What's New* Sessions

Thursday, March 10
9:30 – 10:15 AM
12:30 – 1:25 PM*
3:00 – 3:45 PM

Friday, March 11
9:30 – 10:15 AM

Saturday, March 12
9:40 – 10:25 AM

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

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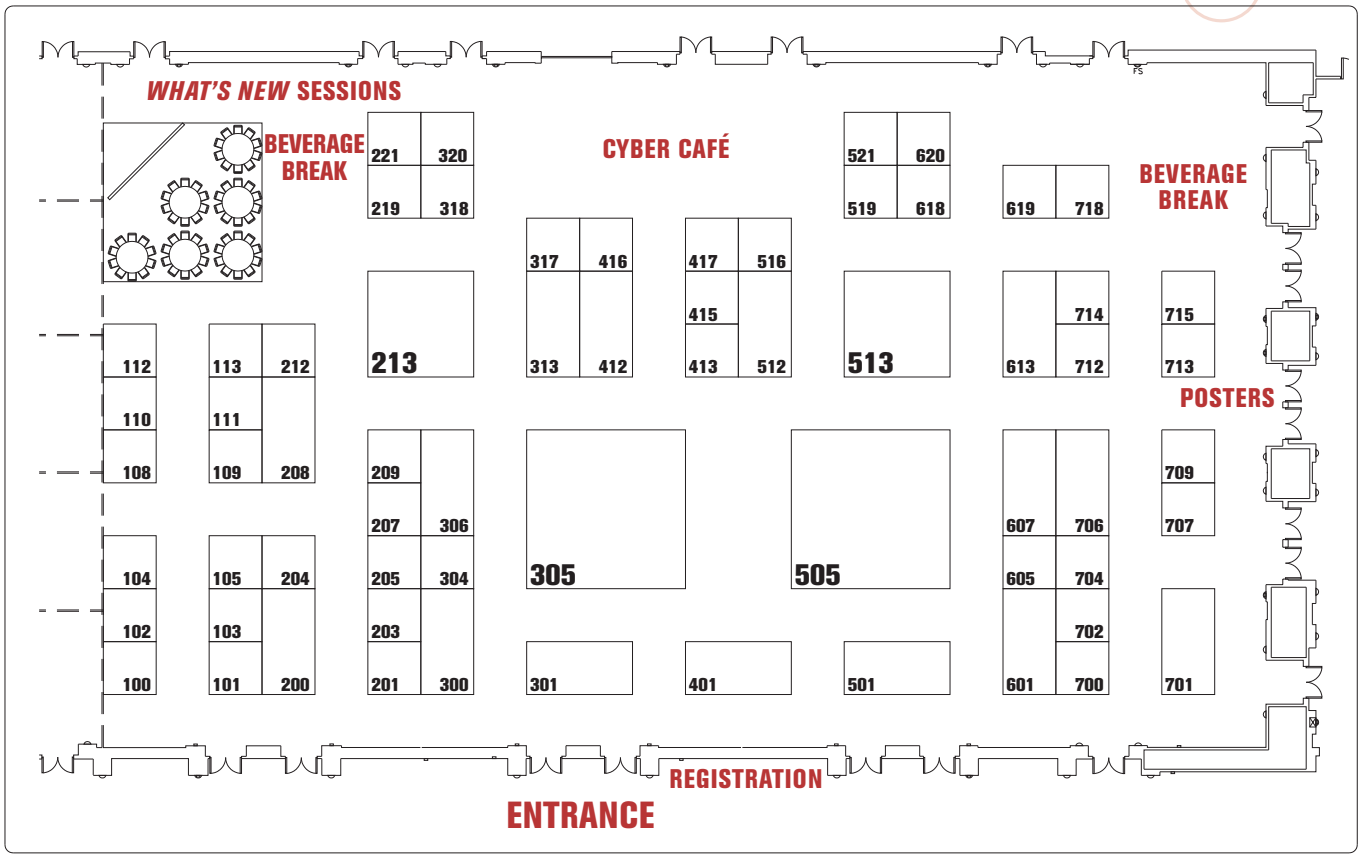

Find the latest research, procedures, products and services during *What's New* sessions! Join these Exhibitors in the Demonstration Theater for special 10-minute presentations!

THURSDAY, MARCH 10, 2011

9:30 – 10:15 AM
Presentations Supported by:
NuVasive
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12:30 – 1:25 PM
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3:00 – 3:45 PM
Presentations Supported by:
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FRIDAY, MARCH 11, 2011

9:30 – 10:15 AM
Presentations Supported by:
Nuvasive
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ORAL PLATFORM ABSTRACTS

Thursday and Friday, March 10-11 at 10:15 AM
Grand Saguaro North

A nine-minute presentation by the primary author is followed by a short discussion period.

100
In Situ Placement of High-dose rhBMP-2 within Spine Tumors Slows Tumor Growth and Decreases Onset to Paralysis in a Rat Model of Metastatic Breast Cancer

Camilo A. Molina, Rachel Sarabia-Estrada, Guergana Panayotova, Antonio Aguilera, Ziya L. Gokaslan, Jean-Paul Wolinksy, Ali Bydon, Daniel M. Sciubba

Introduction: Recombinant human bone morphogenic proteins (rhBMPs) are FDA-approved for specific spinal fusion procedures, but use is contraindicated in spine tumor resection beds due to unclear interaction between tumor tissue and such growth factors. Interestingly, a number of studies suggest that BMPs may slow growth of adenocarcinomas in vitro, and adenocarcinomas represent the majority of histopathologies found in bony spine tumors. In this study, we hypothesized that high concentration rhBMP-2 placed in an intraosseous spine tumor rat model could show tumor suppression and prolong onset to paralysis in such animals.

Methods: 21 female nude athymic rats were randomized into three groups. Group 1 (n=7) underwent transperitoneal exposure and implantation of breast adenocarcinoma (CRL-1666) into the L6 lumbar spine segment, followed by implantation of 15 micrograms of rhBMP-2. Group 2 (n=7) underwent exposure and tumor implantation on the lumbar spine, but no local treatment with rhBMP-2. Group 3 (n=7) solely underwent exposure of the lumbar spine. The Basso-Beattie-Bresnahan (BBB) scale was used to monitor daily motor function regression and time to paresis (BBBscore< 7).

Results: No animals in Group 1 were paretic by day 15 (median BBB score of 20, p=<0.0027). All animals in Group 2 were paretic by day 15 (median BBB score of 0, p=0.0024) with a mean time to paresis (±SD) of 13.5±1.4 days. Time to paresis was significantly different between Group 1 and Group 2 (p<0.001). Group 3 (control) exhibited no neurological motor deficit. Gross and microscopic tumor volume was also significantly (p<0.048) different between Groups 1 and 2.

Conclusion: This study shows that high-dose administration of local rhBMP-2 in a rat spine tumor model of breast cancer not only fails to stimulate local tumor growth, but also decreases local tumor growth and onset of paresis in animals. This is the first preclinical experiment showing that local placement of rhBMP-2 in a spine tumor bed may slow tumor progression and delay associated neurological decline.

101
The Effect of Surgery on Health Related Quality of Life and Functional Outcome in Patients with Metastatic Epidural Spinal Cord Compression: Initial Results of the AOSpine North America Prospective Multicenter Study

Michael G. Fehlings, Branko Kopjar, Alexander R. Vaccaro, Paul M. Arnold, Charles Fisher, Ziya L. Gokaslan, James M. Schuster, Mark B. Dekutoski, Joel Finkelstein, Laurence D. Rhines

Introduction: Metastatic epidural spinal cord compression (MESCC) is common and recent studies have provided evidence that in selected patients combined surgery and radiotherapy provides the optimal neurological recovery. However, patients with MESCC have relatively short life-expectancy and face numerous challenges. Hence, the impact of surgery on improving quality of life outcomes in the setting of MESCC is less clear.

Methods: 72 surgical patients were enrolled in a prospective multicenter, cohort study involving 8 sites in North America. Outcomes were assessed using the pain assessments, ASIA scale, SF-36v2, and EQ-5D.

Results: Average age was 58 years (SD 11), 65% were males. Common primary sites were lungs (32%), prostate (15%), breast (11%), and kidney (11%). The baseline EQ5D was .38; SF36PCS 32; SF36MCS 39, VAS Pain 6.1; ASIA Impairment grade at baseline was 35% (E), 45% (D), 14% (C), 3% (B) and 3% (A). Median survival was 157 days; 93% survived one month; 62% survived 3 months, 41% survived 9 months, 32% survived 12 months. Among the surviving patients, the average improvement at 3 months was for .23 for EQ5D (P< .001), 26 for ODI (P < .001) , 2.6 for VAS Pain (P < .05). Also, there was a significant improvement in ASIA Impairment grade (P < .05). There was no significant change in SF36 PCS and MCS. The gains in EQ5D, ODI and VAS Pain were maintained in patients who survived 6 months.

Conclusion: Surgically treated patients with MESCC have poor survival. Among the surviving patients, the surgical treatment is associated with improvement in symptoms and functional outcomes. However, this does not translate into significant gains in overall health related quality of life. Individuals with less than three month life expectancy may be less than ideal candidates for surgical intervention. Further follow-up and a larger sample size in this ongoing study will help to identify subgroups of patients who may benefit from the surgical intervention.

102
Survival of Patients with Malignant Primary Osseous Spinal Neoplasms from the Surveillance, Epidemiology, and End Results (SEER) Database from 1973-2005

Kaisorn L. Chaichana, Scott Parker, Owoicho Adogwa, Debraj Mukherjee, Oran Aaronson, Joseph S. Cheng, Ziya L. Gokaslan, Matthew J. McGirt

Introduction: Malignant primary osseous spinal neoplasms are aggressive tumors which remain associated with poor outcomes. To date, prognosis is based upon small single center series. In order to assess national trends in histology-specific survival, we reviewed survival data spanning 30 years from the surveillance, epidemiology, and end results (SEER) registry.

Methods: The SEER registry (1973-2003) was queried to identify primary spinal chordoma, chondrosarcoma, osteosarcoma, or Ewing's sarcoma via ICD-O-2 coding. Survival was assessed via Cox proportional-hazards regression analysis.

Results: 1,892 patients were identified with primary osseous spinal neoplasms (414 chordoma, 579 chondrosarcoma, 430 osteosarcoma, 469 Ewing's sarcoma). Chordomas presented in older (59±17, p<0.01) and Ewing's Sarcoma in younger (19±11, p<0.01) patients vs. other tumors. The incidence of each tumor type remained similar per decade. African-Americans comprised a significantly greater proportion of osteosarcoma than other tumors (9.6 vs. 3.5%, p<0.01). Mobile spine vs. sacrum was more often location for chordomas than other tumors (47% vs. 23%, p<0.05). Osteosarcoma and Ewing's Sarcoma were 3-fold more likely to present with metastasis (31% vs. 8%). Surgical

resection was performed more frequently for chordoma (88%) and chondrosarcoma (88%) than osteosarcoma (61%) and Ewing's (53%). Median survival was histology specific (Osteosarcoma: 11mo, Ewing's: 26mo, chondrosarcoma: 37mo; chordoma: 50mo) Survival was worse in patients with metastasis at presentation, Figure 1, but unaffected by site (mobile spine vs. sacrum/pelvis) Figure 2. More recent year of diagnosis was associated with greater utilization of surgery (OR1.23, p<0.001) and improved survival for isolated spinal Ewing's sarcoma (HR, 0.95, p=0.001), chondrosarcoma (HR, 0.98, p=0.009), and chordoma (HR, 0.98, p=0.10) but was not associated with increased utlization of surgery (OR, 1.01, p=0.43) or survival for osteosarcoma, Figure 3.
Conclusion: In our analysis of a 30-year U.S. population based cancer registry (SEER), we provide nationally representative prognosis and survival data for malignant primary spinal osseous neoplasm. Use of surgery and overall survival has improved for isolated spine tumors with advancements in care over the past four decades. These results may be helpful in providing historical controls for understanding the efficacy of new treatment paradigms patient education and guiding level of aggressiveness in treatment strategies.

103
Electrical Stimulation Enhances Axon and Nerve Regeneration

Rajiv Midha, Bhagat Singh, Qing Gui Xu, Colin Franz, Colin Dalton, Tessa Gordon, Doug Zochodne

Introduction: Axon regeneration after peripheral nerve injury is delayed and incomplete. Brief low frequency electrical stimulation (ES) applied immediately after injury is known to improve axonal regeneration. With these findings, we aimed to explore several new features of this interesting property.
Methods: We examined early axon and Schwann cell (SC) outgrowth beyond transection sciatic nerve injuries in mice comparing sham ES to brief ES (3V, 20Hz, and pulse width 0.1 ms for 1 hr) delivered only at the time of injury. In a second approach to examine early axon outgrowth, an identical protocol was examined using harvested adult rat sensory neurons in vitro stimulated over a novel microelectrode array construct.
Results: We identified accelerated outgrowth beyond the repair site of both axons and SCs following ES. These early benefits translated into an ongoing impact of ES on regeneration. There was enhanced myelinated axon repopulation by 21 days across transection sites, with higher numbers of retrogradely labelled motor neurons regenerating their axons. In thy-1 GFP mice with fluorescent peripheral axons, we confirmed the early impact on outgrowth and identified earlier arrival of GFP cutaneous axons in peripheral sensory targets. This was strongly correlated with more rapid recovery of mechanical and thermal sensation in the foot and of compound muscle action potentials beyond the injury site. The in vitro paradigm identified robust immediate rises in neurite initiation of the stimulated neurons and improved outgrowth as compared to control conditions.
Conclusion: These data support the robust role of brief ES following peripheral nerve trunk injuries in promoting axon initiation and outgrowth after transection, in axon maturation and in repopulation of targets. This is a wider repertoire of impact than previously known and its replication in vitro supports the hypothesis that a neuron specific reprogrammed injury response is recruited by the ES protocol.

104
Efficacy and Active Ingredients in an Epidural Analgesic Paste after Lumbar Decompression: A Prospective Randomized Double-Blind Controlled Trial

Roberto Jose Diaz, S. Terence Myles, R. John Hurlbert

Introduction: The purpose of this study was to evaluate the efficacy and active components of a previously described epidural analgesic paste in controlling postoperative pain and facilitating early discharge from hospital after lumbar decompressive surgery.
Methods: A prospective randomized double-blind controlled trial was conducted. Two-hundred and one patients were randomized to one of four analgesic epidural pastes at the time of lumbar spinal surgery: combo paste (morphine + methylprednisolone), steroid paste (methylprednisolone alone), morphine paste (morphine alone), and placebo. The primary outcome measures used were narcotic and non-narcotic use and McGill Pain Questionnaire (MPQ). Secondary outcome measures were: modified ASIA score, SF-36, time to ambulation and discharge from hospital.
Results: Administration of combo and steroid paste, but not morphine paste resulted in a statistically significant reduction in mean PRI and PPI components of the MPQ in the first 3 days after surgery. Narcotic analgesic consumption was reduced on postoperative day 1 in the combo paste and steroid paste groups. No difference in time to ambulation or discharge, general health perception, ABPI scores, or neurological recovery was observed.
Conclusion: We have demonstrated the efficacy of epidural analgesic paste containing methylprednisolone acetate to produce a robust postoperative analgesic effect. This paste should be considered for use in patients undergoing routine lumbar decompressive surgery.

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Radiographic Same-level Recurrent Disc Herniation After Lumbar Discectomy: Prospective Longitudinal Study with Two-year Follow-up

Scott Parker, Richard L. Lebow, Owoicho Adogwa, Scott Parker, Adrija Sharma, Oran Aaronson, Joseph S. Cheng, Matthew J. McGirt

Introduction: To date, the incidence of radiographic same-level recurrent disc herniation has not been studied prospectively with sequential imaging. Furthermore, the clinical relevance of radiographic recurrent disc herniation on MRI after discectomy remains unknown, particularly in patients without symptoms or with poorly localized pain after surgery. We previously reported factors associated with symptomatic same-level recurrent disc herniation from this cohort. In a post-hoc analysis, we set out to determine the incidence of asymptomatic same-level recurrent disc herniation and assess their effect on two-year outcome.
Methods: One hundred and eight patients undergoing lumbar discectomy for a single-level herniated disc at five institutions were prospectively followed for two years. CT and MRI of the lumbar spine were obtained every three months to assess re-herniation and disc height loss. Leg and back pain visual analogue scale (VAS), Oswestry Disability Index (ODI), and quality of life (SF-36 physical component) were assessed 3, 6, 12, and 24 months after surgery.
Results: No patients demonstrated residual disc on postoperative MRI. By two years after discectomy, 25 (23.1%) patients had demonstrated radiographic evidence of recurrent disc herniation at the level of prior discectomy (mean 11.8 ± 8.3 months after surgery), the majority of which were asymptomatic [14 (13%)] patients. The occurrence of asymptomatic re-herniation was not

associated with disc height loss or any outcome measure (VAS, ODI, SF-36) by two years.
Conclusion: In a prospective cohort study with serial imaging, nearly one-fourth of patients undergoing lumbar discectomy demonstrated radiographic abnormality suggestive of recurrent disc herniation at the level of prior surgery, the majority of which were asymptomatic. Asymptomatic disc herniation was not associated with clinical consequences by two years. Clinically silent recurrent disc herniation is not uncommon after lumbar discectomy. When obtaining MRI evaluation within the first two years of discectomy, providers should expect that radiographic evidence of re-herniation may be encountered and that treatment should only be considered when correlating radicular symptoms exist.

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Cost Effectiveness of Multilevel Hemilaminectomy for Lumbar Stenosis Associated Radiculopathy

Erin Fulchiero, Brandon J. Davis, Owoicho Adogwa, Oran Aaronson, Joseph S. Cheng, Clint Devin, Matthew J. McGirt

Introduction: Laminectomy for lumbar stenosis associated radiculopathy is associated with improvement in pain, disability, and quality of life. However, given rising healthcare costs, attention has been turned to question the cost-effectiveness of lumbar decompressive procedures. The cost-effectiveness of multilevel hemi-laminectomy for radiculopathy remains unclear. We set out to assess the comprehensive medical and societal costs of multi-level laminectomy at our institution and determine its cost-effectiveness in the treatment of degenerative lumbar stenosis.
Methods: Fifty-four consecutive patients undergoing multilevel hemi-laminectomy for lumbar stenosis associated radiculopathy after 6 months of conservative therapy were included. Over a two-year period, total back-related medical resource utilization, missed work, and improvement in pain (VAS-LP), disability (Oswestry Disability Index (ODI)), quality of life (SF-12), and health-state values [quality adjusted life years (QALYs), calculated from EQ-5D with U.S. valuation] were assessed. Two-year resource use was multiplied by unit costs based on Medicare national allowable payment amounts (direct cost) and patient and care-giver work-day losses were multiplied by the self-reported gross-of-tax wage rate (indirect cost). Mean total two-year cost per QALY gained after TLIF was assessed.
Results: Compared to preoperative health states reported after at least 6 months of medical management, a significant improvement in VAS-BP, ODI, and SF-12 (physical and mental components) was observed two years after laminectomy, with a mean two-year gain of 0.72 QALYs , Figure 1. Mean ±SD total two-year cost of multilevel hemilaminectomy was $23,477 ±9,912 (Surgery cost: $10,220 ±100; Outpatient resource utilization cost: $2,805 ±1,958; Indirect cost: $10,452 ±9,364). Multilevel hemilaminectomy was associated with a mean two-year cost per QALY gained of $32,606.
Conclusion: Multilevel hemilaminectomy improved pain, disability, and quality of life in patients with lumbar stenosis-associated radiculoapthy. Total cost per QALY gained with multi-level laminectomy was $32,606 when evaluated two years after surgery with Medicare fees, suggesting that multilevel hemilaminectomy is a cost effective treatment of lumbar radiculopathy.

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Provocative Discography Screening Improves Surgical Outcome

Petra Margetic, Marin F. Stancic

Introduction: The objective of the study was comparison of surgical outcomes of patients operated on without discography and patients that underwent discography.
Methods: Study was designed as a randomized controlled trial. According to power analysis study comprised 310 patients divided in the experimental (No=207) and the control (No=103) group. Inclusion criteria were low back pain resistant to the nonsurgical treatment for more than 6 months and conventional radiological findings showing degenerative changes without clear generator of the pain. Exclusion criteria were red flags. Before discography patients filled in Oswestry Disability Index (ODI), SFPF36, Zung and MSPGQ Questioners. At 1-year follow-up examination patients filled in ODI, SFPF36, Likert scale which analyzing satisfaction with procedure and answer to the question would he/she repeat discography if it would be necessary.
Results: With independent t-test group without discography preoperative had ODI P 0.002 between patients with DDD and other generator of the pain while the postoperative had P 0.433. Preoperative SFPF had P 0.001 but postoperative P were 0.360. VAS preoperative had P 0.953 and postoperative 0.003. In a group with discography ODI and SFPF preoperative and postoperative had P<0.001. VAS preoperative had P 0.306 and postoperative <0.001. With dependent t-test in both groups with/without discography ODI, SFPF and VAS preoperative and postoperative had P <0.001.
Conclusion: DDD treated surgically without discography didn't reach clinically significant improvement of 15 ODI points as recommended by FDA for the patients treated with fusion. Provocative discography screening with psychological testing in the trial group made improvement following fusion clinically significant. For other degenerative generators of the pain discography didn't prove useful diagnostic tool. As there were no post discography spondilodiscitis and patients are willing to repeat procedure if it would be necessary, our results suggest discography use in preoperative workout of patients with DDD.

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The Impact of Surgeon Professional Fees to the National Cost of Healthcare

Camilo A. Molina, Ziya L. Gokaslan, Timothy F. Witham, Ali Bydon, Jean-Paul Wolinsky, Daniel M. Sciubba

Introduction: With the increased attention given to the large amount of national funds supporting health care in the United States, there have been significant changes in the reimbursement system for surgical procedures by the federal government. In efforts to decrease overall spending, individual surgeons have seen yearly reimbursement cuts. In this study, we reviewed the charges and reimbursements at a major academic institution for lumbar laminectomy and compared the amounts reimbursed to the hospital and to the surgeon.
Methods: The reimbursement schedule of an academic spine surgeon was collected over twelve months for lumbar laminectomy procedures. Bills and collections by the hospital and professional fees of the surgeon were obtained for comparative analysis.
Results: During a twelve-month period, patients underwent a lumbar laminectomy involving on average 3 levels and stayed in the hospital on average 2.3 days. Complications were uncommon (13%). Average professional-fee billing for the surgeon was $8,200.00 and collection was $1,647.79 (24% for private and 18% for Medicare/Medicaid

insurance). Average hospital billing for the inpatient hospital stay minus professional fees from the surgeon was $19,348 and average collection on such bills was $17,758 (92% for Private and 89% for Medicare/Medicaid insurance). Percentage of total costs for such procedures that was allocated to surgeon reimbursement was 12% for private and 7% for Medicare/Medicaid insurance.
Conclusion: Current strategies for containing rising health care costs include decreasing physician reimbursement; unfortunately, overall health care costs continue to rise. Based on this analysis, the proportion of overall costs allocated to professional fees for surgical procedures is small, while those allocated to hospital costs, which includes hospital stay, drugs, implants, imaging, and rehabilitation, etc., are far greater. Findings suggest that the current focus on decreasing physician reimbursement as the principal cost saving strategy will lead to minimal reimbursement for surgeons without substantial drop in the overall cost of national healthcare.

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Effect of Patient Pain Expectations and Preoperative SF-36 Mental Component Summary Scores on Clinical Outcomes Following Anterior Cervical Discectomy and Fusion

Frances A. Carr, Theresa Hernandez, Kyle M. Healy, Ewell Lee Nelson, Alexander Mason, Sigita Burneikiene, Alan T. Villavicencio

Introduction: The primary purpose of this study was to analyze if preoperative patient expectations and SF-36 MCS scores have any effect on clinical outcomes.
Methods: A prospective clinical study was performed. This study included 79 (38 males, 41 females) patients who underwent one- to three-level ACDF surgery. Preoperatively, patients were asked to rate their expected pain after surgery and complete VAS neck/arm (0-10), NDI and SF-36 PCS/MCS scales. Patients were divided into two groups for the expectation analyses: complete resolution of pain (n=44) and some pain expected (n=35) postoperatively. The above clinical parameters and patient satisfaction with results scores were measured postoperatively. The mean follow up was 38.8 months (range, 7-59).
Results: Overall, all postoperative measures depicted significant improvement (Table 1). Patient demographics and clinical parameters were comparable preoperatively between the expectation groups (Table 2, 3). Controlling for respective preoperative scores, patients who expected no pain reported lower postoperative neck/arm pain ($p<0.02$), higher SF-36 MCS ($p=0.04$) and higher satisfaction with results ($p=0.007$) scores, although no significant differences were detected in postoperative NDI or SF-36 PCS scores compared with patients that expected some pain. Furthermore, controlling for respective preoperative scores, higher preoperative SF-36 MCS scores significantly predicted lower postoperative neck pain ($p=0.003$) and NDI ($p=0.004$) scores, and higher postoperative SF-36 PCS ($p=0.002$), SF-36 MCS ($p=0.001$) and satisfaction ($p=0.03$) scores.
Conclusion: Patients who expected no pain postoperatively reported better postoperative scores on the more subjective outcome measures (VAS arm and neck, satisfaction with results), as well as the SF-36 mental component score. Patients with higher preoperative mental component scores had better clinical outcomes (VAS neck, NDI, SF-36 PCS/MCS, satisfaction with results). The results suggest that optimism in patients' expectations as well as other potential psychological factors predict improved clinical outcomes and patient satisfaction.

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Factors Associated with the Occurrence of Perioperative Complications in the Treatment of Cervical Spondylotic Myelopathy Based on 302 Patients from the AOSpine North America Cervical Spondylotic Myelopathy Study

Justin S. Smith, Christopher I. Shaffrey, Branko Kopjar, Paul M. Arnold, Sangwook Yoon, Alexander R. Vaccaro, Darrel S. Brodke, Michael Janssen, Jens Chapman, Rick Sasso, Eric J. Woodard, Robert J. Banco, Eric M. Massicotte, Mark Dekutowski, Ziya L. Gokaslan, Christopher Bono, Michael G. Fehlings

Introduction: Surgery is often warranted for cervical spondylotic myelopathy (CSM). Our objective was to assess for clinical and surgical factors associated with the occurrence of complications in the surgical treatment of CSM based on a prospective multicenter study.
Methods: The AOSpine North America CSM study is a recently completed prospective multicenter study of patients surgically treated for CSM. Rates of perioperative complications (within 30 days of surgery) were assessed and stratified based on clinical and surgical factors.
Results: 302 patients were enrolled (mean age: 57 years, range: 29-86). Of 332 reported adverse events, 73 were adjudicated to be complications, including 25 major (8%) and 48 minor (16%). Of patients treated with anterior-only (n=176), posterior-only (n=107), and combined anterior-posterior procedures (n=19), 11%, 19%, and 37%, respectively, had one or more complications ($p=0.008$). Procedures including a posterior approach had a significantly higher rate of infection (6.3% vs 0.6%, $p=0.005$). Dysphagia was significantly more common with anterior-only (2.3%) or combined anterior-posterior (21.1%) procedures, compared with posterior-only procedures (0.9%, $p<0.001$). C5 radiculopathy/palsy was not significantly associated with surgical approach ($p=0.8$). Occurrence of complications was significantly associated with increased operative time ($p<0.001$), increased blood loss ($p<0.001$), and inclusion of a fusion ($p=0.01$), but not with age ($p=0.9$), body-mass index (BMI, $p=0.7$), smoking ($p=0.3$), prior surgery ($p=0.09$), or number of operated vertebrae ($p=0.9$).
Conclusion: For the surgical treatment of CSM, operative factors, including surgical approach, operative time and blood loss, have stronger associations with the occurrence of perioperative complications than do patient factors, such as age, BMI, and smoking.

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Comparative Economic Analysis of Ventral vs. Dorsal Surgery for Cervical Spondylotic Myelopathy

Andrew Becker, Robert Gray Whitmore, Susan Christopher, Jill Curran, Benjamin Baskin, Zoher Ghogawala

Introduction: The objective of this study was to determine the optimal surgical approach (ventral vs. dorsal) for patients with 3-4 levels of stenosis resulting in cervical spondylotic myelopathy (CSM).
Methods: A prospective, non-randomized, 8-center trial was conducted. Patients aged 40-79 years with 3-4 levels of degenerative cervical spondylosis resulting in CSM were enrolled. Four outcome assessments (SF-36, Oswestry Neck Disability Index (NDI), mJOA, EuroQol-5D) were obtained preoperatively and postoperatively at 6 months and 1 year. A hospital-based economic analysis used costs derived from total hospital charges and year-specific cost-to-charge ratios.
Results: This study enrolled fifty-six patients (mean age – 62 years; gender –

57% male). Ventral decompression and fusion (VF) was performed on twenty-five patients, dorsal laminectomy with fusion (DF) on twenty-four, and dorsal laminectomy without fusion (L) on nine. One-year follow-up data was available on 73% of the cohort. Baseline demographics and outcome assessments were comparable at baseline. DF patients had significantly longer lengths of stay than VF (4.4 days vs. 3.1 days, P=0.03). VF patients showed significant 1-year improvements for each of the four outcome measures and DF patients showed significant improvement in the mJOA. VF patients showed larger 1-year improvements than DF in 3 of the 4 assessments (Figure 1). Thirteen VF, seventeen DF, and five L patients were included in the cost analysis (Figure 2). VF was clearly cost-effective when compared to DF.

Conclusion: Of the three surgical strategies, ventral decompression with fusion resulted in the most significant 1-year functional improvement when treating 3-4 levels of spondylosis. In addition, ventral decompression with fusion is a cost-effective treatment option for CSM when compared to dorsal laminectomy both with and without fusion.

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Functional and Quality of Life Outcomes in Geriatric Patients with Type II Odontoid Fracture: One-Year Results from the AOSpine North America Multicenter GOF Prospective Study

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

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

Methods: We conducted a prospective multicenter cohort study of subjects > 65 years old with a Type II odontoid fracture at 13 sites in North America. Patients received nonoperative or surgical treatment at the discretion of the surgical team and were followed for 12 months. Outcomes assessments included the SF36, Neck Disability Index (NDI) and rates of mortality and complications.

Results: A total of 166 subjects were recruited (average age: 80.7 (SD 7.6)); 59.6% females of whom 65.6% were treated operatively (15.2% anterior odontoid screw; 76.2% posterior C1- C2 screw fixation; 6.7% posterior transarticular screw fixation and 1.9% other). A total of 26 (15.7%) subjects expired and 5 subjects withdrew from the study. Follow-up was available for 100 (74%) of 135 eligible, surviving subjects. The baseline NDI was 21.9 (SD 17.0) and SF36v2 PCS was 41.0 (SD 10.5). At 12 months, the NDI worsened by 7.5 (SD 18.1) points (P < .001) and SF36v2 PCS declined by 2.3 (SD 10.4) points (P = .03). There was a significant difference in NDI outcomes between the surgically and the conservatively treated group. The decline in NDI among the surgical cases was 4.7 points compared to 13.0 points in the conservatively treated group (P = .017). There were no differences in the SF36v2 PCS outcomes between the treatment groups.

Conclusion: In spite of treatment, elderly patients with Type II odontoid fracture experience significant mortality and decline in functional outcomes at one year follow-up. Our results do suggest that NDI outcomes may be better in the surgical group, though the possibility of selection bias needs to be carefully considered.

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Prospective, Randomized, Multicenter Study of Cervical Arthroplasty: 269 Patients from the Kineflex/C Metal-on-Metal Artificial Disc IDE Study with Minimum Two-Year Follow-up

Domagoj Coric, Richard D. Guyer, Pierce D. Nunley, Charley Gordon, Thomas Dimmig, Cameron Carmody, Donna D. Ohnmeiss, Margaret Boltes

Introduction: This prospective, randomized, multicenter study evaluates the safety and efficacy of a new metal-on-metal cTDR implant (the arthroplasty) by comparing it to ACDF.

Methods: The study was a prospective, randomized FDA IDE pivotal trial conducted at 21 centers across the US. The primary clinical outcome measures included the Neck Disability Index (NDI), visual analog scales (VAS), and a composite measure of clinical success. Patients were evaluated clinically and radiographically preoperatively and at 1.5, 3, 6, 12, and 24 months after surgery.

Results: A total of 269 patients were enrolled and randomly assigned to either cTDR (n=136) or to ACDF (n=133). The overall success rate was significantly greater in the cTDR group (74%) compared to the ACDF group (62%) (p=0.05). In both the cTDR and ACDF groups, the mean NDI and VAS scores improved significantly by 6 weeks after surgery and remained significantly improved throughout the 24-month follow-up (p<0.001). The range of motion (ROM) in the cTDR group was significantly greater than the pre-op at 12- and 24-month follow-up. Adjacent level degeneration was also evaluated in both groups from pre-op to 2 year follow-up and classified as: none, mild, moderate or severe. Pre-op, there were no significant differences between groups when evaluating the different levels of adjacent level degeneration. However, at 2 year follow-up, there were significantly more patients in the ACDF group with severe adjacent level radiographic changes (p<0.01).

Conclusion: The arthroplasty was associated with a significantly greater overall success rate compared to fusion while maintaining motion at the index level. Furthermore, there were a significantly fewer arthroplasty patients showing severe adjacent level radiographic changes at two year follow-up. These results from a prospective, randomized study support that arthroplasty cTDR is a viable alternative to ACDF in select patients with cervical radiculopathy.

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Cervical Disc Replacement: Interim Five-year Follow-up Results from the United States Prospective Randomized Bryan Clinical Trial

Richard G. Fessler, Rick Sasso, Paul Anderson, John Heller

Introduction: The purpose of this study is to evaluate the currently available data at half of a decade to determine their consistency over time and to assess complications and revision surgeries.

Methods: 463 patients were enrolled and received the study surgical treatments in a prospective, randomized, controlled, multicenter study with a 1:1 randomization scheme. No statistical differences were seen between the groups for demographics and preoperative measures. As of May 28, 2010, 5-year follow-up data were available for 193/242 (79.8%) of the arthroplasty patients and 159/221 (71.9%) of the control patients. The study's primary outcome measure, overall success, as well as secondary functional outcome measures (NDI, SF-36, arm and neck pain scores), were collected at pre-defined time points out to 60 months postoperatively.

Results: At 60 months: Overall success rate: 160/193 (82.9%) for the arthroplasty group, 119/159 (74.8%) for the control group, p=0.043; NDI score: 15.9 arthroplasty, 19.1 control, p=0.020 (Change from preop: -35.6 arthroplasty, -30.2 control, p=0.020); Neck pain score: 23.8 arthroplasty, 28.8 control, p=0.031 (Change from preop: -51.3 arthroplasty, -45.2 control, p=0.031); and SF-36 PCS: 47.3 arthroplasty, 44.0 control, p=0.006 (Change from preop: 14.4 arthroplasty, 11.8 control, p=0.006); Cumulatively up to 60 months: Second surgery at index level: 11 (4.5%) arthroplasty, 11 (5.0%) control; Possibly device-related AEs: 9 (3.7%) arthroplasty, 14 (6.3%) control; Possibly device-related and serious (grade 3 or 4) AEs: 4 (1.7%) arthroplasty, 9 (4.1%) control.
Conclusion: Excellent results continue out to 5 years in both the arthroplasty and ACDF groups. Statistically significant differences are present for overall success that favor the arthroplasty cohort. The NDI, SF-36 PCS and neck pain scores also showed improvement in the arthroplasty group that was statistically significant at 60 months compared to the control group. Second surgery and adverse events were very low in both groups with no statistically significant differences between groups at half a decade postoperatively.

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Are Closed Suction Drains in Posterior Spinal Surgery "The Devil's Highway" for Infection?

James S. Harrop, Srinivas K. Prasad, John Kevin Ratliff, Mitchell Gil Maltenfort, Phyllis Flomenberg, Ashwini Dayal Sharan, Alex Vaccaro, Shilpa Rao

Introduction: Surgeons advocate placement of extra-axial subfascial drains after posterior spine surgery to reduce postoperative collections (i.e.: hematomas). This may potentially decrease neurologic complications and possibly decrease infectious rates. However, the potential adverse consequences of increased infection rate due to foreign body placement have not been determined.
Methods: A retrospective analysis of an infection control prospective database of a single tertiary care surgery population was performed over a one-year period. Posterior instrumented spinal fusion procedures were assessed for surgical site infections (SSIs) and analyzed against case-controls (1:3 ratio). Specifically, the placement of subfascial drains and their duration of placement and how this correlated was explored
Results: 1587 fusion procedures were performed during this one-year period of which 42 posterior instrumented fusions developed wound site infections (2.6%). Infections were diagnosed a mean of 14.6 ±9 days post-procedure and skin flora (Staphylococcus aureus) was the most common pathogen (65%). Infected instrumented posterior spinal fusion procedures had a longer duration of subfascial drains than controls (median 5 days vs. 3 days, respectively [p<0.0001; log-rank test]). At a breakpoint of drain duration > 5 days, the OR of infection was 14.2 (95% CI = 5.6-35.9; p < 0.0001) Multivariate logistic regression indicated that likelihood of infection increased with drain duration (Odds Ratio, 1.5 per day drain present [95% CI, 1.2 - 2.0; p < 0.0001]) and was higher for males (OR 2.8; 95% CI 1.2-6.6; p = 0.01). Proportional hazards test determined that the probability of drains being removed on any given day was lower (i.e., longer drain duration) for infected cases (Risk Ratio 0.4, 95% CI=0.3-0.6, p < 0.0001) and possibly for longer surgeries (RR per hour 0.9, 95% CI = 0.8-1.01, p=0.08).
Conclusion: The increased duration of time after the placement of posterior subfascial closed suction drains after instrumented spinal fusions appears to correlate with an increased incidence of surgical site infection. Therefore, shorter durations of time (specifically lesss than four days) or elimination of these drainage catheters may decrease the overall infection rates in this subpopulation of spine surgery patients.

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Clinical and Radiographic Factors Driving the Transition from Nonoperative to Operative Treatment in Elderly Adults with Degenerative Scoliosis

Kai-Ming G. Fu, Justin S. Smith, Christopher I. Shaffrey

Introduction: Few studies report the long-term outcomes of elderly adult degenerative scoliosis patients treated nonoperatively. In addition, the rate of crossover of nonoperatively managed patients and the factors influencing this crossover has not been demonstrated. In order to address these questions, we prospectively followed a cohort of such patients presenting to a surgical clinic for evaluation.
Methods: 92 consecutive adult degenerative scoliosis patients (age >60, mean 69) were followed prospectively upon presentation to the surgical clinic. All were initially managed nonoperatively. Quantitative measures of health status (SF-12 and ODI), VAS pain scores, and radiographic parameters were recorded. Patient follow-up was recorded at specified biennial time points or when a patient was treated operatively. Statistical analysis was performed via T-Test with a P<0.5 considered significant.
Results: 73 patients (79%) were followed for a minimum of 2 years (mean 2.64 years) or became operative patients. Of these 18 (25%) went on to have surgery in the follow-up period with a mean time to surgery of 1.6 years. There were no differences at presentation in age, health status (SF-12, ODI), leg pain, back pain, or sagital balance between those that crossed over and those that were "successfully" treated conservatively. At last follow-up or pre-surgical follow-up, crossover patients had lower SF-12 scores (P=.033), higher disability scores (p=0.04), and worse back (6.8 vs. 4.8 (p=0.002)) and leg (5.4 vs. 3.0 (p=0.002)) pain. There were no differences in radiographic parameters. Of note there was no significant overall progression of sagittal balance or maximum coronal curve. Patients continuing conservative therapy did not demonstrate significant changes in SF -12 and ODI scores.
Conclusion: There is a significant rate of crossover in nonoperatively managed elderly scoliosis patients. Those crossing over reported higher disability and worse pain and health. Patients continuing nonoperative therapy report stable, but not improved, outcome measures.

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Incidence of Vascular Encroachment Resulting from Free Hand Placement of Pedicle Screws in the Thoracic and Lumbar Spine: Analysis of 6,816 Consecutive Screws

Scott L. Parker, Anubhav Amin, Ali Bydon, Daniel M. Sciubba, Jean-Paul Wolinsky, Ziya L. Gokaslan, Timothy F. Witham

Introduction: Iatrogenic major vascular injuries during anterior instrumentation procedures have been reported by several authors, but there is a paucity of data regarding major vascular injuries during posterior instrumentation procedures. The purpose of this study is to evaluate the incidence and clinical significance of vascular encroachment resulting from free-hand placement of pedicle screws in the thoracic and lumbar spine.
Methods: We retrospectively reviewed records of all patients undergoing free-hand pedicle screw placement without image guidance in the thoracic or lumbar spine between June 2002-June 2009.

Incidence and extent of vascular encroachment by a pedicle screw was determined by review of routine postoperative CT scans obtained within 24 hours of all surgeries. Vascular encroachment was defined as a screw touching or deforming the wall of a major vessel.

Results: Nine-hundred sixty-four patients received 6816 free-hand pedicle screws in the thoracic or lumbar spine. Fifteen (0.22%) screws were identified to encroach upon a major vascular structure. Ten (67%) thoracic screws encroached on the aorta, 4 (27%) lumbar screws on the common iliac vein, and 1 (6%) S1 screw on the internal iliac vein,Figure 1. The spinal level of involvement is depicted in Figure 2. Consultation with vascular surgery was utilized to determine if revision surgery was recommended and the technique/approach for the revision procedure. Two (11.7%) patients required revision surgery to remove the encroaching pedicle screw (T5 and T8) due to concern for vascular injury. Both patients requiring revision were asymptomatic and recovered without further complications after revision surgery.

Conclusion: Vascular encroachment of major vessels occurs rarely in the setting of free-hand pedicle screw placement in the thoracic and lumbar spine. Although rare, delayed vascular injury from errant pedicle screw placement has been reported in the literature. Aorta is the vessel at highest risk of injury. Routine intraoperative and postoperative CT scanning allows for early identification of screws encroaching on vascular structures thereby facilitating early revision surgery.

AWARDS PROGRAM ABSTRACTS

Friday, March 11
9:00 AM
Grand Saguaro North

An eight-minute presentation by the primary author is followed by a short discussion period.

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MAYFIELD BASIC SCIENCE AWARD
Evidence of Descending Supraspinal Control of Nociception and Pain Behavior in Experimental Disc-Herniation Radiculopathy

Mohammed F. Shamji, Priscilla Hwang, Kyle D. Allen, Mosfata Gabr, J. Chen, Liufang Jing, William J. Richardson, Lori A. Setton

Introduction: Disc-herniation induced radiculopathy involves both mechanical compression and biochemical inflammation of apposed neural elements.(1-3) Recent evidence suggests heterotopic disc placement induces early and persistent allodynia alongside transient pathological gait asymmetry.(1) This suggests divergent molecular effects at spinal and supraspinal levels. This study evaluated the inflammatory and analgesic molecular profile observed at the dorsal root ganglion (DRG) and midbrain periaqueductal grey and red nucleus in an animal disc-herniation disease model.

Methods: Sprague-Dawley rats underwent surgical procedure including harvesting autologous nucleus pulposus (NP) from a tail intervertebral disc and exposure of the L5 dorsal root ganglion (DRG). Control animals (n=12) underwent exposure only and experimental animals received NP placement onto the DRG (n=12). Animals were evaluated for mechanical allodynia and for stance and gait symmetry. Following sacrifice (1 or 4 weeks), the DRG and midbrain were evaluated by immunohistochemistry for inflammatory activation and neurotransmitter receptors respectively.

Results: Persistent mechanical allodynia occurred in rats subjected to NP stimulation at 1 and 4 weeks, although this heightened sensitivity had the functional consequence of early gait asymmetry (1 week) with late normalization (4 weeks) (Figure 1). Injured animals revealed early and persistent inflammatory glial cell activation at the DRG, paralleling the allodynia phenotype. Conversely, midbrain studies reveal persistently high glutamate receptor expression, high serotonin receptor expression at 1 week with late normalization, and early normal opioid receptor expression with late escalation at 4 weeks (Figure 2).

Conclusion: Persistent mechanical allodynia with only transient gait abnormality in this model of non-compressive disc herniation suggests deficits to be mediated by both spinal and supraspinal mechanisms. Inflammatory DRG activation may generate persistent allodynia and promote gait asymmetry. Early midbrain serotonin and glutamate receptor expression may aggravate this deficit while late opioid receptor expression may permit adaptive response to normalize behavior.

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MAYFIELD CLINICAL SCIENCE AWARD
Perioperative Use of Dexamethasone in Multilevel Anterior Cervical Spine Surgery: Preliminary Results of a Prospective, Randomized, Double-Blinded Trial

Tyler J. Kenning, Karen Petronis, John W. German, Doniel Drazin, Darryl J. Dirisio

Introduction: Anterior approaches to the cervical spine involve some retraction affecting the midline structures of the anterior neck. Steroids given intraoperatively may reduce the incidence of adverse outcomes, such as dysphagia and airway compromise. Their use has historically been controversial during spinal arthrodesis procedures due to concern that anti-inflammatory agents could reduce bony fusion rates.

Methods: A prospective, randomized, double-blinded study in patients undergoing multilevel anterior cervical spine surgery is being conducted at Albany Medical Center. Our hypothesis is that perioperative steroids decrease postoperative swallowing and airway complications and don't impact long-term fusion rates. The target enrollment is 200 subjects with 2-year follow-up. This preliminary data reflects an interim analysis of the first 53 patients. We studied patients undergoing multilevel (>2 motion segments) anterior cervical spine procedures. Patients were randomized to receive intraoperative doses of either intravenous dexamethasone (0.2 mg/kg IV; n=28) or an equivalent volume infusion of saline (n=25). Four postoperative doses of 0.06mg/kg of steroid or placebo were

administered every 6 hours for the first 24 hours. Preoperative parameters,including baseline demographics, smoking history, pain and functional status (mJOA,NDI,SF-12,VAS), swallowing function (functional outcome swallowing scale, FOSS) and diagnosis were reviewed. Postoperative data included length of inpatient stay, FOSS, mJOA, VAS, SF-12, and fusion status, assessed by CT, at 6 months. Any postoperative complications were noted.
Results: There were no statistical differences in preoperative parameters of age, gender, diagnosis, smoking history, number of operative levels, mJOA, FOSS, NDI, SF-12, or VAS between the 2 groups. FOSS, when assessed in the immediate postoperative period, was significantly lower in the steroid(S) group when compared to the placebo(P) group (S:0.59±0.80, P:1.23±0.92, p=0.01). This significance was lost at the 1, 3, and 6-month follow-up. There were no significant differences in any of the other postoperative measures,including 6 month fusion status. One patient in the placebo group required postoperative re-intubation, and one patient in the steroid group required PEG tube placement secondary to prolonged dysphagia.
Conclusion: Our preliminary data suggests that perioperative steroids decrease postoperative swallowing complications without negatively impacting long-term fusion rates.

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OUTCOMES COMMITTEE AWARD
Analysis of the Three United States FDA-IDE Cervical Arthroplasty Trials

Cheerag Upadhyaya, Jau-Ching Wu, Regis W. Haid, Vincent C. Traynelis, Bobby Tay, Domagoj Coric, Gregory R. Trost, Scott A. Meyer, Praveen V. Mummaneni

Introduction: There are three randomized, multicenter, United States FDA IDE, industry sponsored studies comparing arthroplasty with anterior cervical discectomy and fusion (ACDF) for single level cervical disease with complete 2-years of follow-up. The studies evaluated the PRESTIGE ST, BRYAN, and ProDisc-C artificial discs. We analyzed the combined results of these three trials.
Methods: A total of 1,213 patients with symptomatic, single-level cervical disc disease were randomized into two treatment arms in the 3 randomized trials. 621 patients received an artificial cervical disc and 592 patients were treated with ACDF. 94% of the arthroplasty group and 87% of the ACDF group have completed two years of follow-up. We analyzed the 2-year data from these three trials including previously unpublished source data. Statistical analysis was performed with both fixed and random effects models.
Results: Analysis demonstrated preserved segmental sagittal motion with arthroplasty (preoperatively 7.26 degrees and postoperatively 8.14 degrees) at the two-year timepoint. The fusion rate for ACDF at two years was 95%. The NDI, SF-36 MCS, SF-36 PCS, VAS neck pain, and VAS arm pain scores were not statistically different between groups at 24-months follow-up. The arthroplasty group demonstrated superior results at 24-months in neurological success (RR 0.595, I^2=0%, p=0.006). The arthroplasty group had a lower rate of secondary surgeries (RR 0.508, I^2=0%, p=0.018). The reoperation rate for adjacent level disease was lower for the arthroplasty group when we analyzed the combined data set using a fixed effects model (RR 2.23, I^2=2.9%, p=0.026).
Conclusion: Both ACDF and arthroplasty demonstrate excellent two year surgical results for the treatment of one level cervical disc disease with radiculopathy. Arthroplasty is associated with a lower rate of secondary surgery and a higher rate of neurological success at 2 years. Arthroplasty may be associated with a lower rate of adjacent level disease at 2 years.

ORAL POSTER ABSTRACTS

Thursday and Saturday, March 10 at 3:45 PM
Grand Saguaro North
Grand Canyon 9
March 12 at 6:55 AM & 11:05 AM
Grand Saguaro North

Five-minute presentations by the primary authors are followed by a short discussion period during these concurrent sessions.

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Pulsed Electromagnetic Field Bone Growth Stimulation for High Risk Fusion Patients: An Analysis of 452 Consecutive Cases

Naresh P. Patel, Barry D. Birch, Mark K. Lyons, Richard S. Zimmerman, Stacie DeMent, Gregg Elbert, Orland K. Boucher, Amy Theiler

Introduction: Pseudarthrosis occurs in up 10-15% of instrumented spinal fusion cases, often requiring revision surgery (1). High risk patients including diabetics, smokers, and those undergoing multi-level fusion or revision surgery have demonstrated higher pseudarthrosis rates(1,2). Patients with multiple risk factors pose an even greater treatment challenge(3,4). Bone Morphogenetic Protein (BMP) has been used increasingly to help promote fusion in high risk patients, but due to side effects, risks and cost may not be suitable for all patients(5). The authors describe their experience with a consecutive series of patients undergoing adjunctive treatment with an external bone growth stimulator to achieve successful fusion.

Methods: Between 2001-2009, 452 high risk patients underwent instrumented fusion surgery at the Mayo Clinic Arizona. 95 cervical and 357 lumbar cases were identified. Fusion was performed with iliac crest autograft and allograft in the lumbar spine and allograft alone in the cervical spine. No BMP was used. Each patient was fitted with an external pulsed electromagnetic field bone growth stimulator within two weeks of surgery which was worn for at least 2 hours/day for a minimum of 6 months. Follow-up was obtained at two week, three month and one year postoperatively with radiographs and CT scans.

Results: In the cervical fusion group there were 88 solid fusions and 7 pseudarthroses (92.6% fusion rate). In the lumbar group there were 339 solid fusions and 18 pseudarthroses (94.9% fusion rate). There were no complications or side effects associated with the use of the stimulator.

Conclusion: Bone growth stimulation following standard fusion techniques in this large series of high risk patients led to fusion rates greater that 90% in both the cervical and lumbar spine. Based on efficacy and safety, external bone growth stimulation appears to be a reasonable adjunctive treatment to promote fusion in high risk patients.

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Preservation of Segmental Motion with Anterior Contralateral Cervical Microdiskectomy and Interbody Fat Graft: Prospective Study

Yunus Aydin, Halit Çavusoglu, Cengiz Tuncer, Osman Nuri Türkmenoglu, Ahmet Murat Müslüman

Introduction: The aim of our study is to evaluate the results and effectiveness of this minimal invasive technique with or without interbody fat graft replacement in patients with cervical paramedian disc herniations.

Methods: This prospective observational study was undertaken for the analysis of 330 patients with cervical paramedian disc herniation who underwent one -or adjacent two-level anterior contralateral microdiskectomy without fusion between 1992 and 2009. Interbody fat graft raplacement were performed on 91 of 340 patients (Group 2). The mean follow up time was 10 years (range 1 - 16 years). Preoperative and postoperative lateral dynamic cervical radiographs were obtained and, the presence of a reduction in the height of interspace and spontaneous osseous union at the diskectomy level were investigated. Surgeries were done by the senior author (YA). Clinical outcomes were assessed using the Neck Disability Index and Short Form 36.

Results: Despite fusion procedures were not performed, spontaneous radiological fusion signs were obtained in 12% of group 1 patients. Follow-up radiological studies revealed healing without fusion in group 2 patients. There was no significant change in the mean overall cervical curvature (C2 - 7) angles postoperatively in late follow-up findings ($p = 0.77$). It represented a statistically significant mean loss of 2.24 degree of segmental lordosis ($p < 0.001$). The NDI scores decreased significantly in both early and late follow-up evaluations and the SF-36 scores demonstrated significant improvement in late follow-up results in two groups. Analysis of clinical outcome showed no statistical differences between two groups ($p = 0.77$).

Conclusion: Anterior contralateral microdiscectomy without fusion achieves better exposure for resection of the offending foraminal or far lateral lesions, ventral osteophytes, or a disc fragment under direct microscopic visualization. Collapse, loss of motion and, instability of the involved disc level can also be avoided via this less invasive technique and interbody fat graft.

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Radiographic Outcomes in Two-level ACDFs: Comparison of PEEK and Allograft Interbody Devices at 1 and 2-Year Follow-up

Jody A. Rodgers,W.B. Rodgers, Edward J. Gerber

Introduction: In our single-site prospective series of 184 two-level ACDF patients, 100 had the PEEK interbody device, and 84 had the Allograft device. To date, 60 patients have presented for 24-month follow-up.

Methods: 184 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 184 patients, 84 were treated with allograft interbody dowels (27M, 57F; age 60.8 yrs; 33 smokers) and 100 were treated with PEEK spacers (23M, 42F; age 52.4yrs; 15 smokers). Average 12-month Lenke score across all subsets was 1.07 (allograft 1.15; PEEK 1.01). At 24 months, average Lenke scores across all subsets was 1.03 (allograft 1.10, 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-local bone composite contained within allograft dowels or PEEK spacers resulted in similar fusion rates (> 97%) at 12 months postoperatively. Based on Lenke scores, allograft dowels appear to fuse more slowly than PEEK spacers but this may be perceptional.

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Safety, Efficacy, and Dosing of Recombinant Human Bone Morphogenetic Protein-2 (rhBMP-2) for Posterior Cervical and Cervico-thoracic Instrumented Fusion with a Minimum Two-year Follow-up

D. Kojo Hamilton, Justin S. Smith, Davis Reames, Brian Jeremy Williams, Daniel R. Chernavvsky, Christopher I. Shaffrey

Introduction: Considerable attention has focused on concerns of increased complications with rhBMP-2 use for anterior cervical fusion, but few reports have assessed its use for posterior cervical fusions. This study evaluates the safety, efficacy, and dosing of recombinant human bone morphogenetic protein (rhBMP-2) as an adjunct for instrumented posterior cervical arthrodesis using a retrospective consecutive case series.

Methods: All patients were treated by the senior author with posterior cervical or cervico-thoracic instrumented fusion augmentated with rhBMP-2 and had minimum follow-up of two-years. Diagnosis, levels fused, rhBMP-2 dose, complications, and fusion (Lenke grade applied by two neuroradiologists) were assessed.

Results: 53 patients (22 men/31 women) met inclusion criteria, with a mean age of 55.7 years and an average follow-up of 40 months. Surgical indications included basilar invagination (n=6), fracture (n=6), atlanto-axial instability (n=16), kyphosis/kyphoscoliosis (n=22), osteomyelitis (n=1), spondylolisthesis (n=1), cyst (n=1). 15 patients had confirmed rheumatoid disease. The average rhBMP-2 dose was 1.79mg/level with a total of 282 levels treated. Among 53 patients, only 2 complications (3.8%) were identified, a superficial wound infection and an adjacent level degeneration. At last follow-up, all patients had achieved fusion.

Conclusion: Augmentation of posterior cervical fusion with rhBMP-2 appears to be safe and has a very low complication rate. Despite complex pathology and/or rheumatoid arthritis, a 100% fusion rate was achieved, which is considerably higher than comparable historical comparisons without rhBMP-2 (62-94%). Collectively, these data suggest that use of rhBMP-2 as an adjunct for posterior cervical fusion is safe and effective at an average dose of 1.8mg per level.

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Prospective Results from the US IDE Feasibility Study of a Novel Peek-On-Peek Nucleus Replacement Device with Minimum Two-Year Follow-up

Domagoj Coric, Matthew Songer, John J. Regan

Introduction: Nucleus replacement (partial disc replacement) offers a less invasive alternative to traditional fusion or total disc replacement techniques in the treatment of symptomatic lumbar degenerative disc disease (DDD). NUBACTM is the first PEEK-on-PEEK articulated intradiscal arthroplasty device. The authors report the results of 20 consecutive patients treated with NUBAC nucleus replacement in the prospective, multicenter US FDA IDE feasibility clinical study. On the strength of the results of this pilot feasibility study, NUBAC became the first nucleus replacement device to enter US IDE pivotal study.

Methods: Patients with symptomatic DDD at L4-5 were enrolled at three investigational sites in the IDE feasibility study. All devices were placed via a lateral transpsoas approach. Effectiveness is evaluated by prospectively recording pre-op and post-op (at 1.5, 3, 6, 12 and 24 months) Oswestry Disability Index (ODI) and Visual Analog Scale (VAS) scores.

Results: A total of 20 NUBAC devices were implanted in 20 patients. Average OR time was 124 minutes; EBL was 47 cc. Average time to discharge home was 1.4 days. There were no major intra- or postoperative neurological or vascular complications. Average age=41 years. Clinical results showed statistically significant improvement in pain relief and function compared to preop at all time intervals. The mean preoperative VAS (7.1) and ODI (53.9) scores improved significantly at six weeks (3.4 and 30.7, respectively) and were maintained through 2 years (1.8 and 6.3, respectively). There were no device expulsions or reoperations.

Conclusion: This early, prospective clinical experience with NUBAC PEEK-on-PEEK nucleus replacement is promising. NUBAC is currently in prospective, randomized, multicenter FDA IDE pivotal study and those results will continue to define the role of nucleus replacement in the treatment of symptomatic DDD.

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Preoperative Grading Scale To Predict Survival in Patients Undergoing Resection of Malignant Primary Osseous Spinal Neoplasms

Scott Parker, Kaisorn L. Chaichana, Oran Aaronson, Joseph S. Cheng, Ziya L. Gokaslan, Matthew J. McGirt

Introduction: Large population-based studies of malignant primary osseous spinal neoplasms are lacking and are necessary for sufficient power to determine prognostic factors. Using a 30-year U.S. national cancer registry (SEER), we introduce a preoperative grading scale that is associated with survival in patients undergoing surgical resection for malignant primary osseous spinal neoplasms.

Methods: The SEER registry (1973-2003) was queried to identify adult patients undergoing surgical resection of histologically confirmed primary spinal chordoma, chondrosarcoma, or osteosarcoma via ICD-O-2 coding. Variables independently associated with survival were determined via Cox proportional-hazards regression analysis for all tumor types. A grading scale comprised of these independent survival predictors was then developed and applied to each histology-specific tumor cohort.

Results: 342 patients were identified that underwent surgical resection of a malignant primary osseous spinal neoplasms (114 chordoma, 156 chondrosarcoma, 72 osteosarcoma). Overall median survival after surgical resection was histology specific (osteosarcoma: 22 months; chordoma: 100 months; chondrosarcoma: 160 months). Increasing age (years) and increasing tumor extension (1. confined to periosteum; 2. invasion through periosteum into adjacent tissues; 3. distal site metastasis) were the only variables independently associated with decreased survival ($p<0.05$) for all tumor types. For spinal chordoma, sacrum/pelvic location ($p<0.05$) and earlier year of surgery ($p<0.005$) were also independently associated with decreased survival. Utilizing variables of patient age, extent of local tumor invasion, and metastasis status in a five-point grading scale, increasing score (1-5) closely correlated ($p<0.001$) with decreased survival for chordoma, chondrosarcoma, and osteosarcoma, Figure 1.

Conclusion: In our analysis of a U.S. population based cancer registry (SEER), a grading scale consisting of age,

metastasis status, and extent of local tumor invasion was associated with overall survival after surgical resection of chordoma, chondrosarcoma, and osteosarcoma of the spine. This grading scale may offer valuable prognostic data based on variables available to the surgeon and patient prior to surgery and may help guide level of aggressiveness in subsequent treatment strategies.

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Clinical Outcomes Following En Bloc Sacrectomies via Posterior Approach

Michelle J. Clarke, Daniel M. Sciubba, Matthew J. McGirt, Timothy F. Witham, Ali Bydon, Patrick C. Hsieh, Ziya L. Gokaslan, Jean-Paul Wolinsky

Introduction: En bloc resection of primary sacral tumors has a demonstrated survival benefit. Total and high sacral amputations traditionally involved both an anterior and posterior approach. However, we have found that en bloc resection and biomechanical reconstruction is possible from a posterior-only approach in many cases.
Methods: Sixty-nine consecutive patients underwent sacral resections for tumor at our institution between 2004 and 2009. Medical records of all patients were reviewed, and patients were excluded if they had an intentional intralesional resection, hemipelvectomy or were previously operated. The records of the resulting 37 consecutive patients who underwent primary posterior-only en bloc sacral resections and all 4 patients who underwent a traditional anterior-posterior en bloc sacrectomy were retrospectively reviewed.
Results: All posterior-only patients underwent midline posterior approaches for en bloc sacral resection. Surgical level was defined by the anatomic level of the rostral osteotomy site: total with lumbopelvic reconstruction (L5S1; n=5), high (S1S2; n=9), middle (S2S3; n=17), and low (below S3; n=6). Chordoma was the most common tumor (n=30) and wide surgical margins were attained in 35 cases. The level of sacral amputation correlated with estimated blood loss ($p<0.005$), and length of stay ($p<0.001$). There were 14 complications including 9 wound infections/revisions. In the anterior-posterior cohort (n=4), rectal carcimoma was the most common diagnosis. Patients required anterior-posterior procedures because of rectal invasion (n=3) or tumor extending above the L5S1 disc space (n=1). All 4 patients suffered wound complications, and there was 1 life-threatening hemorrhage. Operative time, blood loss, and length of stay was higher than similar posterior-only procedures. In both cohorts, extent of root sacrificed correlated with functional outcome.
Conclusion: It may be possible to perform a posterior-only approach to en bloc sacral resections/reconstructions in patients with tumors that do not extend beyond the lumbosacral junction or invade the bowel.

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Generation of Chordoma Cell Line, JHC7, and the Identification of Brachyury as a Novel Molecular Target

Wesley Hsu, Ahmed Mohyeldin, Sagar R. Shah, Lakesha Johson, Neda I. Sedora-Roman, Thomas Kosztowski, Colette Ap Rhys, Ola Awad, Edward McCarthy, David Loeb, Jean-Paul Wolinsky, Ziya L. Gokaslan, Alfredo Quinones-Hinojosa

Introduction: Recent genomic interrogation of chordomas has identified Brachyury gene duplication as a major susceptibility mutation in familial chordomas. Current understanding of the role of this transcription factor in chordoma is limited due to the lack of a fully characterized chordoma cell line expressing Brachyury. We report the establishment of the first fully characterized primary chordoma cell line (JHC7) expressing Brachyury and demonstrate that silencing of Brachyury using shRNA leads to complete growth arrest in vitro.
Methods: Establishment of Chordoma Cell Line Intraoperatively obtained chordoma specimen was dissociated into single cells using techniques published previously. Confluent cells were passaged to adherent cell culture flasks for expansion. Chordoma cells (JHC7) were maintained in DMEM/F12 (10% FBS) with antibiotic/antimycotic. Lentiviral Transduction A pKLO.1-based lentiviral vector containing shRNA targeting Brachyury was obtained from the TRC-Hs1.0 library from Open Biosystems. Brachyury shRNA and empty plasmids were packaged into lentivirus by transfecting 10µg of packaging plasmids in packaging cells. Forty-eight hours after transfection, lentiviral supernatant was used to infect JHC7 chordoma cells. Growth curve studies were performed using the MTT assay 10 days after transduction.
Results: A novel chordoma cell line was created (JHC7). Cultured cells were morphologically identical to classical chordoma, including the characteristic physaliferous phenotype (Figure 1A). The presence of Brachyury was confirmed by Western Blot and immunohistochemistry (Figure 1B, C). Loss of Brachyury expression after shRNA transduction was confirmed by Western Blot (Figure 2A). Loss of Brachyury expression abolished the classical phenotype of chordoma cells and led to a more differentiated, epithelial-like state (Figure 2B) with a near complete loss of proliferation capacity (Figure 2C).
Conclusion: The JHC7 chordoma cell line represents the first in vitro system with chordoma cells characterized for Brachyury expression. We propose that shRNA-mediated suppression of Brachyury is a novel and attractive therapeutic target in the treatment of chordoma.

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Reconstruction of Extensive Defects from Posterior En Bloc Resection of Sacral Tumors Using Human Acellular Dermal Matrix and Gluteus Maximus Myocutaneous Flaps

Hormuzdiyar H. Dasenbrock, Michelle J. Clarke, Ali Bydon, Timothy F. Witham, Daniel M. Sciubba, Oliver P. Simmons, Ziya L. Gokaslan, Jean-Paul Wolinsky

Introduction: Performing a sacrectomy solely from a posterior approach allows for the en bloc resection of tumors without the additional morbidity of a laparotomy. However, the reconstruction of the resultant extensive soft-tissue defects is challenging, particularly as a vertical rectus abdominis myocutaneous flap is not harvested. We report the largest series (with the longest follow-up) of sacral reconstructions using a combination of human acellular dermal matrix (HADM) and gluteus maximus myocutaneous flaps.
Methods: 34 patients with sacral tumors who had a follow-up of at least one year were reviewed retrospectively. Intraoperatively, after the tumor was excised, HADM (AlloDerm) was secured to create a pelvic diaphragm. Subsequently, the gluteus maximus muscles were freed from their origins, elevated, rotated or advanced in the midline to cover the HADM, and sutured together.
Results: The mean age of the patients was 50 years and the histopathology revealed a chordoma in 82.4%. 8 patients (23.5%) developed a postoperative wound dehiscence, of whom 6 (17.6%) required operative debridement. An estimated blood loss of >2500 mL and an operative

time of >9 hours during sacrectomy, as well as postoperative bowel or bladder incontinence, were all associated with a significantly higher rate of subsequent debridement procedures (p=0.018). The average length of hospital stay was 12.2 (range 3-66) days; the development of a surgical site infection and the performance of a debridement procedure were both associated with a longer length of hospital stay (p=0.037). With a mean follow-up of 45.7 months, only 1 patient developed an asymptomatic para-sacral hernia, which was adjacent to a local tumor recurrence.
Conclusion: Reconstruction of posterior sacrectomy defects with HADM and gluteus maximus myocutaneous flaps may be a valid technique. This approach may have rates of wound dehiscence comparable to other techniques and low rates of para-sacral herniation.

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En Bloc Resection of Cervical Chordomas: Series of 12 Patients and Clinical Outcomes

Daniel M. Sciubba, Camilo A. Molina, Ziya L. Gokaslan, Dean Chou, Jean-Paul Wolinsky, Timothy F. Witham, Ali Bydon, Christopher P. Ames
Introduction: Chordomas of the mobile spine often undergo en-bloc resection with reconstruction to optimize local control and possibly offer cure. In the cervical spine, local anatomy is challenging and obtaining clean margins may be limited. Complications may also be higher due to juxtaposition of the skull base, vasculature, aerodigestive system and upper spinal cord. In this review, we present a series of 12 cases of cervical chordomas removed en-bloc. Particular attention was paid to clinical outcome, complications, and recurrence. In addition, outcomes were assessed according to position of tumor in C1/C2 vs. the subaxial spine.
Methods: The patients undergoing en-bloc resection of cervical chordoma were reviewed from two large spine centers. Patients were included if the lesion epicenter was involving C1 to C7 vertebral bodies. Demographics, details of surgery, follow-up course, and complications were obtained. Outcome was correlated with presence of tumor in C1/2 vs. subaxial spine(C3-C7) via a student's t-test.
Results: 12 patients were identified with a mean age at presentation of 60. 7/12 (58%) and 5/12 (42%) of cases involved the C1/C2 and subaxial spine, respectively. En-bloc resection was attempted via an anterior approach in 33% of cases (29%-C1/C2; 40%-subaxial), a posterior approach in 25% of cases (43%-C1/C2; 0%-subaxial), and a combined approach in 42% of cases (29%-C1/C2; 60%-subaxial). Tumor margins were found to be wide in 2/12 (17%-overall; 14%-C1/C2; 20%-subaxial), marginal in 6/12 (50%-overall; 29%-C1/C2; 80%-subaxial), or contaminated in 3/12 (25%-overall; 43%-C1/C2; 0%-subaxial) of cases. No operative complications were encountered. Postoperative complications occurred in 5/12 (42%-overall; 57%-C1/C2; 20%-subaxial; $p<0.05$) patients and included: hoarseness, dysphagia, prolonged/permanent use of a feeding tube, and pneumonia. Average follow-up was 42 months (range 30-60 months). Recurrence occurred in 5/12 (42%-overall; 57%-C1/C2; 20%-subaxial; $p<0.05$) cases. Of note, in comparing C1/C2 tumor resections with subaxial lesions, we found a greater incidence of postoperative complications and rates of recurrence.
Conclusion: En-bloc resection of cervical chordomas involving the upper cervical spine(C1-2) are associated with poorer outcomes such as higher rates of complications, and recurrence.

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Identification of Cancer Stem Cells in Human Chordoma

Wesley Hsu, Ahmed Mohyeldin, Sagar R. Shah, Thomas Kosztowski, Lakesha Johnson, Ola Awad, Neda I. Sedora-Roman, David Loeb, Edward McCarthy, Jean-Paul Wolinsky, Ziya L. Gokaslan, Alfredo Quinones-Hinojosa
Introduction: Chordomas are the most common malignant primary tumor of the osseous spine. The mechanisms underlying the resistance of chordoma to chemotherapy and radiation therapy is unknown. The role of cancer stem cells (CSCs) in chordoma pathophysiology has not been defined. We have performed a series of experiments that provide evidence for the presence of CSCs within human chordoma.
Methods: Establishment of Chordoma Sarcospheres: Chordoma tumor samples were dissociated into single cells, plated in adherent conditions, and expanded to confluence. Cells were then transferred into serum-free, non-adherent conditions to form sarcospheres. Differentiation Studies: For adipogenic differentiation, chordoma sarcospheres were plated at 100% confluency and differentiated using a commercial human adipogenic differentiation kit. Differentiation was evaluated using oil red staining using normal human mesenchymal stem cells as a positive control. For neuronal and astrocyte differentiation, chordoma sarcospheres were maintained in serum free media and plated in 10% FBS for 10 days. Xenograft Studies: BALB/c male nude mice were injected subcutaneously with either chordoma sarcospheres (500,000, 1 million, or 2 million cells) or non-sphere chordoma cells in 50 ul PBS:Matrigel (1:1).
Results: We have established a stable chordoma cell line that is morphologically identical to classic chordoma with expression of brachyury, S100 and keratin. Using this cell line, we have isolated and characterized chordoma sarcospheres that are self-perpetuating and exhibit higher expression of the functional stem cell marker ALDH1 compared to typical chordoma cells. Furthermore, sarcospheres can be successfully differentiated into neuroepithelial and mesodermal cell types. Subcutaneous injection of chordoma sarcospheres into an athymic mouse host induced the formation of tumors that successfully recapitulated the phenotypic characteristics of the parent chordoma.
Conclusion: We present the first evidence for the existence of chordoma CSCs and have developed the first animal model for this disease.

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Sacral Laminoplasty for the Treatment of Symptomatic Sacral Perineural (Tarlov) Cysts, Clinical Outcomes and Surgical Observations

Zachary Adam Smith, Larry T. Khoo
Introduction: The surgical treatment of symptomatic sacral perineural cysts or Tarlov cysts remains controversial. Traditional approaches have been described using sacral laminectomy. Our aim was to evaluate the efficacy and potential complications of treatment of these cysts with microsurgical fenestration, local muscle/fat grafting, and laminoplasty of the sacral lamina.
Methods: This is a retrospective study of 17 prospectively followed patients with 19 large sacral perineural cysts (averag-2.40 cm, range 1.1-8.0 cm) of the sacrum treated by the senior author between May 2004 and June 2010. All patients presented with symptoms non-responsive to medical treatment. Presenting symptoms included coccydynia (n=17), radiculopathy (n=14),

back pain (n=11), perineal parasthesias (n=8), incontinence (n=8), and weakness (n=6). We performed a sacral laminoplasty with fenestration of the cyst with intraoperative electromyography in all patients. All patients had closures reinforced with either fat or muscle graft with fibrin glue with subsequent fixation of the sacrum with titanium mini-plates. Outcomes were evaluated by telephone questionnaire or clinic follow-up at average 12.5 months (range 4-44 mo).
Results: After surgery, coccydynia (13/17 pts, 76.5%), radicular pain (11/14 pts, 78.6%), and perineal parasethesias (6/8, 75.0%) improved most consistently following operation. One patient without pre-existing sensory symptoms developed new perineal parasethesias. Bladder control returned in 5 of 8 patients (62.5%) and a single patient developed new bowel and bladder incontinence. There was a single cerebrospinal fluid leak that required return to OR. MRI was completed in all 14 patients with >6-month follow-up and no imaging demonstrate evidence of recurrence.
Conclusion: Microsurgical fenestration with laminoplasty is a safe and effective treatment for carefully selected patients with large, symptomatic Tarlov cysts. The authors describe their results for this subset of patients who may benefit from surgery.

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Hydrostatic Strength Dural Patch Repair Materials

Michael A. Finn, Paul Anderson, Nathan Faulkner

Introduction: We hypothesize that different dural patch materials will vary in their initial hydrostatic strength and that the use of a biologic glue will increase the hydrostatic strength of dural patch repairs.
Methods: Twenty-four calf thoracic spines were prepared with laminectomies and spinal cord evacuation, leaving the dura intact. Foley catheters were inflated on either side of a planned dural defect and baseline hydrostasis was measured using a fluid column at 30, 60 and 90 cm of water. A standard dural defect (1x2cm) was created and 8 patches of each material (human fascia lata, Duragen, and Preclude) was sutured in place using a 5-0 Prolene HS running suture. Hydrostasis was again tested at the same pressures. Finally, Duraseal was placed over the defect and hydrostasis was again tested. Results were analyzed with ANOVA.
Results: Leakage rate increased significantly at each pressure tested for all conditions. All patch materials allowed significantly greater leakage than the intact condition. There was no difference in leakage between the three patch materials. The use of duraseal reduced leakage significantly at all pressures when used with Duragen, and at 90 cm of water when used with Preclude. There was a trend towards reduced leakage with duraseal under the remaining conditions. There was no significant difference between the Duraseal group and the intact dura.
Conclusion: The use of all three dural patch materials were of similar hydrostatic strength and allowed greater leakage than intact. The use of Duraseal reduced leakage rates to levels similar to inact.

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Hydrostatic Comparison of Titanium Clip and Suture Repair of Durotomy

Michael A. Finn, Paul Anderson, Nathan Faulkner

Introduction: We hypothesize that the hydrostatic strength of durotomy repairs will vary with the type of suture used and between suture and non-penetrating titanium dural clips.
Methods: Twenty-four calf thoracic spines were prepared with laminectomies and spinal cord evacuation, leaving the dura intact. Foley catheters were inflated on either side of a planned dural defect and baseline hydrostasis was measured using a fluid column at 30, 60 and 90 cm of water. A standard 1 cm durotomy was created and was repaired in 8 specimens each using 5-0 Surgilon, 5-0 Prolene HS, or non-penetrating dural clips. Hydrostasis was again tested at the same pressures. The time required for each repair was measured. Results were analyzed with ANOVA.
Results: Leakage rate increased significantly at each pressure tested for all conditions. There was no difference between the intact condition and the titanium clip repair at any pressure. There was significantly greater leakage than intact in both suture repair groups detected at all pressures. There was no difference between the suture types. Clip repairs took approximately half as long as suture repairs, a significant difference.
Conclusion: The use of non-penetrating titanium dural clips provided better immediate hydrostasis and took less time than tradition suture repair.

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Prospective Randomized Controlled Trial in Spine Patients to Compare Low Swell Formulation of a Polyethylene Glycol Hydrogel Spinal Sealant with Other Methods of Dural Sealing

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Introduction: As an adjunctive measure to sutured dural repair, spine surgeons utilize a variety of methods to ensure that no active leak is present before closing the wound. In 2009, the FDA approved the DuraSeal™ spinal sealant specifically as an adjunct to sutured repair during spine surgery. This IDE study compared the safety and efficacy of low swell (10% and 39% of its original volume) PEG hydrogel formulation to other methods of dural sealing.
Methods: Prospective, multicenter, randomized controlled study was conducted to compare a low swell formulation of a PEG hydrogel with other common dural sealing methods as an adjunct to sutured dural repair. To evaluate those patients operated only in spine, Chiari malformation surgery was excluded. The primary endpoint was the efficacy of intraoperative watertight dural closure confirmed by Valsalva maneuver at 20-25 cm H2O. Safety was measured by the assessment of postoperative CSF leak and surgical site infection.
Results: 51 patients were randomized to low swell PEG hydrogel spinal sealant (treatment) and 16 patients to other methods of dural sealing such as additional sutures and/or adhesive glue (control). Efficacy measured by intraoperative watertight closure was higher in the treatment group compared to the control (98% vs. 75%, p=0.010). Also treatment group had lower rate of postoperative CSF leak compared to the control (2% vs. 12.5%, p=0.143) and lower rate of surgical site infection (6% vs. 18.8%, p=0.148).
Conclusion: Common methods for achieving a watertight dural closure during spine surgery include the use of additional sutures and adhesive glue. With this method, however, about 3 out of 4 patients fail to achieve a watertight dural closure. Low swell PEG hydrogel

spinal sealant is much more effective in achieving intraoperative watertight dural closure without compromising the safety of the patients.

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Assessment of Thoracic Laminar Dimensions in a Pediatric Population: A CT-Based Feasibility Study for Pediatric Thoracic Translaminar Screw Placement

Camilo A. Molina, Christopher Chaput, Daniel M. Sciubba, P. Justin Tortolani, George I. Jallo, Ryan M. Kretzer

Introduction: Translaminar screws (TLSs) were originally described by Wright as a safer alternative to pedicle screw fixation at C2.1 More recently, TLSs have also been used as bail-out procedure following failed pedicle screw placement in the treatment of adolescent idiopathic scoliosis.2,3 To date, there are no studies that report the anatomical features of the thoracic lamina in the pediatric population.

Methods: 52 patients (26 male, 26 female), average age 9.5 4.8 years, were selected by retrospective review of a trauma registry database after IRB approval. Study inclusion criteria were ages 2 to 16, standardized axial bone-windowed CT images of the thoracic spine, and an absence of spinal trauma. For each thoracic lamina the following anatomical features were measured using eFilm Lite software: width (outer cortical and cancellous), maximal screw length, optimal screw trajectory, and laminar height. Subjects were stratified by age as follows: <8 yrs. of age(yo) vs. >8 yrs. of age(yo) based on presumed spinal maturity.

Results: Collected data (Table 1) demonstrate the following trends: 1) decreasing maximal screw length, 2) stable lamina width (Figure 1), 3) increasing laminar height, and 4) increasing ideal screw trajectory angle as one descends the thoracic spine from T1-T12. When stratified by age, subjects >8yo had significantly larger lamina in both width and height, and allowed significantly longer screw placement at all thoracic levels than the <8yo subgroup ($p<0.05$). Importantly, all thoracic spinal levels had an average bicortical diameter greater than 3.5 mm, indicating that a 3.5 mm screw could be placed in the majority of cases.

Conclusion: The data collected provide preliminary information regarding optimal TLS length, diameter, and trajectory for each spinal level in the pediatric thoracic spine. Furthermore, based on CT evaluation, bicortical width provides no anatomical limitation to the placement of translaminar screws in the pediatric population.

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CT Hounsfield Units for Assessing Bone Mineral Density: A Tool For Osteoporosis Management

Paul A. Anderson, Joseph Schreiber

Introduction: Osteoporosis is a common disease with enormous implications for affected individuals and society as a whole. Measurements obtained from computed tomography (CT) examinations obtained for other reasons, may yield information regrading decreased bone mineral density, without added expense to the patient. The purpose of this study was to determine if Hounsfield Units, the standardized computed tomography attenuation coefficient, correlate with bone mineral density (BMD) as measured by DEXA.

Methods: Twenty-five patients mean age 71.3 years undergoing both lumbar spine Dual-Energy X-Ray Absorptiometry (DEXA) scans and CT were evaluated. In a region of interest, the Hounsfield Units was measured and correlated with DEXA BMD and DEXA T-scores. Normative data was generated from CT performed on 80 trauma patients.

Results: HU decreased relatively linearly by decade ranging from a mean of 255.1 in the second decade to 78.7 in the ninth decade. Mean HU for the 25 subjects was 107.1(36.8). Mean T-score was -1.42(1.51) and BMD 1.104(0.186)g/cm². Strong correlations were found between Hounsfield Units and bone mineral density, age, T-scores ($p < 0.0001$), Figure 1 and 2. The mean HU and 95% confidence intervals for normal, osteopenic, and osteoporotic subjects were 133.0(CI 118.4 - 147.5), 100.8(CI 93.1 - 108.8), and 78.5(CI 61.9 - 95.1).

Conclusion: CT Hounsfield Units correlate strongly with DEXA scores, and can potentially provide an alternative method in determining regional bone mineral density at no additional cost to the patient. The information could conceivably be applied toward fracture risk assessment, diagnosis of osteoporosis, and early initiation of needed treatment. While we are not recommending CT as a substitute for DEXA, when a CT has been obtained for other reasons, regional HU can be measured to aid surgical decision making and as a guide for further testing.

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Effects of Epidural Steroid Injections on Blood Glucose Levels in Patients with Diabetes Mellitus

Owoicho Adogwa, Jesse Even, Kirk McCullough, Clint Devin, Matthew J. McGirt

Introduction: Epidural steroid injections (ESI) are commonly used in the treatment of multiple spinal disorders. Corticosteroid injections have been evaluated in the total joints and hand literature showing systemic effects to diabetics. There has not been a clinical study to evaluate if ESI cause systemic effects in diabetics.

Methods: Diabetic patients who were scheduled for an ESI were given an opportunity to enroll in our IRB approved study. We collected the patient's most recent hemoglobin A1c (hA1c) and then asked them to track their blood glucose numbers at least twice per day for two weeks prior to and after their ESI.

Results: We noted a statistically significant increase in blood glucose levels in diabetic patients (N=30) after epidural steroid injection. The mean blood glucose level prior to ESI injection was 157.97 ± 45.71 and after ESI it was 304.00 ± 112.63. This represents an average 146.03 ± 88.5 increase in blood glucose levels after injection, which was significantly higher than 0 ($p=0.0001$, Wilcoxon singed-rank test). Using a nonlinear mixed effect model the estimated half life of this increase was 1.54 days (95% CI 0.86, 7.37), meaning that the patients were back within their normal standard deviation mean glucose levels within two days of injection. The Spearman correlation when evaluating the association between pre injection hA1c levels and maximum blood glucose change was 0.174 ($p=0.502$) indicating there is no correlation between pre injection hA1c levels and systemic response to ESI.

Conclusion: Epidural steroid injections were noted to cause a significant increase in the blood glucose levels in diabetics. There was no correlation between pre injection diabetic control, represented by hA1c levels, and post injection response. Diabetics who are candidates for ESI should be counseled that a blood glucose increase may be apparent post intervention but effects should not last longer than approximately two days.

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The Prognostic Value of a Cervical Selective Nerve Root Block: A Correlation with Surgical Outcomes

Luis M. Tumialan, David C. LoPresti, Angelina N. Garvin, Wayne Gluf

Introduction: To compare the results of a selective nerve root block in the cervical spine with surgical outcomes from posterior cervical foraminotomy or anterior cervical discectomy for management of a single level cervical radiculopathy.

Methods: The authors prospectively followed patients with a unilateral single level cervical radiculopathy. All patients in this study had radicular symptoms which correlated with clinical history, neurological examination and MR imaging findings and had failed nonoperative management for a minimal period of 3 months. All patients were initially managed with a CT guided selective nerve root block. Pre-injection, post-injection and postoperative visual analogue scores (VAS) were obtained at 0, 30 and 90 days. Duration of relief was also documented.

Results: A total of 42 patients underwent a transforaminal cervical selective nerve root block for initial management of their unilateral single level cervical radiculopathy. Fifteen of these patients experienced recurrence or only temporary relief of their symptoms and opted for operative management. At 6 months, the remaining 37 patients required no further intervention. The mean preinjection/preoperative VAS was 57.1 mm (21-97). The mean post-injection VAS was 15.2 mm (0-45). The mean duration of relief was 20.3 days (1-75). The mean postoperative VAS at 30 days was 18.4 mm (0-60). A regression analysis demonstrated that reduction in pain from the baseline VAS to the postinjection VAS was highly predictive of outcomes 30 days after surgery ($p = 0.034$). The coefficient of determination was 32%.

Conclusion: The pain reduction at 30 days after a posterior cervical foraminotomy or anterior cervical discectomy is well predicted by the initial reduction from the selective nerve root block. There is prognostic value in the cervical selective nerve root block for prospective surgical patients.

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The Prognostic Value of a Lumbar Selective Nerve Root Block: A Correlation with Surgical Outcomes

Luis M. Tumialan, David C. LoPresti, Angelina N. Garvin, Wayne Gluf

Introduction: To compare the results of a selective nerve root block in the lumbar spine with surgical outcomes from a microdiscectomy for management of a single-level lumbar radiculopathy.

Methods: The authors prospectively followed patients with a unilateral single-level lumbar radiculopathy. All patients in this study had radicular symptoms which correlated with clinical history, neurological examination and MR imaging findings and had failed nonoperative management for a minimal period of 3 months. All patients were initially managed with a CT guided selective nerve root block. Pre-injection, post-injection and postoperative visual analogue scores (VAS) were obtained at 0, 30 and 90 days (when applicable) along with preinjection/preoperative and postoperative Owestry Disability Indices (ODI).

Results: A total of 51 patients underwent a transforaminal selective nerve root block for initial management of their unilateral single level radiculopathy. Fifteen of these patients experienced recurrence or only temporary relief of their symptoms and opted for operative management. At 6 months, the remaining 36 patients required no further intervention. The mean preinjection/preoperative VAS and ODI was 56.8 mm (17-98) and 23.5 (11-35) respectively. The mean post-injection VAS was 17.25 mm (0-38). The mean duration of relief was 18.3 days (0-70). The mean postoperative VAS and ODI at 30 days were 21.4 mm (0-57) and 13.4 (1-33) respectively. A regression analysis demonstrated that reduction in pain from the baseline VAS to the postinjection VAS was highly predictive of outcomes 30 days after surgery ($p < 0.001$). The coefficient of determination was 81%.

Conclusion: The pain reduction at 30 days after a microdiscectomy is well predicted by the initial reduction from the selective nerve root block. There is prognostic value in the selective nerve root block for surgical patients.

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Proximal Junctional Kyphosis in Adult Thoracolumbar Instrumented Fusion: Time to Development, Clinical and Radiographic Characteristics, and Management Approach in 32 Consecutive Cases

Davis Reames, Justin S. Smith, D. Kojo Hamilton, Vincent Arlet, Christopher I. Shaffrey

Introduction: Proximal junctional kyphosis (PJK) is a common mode of failure following instrumented thoracolumbar deformity surgery and often necessitates revision. Our objective was to assess the clinical and radiographic factors in a consecutive series of adults who developed PJK.

Methods: Consecutive cases of adults treated for thoracolumbar deformity that developed PJK from the contributing authors from 2004-2009 were identified. PJK was defined based on previously published criteria. Clinical records were reviewed and standard radiographic measurements were performed.

Results: 32 cases of PJK were identified (mean age 66 years, range: 46-80; 24 women/8 men). 17 (53%) had surgery prior to the index procedure. The most common comorbidities included osteopenia/osteoporosis (31%), hypothyroidism (31%), osteoarthritis (22%), and movement disorder (13%). The most common diagnosis for the index procedure was degenerative scoliosis (n=26, 81%). The upper-most instrumented vertebrae were T4 (n=1), T10 or T11 (n=30), or L1 (n=1), and the lower-most instrumented levels were: L4 (n=1), L5 (n=1), S1 (n=5), or ilium (n=25). Mean follow-up was 34 months. 16 (50%) required revision (mean of 1.7 revisions, range: 1-3) at a mean of 9.6 months (range: 0.7-40), and 16 (50%) did not require revision at last follow-up. Respective comparison of pre- and post-index surgery radiographic parameters showed no significant change in sagittal balance (9.6 vs. 8.0 cm, $p=0.76$), but there was a significant increase of lumbar lordosis (24 vs. 42 degrees, $p<0.001$) and T5-T12 kyphosis (30 vs. 53 degrees, $p<0.001$) and reduction of pelvic tilt (29 vs. 23 degrees, $p=0.011$).

Conclusion: Collectively, these data suggest that susceptibility to PJK may relate to development of an exaggerated postoperative compensatory thoracic kyphosis to offset a significant, intended surgical correction of lumbar lordosis. The resulting inadequate maintenance of sagittal balance, combined with the increased kyphosis, may predispose to development of PJK.

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Direct Vertebral Body Derotation: A Comparison of Different Techniques

Amer F. Samdani, Steven Wei-Hung Hwang, Michelle Marks, Tracey Bastrom, Randal Betz, Patrick Cahill

Introduction: Pedicle screw fixation has permitted the application of rotational forces to assist in correcting the 3-D deformity of the scoliotic spine. Surgeons

may routinely apply a combination of derotation techniques when correcting deformity, but little is known of the impact from each maneuver. Theoretically, unnecessary derotation maneuvers may weaken the screw-bone interface. We sought to compare outcomes of various direct vertebral body derotation (DVBD) techniques as defined by inclinometer measures.
Methods: A large, multicenter, prospective database was retrospectively queried for patients with the diagnosis of AIS who have undergone posterior spinal fusion with application of DVBD techniques. All patients had at least 2 years of follow-up, and those having undergone thoracoplasty were excluded. Segmental derotation was defined as corrective rotational forces applied to one vertebral level, whereas en-bloc derotation referred to maneuvers involving more than one level.
Results: A total of 195 patients were identified. 104 patients underwent segmental derotation, 20 had en-bloc derotation performed, and 71 patients had both. No significant radiographic or clinical differences existed between the groups preoperatively or postoperatively. When subdivided into categories based on the magnitude of preoperative inclinometer measures (0-9 degrees, 10-15 degrees, and 16+ degrees), no significant difference in postoperative inclinometer measures were identified (p=0.43 to 0.95) (Table 1).
Conclusion: The use of varying derotation techniques in the correction of AIS deformity did not correlate with any difference in outcomes based on inclinometer measures. The additional use of en-bloc derotation to segmental maneuvers does not provide any more rib prominence correction.

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Direct Vertebral Body Derotation, Thoracoplasty or Both: Which is Better with Respect to Inclinometer and SRS-22 Scores?

Amer F. Samdani, Steven Wei-Hung Hwang, Peter Newton, Baron Lonner, Michelle Marks, Tracey Bastrom, Patrick Cahill, Randal Betz

Introduction: Direct vertebral body derotation (DVBD) and thoracoplasty (Th) are powerful tools for correction of rib deformities in patients with AIS. We evaluated Th, DVBD, and both (Th/DVBD) with respect to postoperative inclinometer readings and SRS scores to determine which provides the best correction of rib deformity and better patient satisfaction.
Methods: A prospective longitudinal database was queried to identify AIS patients who underwent a posterior spinal fusion with pedicle screws and 2 years' follow-up. 203 patients were identified grouped as follows: 1) Th alone (N=30), 2) DVBD alone (N=122), and 3) both Th/DVBD (N=51). Patients were subdivided based on their preoperative inclinometer reading: 1) = 9 degrees (mild), 2) 10-15 degrees (moderate), and 3)=16 degrees (severe). Pre- and postoperative inclinometer readings and SRS scores were compared using ANOVA.
Results: Overall, the groups were similar preoperatively except for the DVBD group having higher percent thoracic flexibility. The preoperative rib deformity values were Th=13.2, DVBD=14.0, and Th/DVBD=12.9 (p=0.27). Taken collectively, the post-op 2 year inclinometer readings were similar for all three groups (Th=5.2, DVBD=7.0, Th/DVBD=5.6, P=0.66). However, the SRS-22 self-image scores were significantly better for patients having both Th/DVBD (Th=3.4, DVBD=3.4, Th/DVBD=3.8, P<0.01). When patients were stratified by severity of pre-op rib deformities, all with mild prominences achieved similar corrections, although SRS self-image scores were highest in the Th/DVBD group. In patients with moderate and severe preoperative rib prominences, the addition of Th was necessary for optimal rib deformity correction, but there was no difference in SRS-22 domains (Table 1).
Conclusion: Our results suggest that Th alone, DVBD alone, or both provide equivalent inclinometer results in patients with mild preoperative rib deformities, but higher SRS-22 self-image scores are achieved using both Th/DVBD. For more severe rib prominences (> 10 degrees), better inclinometer readings are achieved with thoracoplasty, although SRS-22 self-image scores are comparable.

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Differences in Treatment and Inpatient Outcomes for Hospitalized Scoliosis Patients in the United States from 1998 to 2007

Doniel Drazin, Miriam Nuno, Frank L. Acosta

Introduction: Differences in access to treatment and outcomes have been documented in a variety of conditions in recent years. This study evaluates potential disparities in treatment selection and outcomes for hospitalized scoliosis patients. Patient- and hospital-specific factors were analyzed as independent variables for predicting surgical vs. non-surgical management of these patients, as well as for in-hospital patient outcomes.
Methods: Using Nationwide Inpatient Sample (NIS) administrative 1998-2007 data, we captured cases having a primary diagnosis of scoliosis. Univariate and multivariate analyses evaluated race, gender, socioeconomic factors, and hospital characteristics as predictors of treatment (surgical vs. non-surgcial) and in-hospital outcomes (discharge, mortality, and complications).
Results: The study analyzed 9522 (surgical) and 2617 (non-surgical) cases. Univariate analysis showed both patient- and hospital-level variables as strongly associated with treatment selection and outcomes. Concerning treatment selection, multivariate analysis revealed African-Americans and Hispanics as less likely to be treated surgically, while Caucasians and private insurance patients were more likely to undergo surgery (p<0.05). These differences in treatment selection for minorities persisted even when controlling for comorbidities. Additionally, Caucasians showed a reduced risk of mortality, complications and adverse discharge compared to African-Americans and Hispanics (p=0.01). Large hospitals had higher surgical treatment rates than small or medium-sized facilities as well as a lower risk of mortality. Higher proportions of Caucasian patients were admitted to large teaching hospitals than African-American or Hispanic patients.
Conclusion: Significant disparities were found in the selection of operative vs. non-operative treatments, as well as in in-hospital morbidity and mortality for hospitalized scoliosis patients based on racial and socioeconomic variables. This may in part be due to differences in access to the resources of large teaching hospitals for different racial and socioeconomic groups. Additional reasons for these disparities, and their impact on quality-of-life measures and future health resource utilization for scoliosis patients requires additional research.

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The Safety and Efficacy of Transforaminal Lumbar Interbody Fusion for Deformity Correction in Degenerative Scoliosis with Spinal Stenosis

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Introduction: The utilization of a TLIF (Transforaminal Lumbar Interbody Fusion) approach for scoliosis offers patients deformity correction without the morbidity associated with more invasive reconstructive surgeries. The purpose of this study was to analyze intra- and postoperative complications associated with the TLIF surgical approach in patients undergoing surgery for spinal stenosis and degenerative scoliosis correction.

Methods: This study included a total of 29 patients that underwent TLIF for degenerative scoliosis with neurogenic claudication and painful lumbar degenerative disc disease. TLIF surgery was performed using a posterolateral pedicle screw construct. The average follow-up time was 27.4 months (range, 6 - 47).

Results: The average age of patients was 65.9 years (range, 49 83). TLIF procedures were performed at 2.2 levels on average (range, 1 - 4) in addition to 7.0 (range, 3 - 11) levels of posterolateral fusion. The mean preoperative coronal Cobb angle was 32.3 degrees (range, 15 - 55) compared to the mean of 15.4 degrees (range, 1 - 49) postoperatively. The mean operative time was 8.8 hours (range, 4.6 - 15.1), EBL - 1091.7 mL (range, 150-2500) and hospitalization time was 8.0 days (range 3 - 28). Clinical outcome was excellent/good in 17 (77%) of patients. The overall patient satisfaction rate was 77% (range, 42 - 100). Mean VAS decreased from 7.6 (range, 4 - 10) preoperatively to 3.6 (range, 0 -8) postoperatively. There was a total of 14 (48.3%) hardware and/or surgical technique related complications, 8 (27.6%) of which required additional surgeries. The systematic complications (31%) included death (1), cardiopulmonary arrest with resuscitation (1), myocardial infarction (1), pneumonia (5) and pulmonary embolism (1). A total of 5 patients (17.2%) had pseudoarthrosis.

Conclusion: This study suggests that the TLIF approach is a feasible and effective approach to treat degenerative adult scoliosis, but is still associated with a high rate of intra- and postoperative complications and a long recovery process.

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Biomechanical Analysis of Iliac Screws vs. S2 Alar-Iliac Screws

Cyrus Wong, Chase Corn, Colin Crosby, Jesse Even, Gregory A. Mencio, Clinton J. Devin, Matthew J. McGirt

Introduction: Current techniques of pelvic fixation have been associated with high rates of lumbo-sacral pseudarthrosis, failure of fixation and hardware complication. Hence, newer techniques were devised that allow for placement of screws into the ilium across the lumbosacral pivot point to improve biomechanical stability. However, some of these techniques require additional incisions and extensive soft-tissue dissection. This study describes and compares the biomechanical strength of two techniques that provide low-profile, in-line fixation without the necessity of additional incisions or soft-tissue dissection.

Methods: Embalmed cadaveric specimens (n=8, 4-male, 4-female) were utilized. Anatomically-referenced iliac screws and S2 alar-iliac screws measuring 7.5mm by 80mm were placed in-situ on opposite sides of each specimen, alternating between right and left for each type of fixation. Appropriate placement of screws was confirmed with fluoroscopy and direct examination after dissection of each pelvis. The pelvi were then harvested, hemi-sectioned and potted for biomechanical testing. Utilizing an MTS Bionix 858 Machine, screws were coaxially loaded at a rate of 5 mm/minute and pull out strength was measured in Newtons.

Results: Mean pull-out strength for anatomically-referenced iliac screws and S2 alar-iliac screws were 576 N (SD- 185) and 933 N (SD- 440), respectively. A statistically significant higher pull-out strength was noted in the S2 alar-iliac screws as compared to standard iliac screw ($p<0.05$).

Conclusion: Iliac fixation is often performed in a revision setting to successfully achieve arthrodesis across the lumbosacral junction. In this study, we demonstrate that utilizing an S2 alar-iliac fixation technique provides superior pullout strength potentially avoiding these complications and helping achieve arthrodesis.

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Reduced Surgical Site Infections in Patients Undergoing Posterior Spinal Stabilization of Traumatic Injuries Using Vancomycin Powder

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Introduction: Despite improvements through the use of prophylactic systemic antibiotics, surgical site infections remain a significant problem in the treatment of traumatic spine injuries. Infection rates as high as 10% have been reported in this population. The impact on patients and cost of treating such infections is profound. Local delivery of antibiotics has been found to be efficacious in animal and human studies as an adjunct to systemic antibiotics in surgical site infection prophylaxis. We set out to evaluate the efficacy of using vancomycin powder in surgical sites to prevent infections.

Methods: Fifty-eight consecutive patients with traumatic spine injuries treated with instrumented posterior spine fusions at a single academic center received intraoperative vancomycin powder applied to their surgical site and prospectively followed for infection. This propsective cohort was compared to 60 consecutive patients undergoing posterior fusion for trauma immediately prior to the prospective cohort. History of previous spine surgeries, substance use, diabetes, and body mass index were compared. Incidence of infection was the primary outcome evaluated.

Results: The control (N=60) and treatment groups (N=58) were statistically similar, Table 1. There were no adverse reactions to the vancomycin powder. A statistically significant difference in infection rate was found between the treatment group (0%) and control group (12%, p=0.02), Table 2. No adverse effects were noted from use of the vancomycin powder.

Conclusion: The use of vancomycin powder in surgical wounds may significantly reduce the incidence of infection in patients with closed traumatic spine injuries treated with instrumented posterior spine fusion. Applying vancomycin powder to surgical wounds is a promising means of preventing costly and harmful postoperative wound infections.

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Intraoperative Glucose Levels and its Association with Developing Postoperative Surgical Site Infections Following Spine Surgeries

Frances Mao, Ajit A. Krishnaney

Introduction: Postoperative wound infections following major surgical procedures continue to be a significant source of morbidity and mortality in the United States. Current recommendations from ICU and cardiac surgery management indicate that aggressive management of intraoperative glucose levels result in lower rates of surgical site infections. This study is a retrospective cohort analysis to determine the incidence of surgical site infections following elevated intraoperative glucose levels during spine surgeries.

Methods: Peri-operative glucose levels and infection control surveillance data were analyzed for 2208 patients who underwent cervical, thoracic, or lumbar spine surgical procedures at the Cleveland Clinic Center for Spine Health between March 2005 and March 2010.

Results: Out of 2208 patients, 112 (5.1%) developed a surgical site infection during the 30-day postoperative period. Non-infected patients had a mean intraoperative glucose level of 132.11 mg/dl (95% CI 130.72 - 133.5) compared to infected patients with a mean intraoperative glucose level of 130.95 mg/dl (95% CI 126.03 - 135.87 mg/dl. An independent two sample t-test found no significant difference in mean intraoperative glucose level between these two groups ($p = 0.6523$). Univariate logistic regression revealed a risk ratio per unit glucose of 1.00116 (95% CI 0.9953 - 1.0075, $p = 0.7081$). Chi-square analysis found no association between high glucose level (>110 mg/dl) and surgical site infection (chi-square value = 0.232, $p = 0.6304$). Follow-up analyses will be repeated to account for diabetes status.

Conclusion: We did not find a significant association between elevated intraoperative glucose levels and a higher incidence of postoperative surgical site infection. Our results add to previous case-control studies exploring the same association in neurosurgery. Because the causes of surgical site infection are multi-factorial, the role of other peri-operative variables in decreasing SSI incidence should be explored.

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Multiple-day Drainage when Using BMP for Long Segment Thoraco-lumbar instrumented Fusions Results in Low Reoperation Rates for Infection and Seroma

Dwight Saulle, Kai-Ming G. Fu, Justin S. Smith, Christopher I. Shaffrey

Introduction: Concerns over increased infection and seroma rates have been raised when BMP is employed as an aid to fusion in spinal surgery. Few studies have explicitly documented these complications. In this study we evaluated 87 consecutive patients undergoing long segment thoracolumbar spinal fusions with BMP to assess drain output and the rates of reoperation for infection or seroma.

Methods: Inclusion criteria included: patients undergoing 4 or more levels of posterior instrumented thoracolumbar fusion, use of BMP for posterolateral arthodesis, age >18 years, and a perioperative followup of 60 days. 87 consecutive cases from a single institution were assessed. Typically, 2 1/8th inch hemovac drains were placed at surgery and discontinued when two consecutive shifts (8 hrs) demonstrated less than 30cc of output. Drain output, length of time of drainage, and need for reoperation for wound seroma or infection were retrospectively reviewed.

Results: Mean age was 58.5 (SD 16.2, range 20- 81). Primary operative indications were deformity, with 43 patients undergoing revision surgery. The average number of levels instrumented and arthrodesed with BMP was 9.2 (SD 3.7, range 4-18). The average dose of BMP was 31.2 mg or 2.6 large sponges (SD 9.6mg, range 12-48). Patients required drainage for a mean of 4.9 days (SD 1.3 days, range 3-9 days). The average total output was 1856cc (SD 787, range 530-4310cc). There were no significant differences between dose of BMP used and amount or days of drainage ($p=0.3$ and $p=0.3$, respectively). The wound infection rate was 2.3% (2 cases, deep wound infection, required reoperation), and 2 (2.3%) sterile seroma occurred that required reoperation for drainage. No other wound complications were noted.

Conclusion: Use of BMP for long-segment posterior thoracolumbar fusions may be associated with significant drain output, requiring multiple days of drainage. However, when drained adequately, reoperations for infections and seromas occur infrequently

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Efficacy of Prophylactic Preoperative Inferior Vena Cava Filters for Major Spinal Surgery in Adults: A Review of 219 Patients at a Single Institution

Jamal McClendon, Brian A. O'Shaughnessy, Timothy R. Smith, Patrick Alexander Sugrue, Ryan J. Halpin, Tyler R. Koski, Stephen L. Ondra

Introduction: Venous thromboembolism (VTE) is a serious complication following major spinal reconstructive surgery in adults. Specifically, pulmonary embolism (PE) can result in significant morbidity and mortality, and has been reported in up to 13% of patients. Placement of prophylactic inferior vena cava filter (IVCf) was initiated as standard protocol for all high-risk spine patients after a pilot study demonstrated decreased VTE-related morbidity and mortality.

Methods: After IRB approval, medical records of all patients receiving an IVCf at a single institution were reviewed. Age, sex, surgical approach, postoperative deep vein thrombosis (DVT), postoperative superficial thrombus, presence of PE or paradoxical embolus, mortality, and IVCf complications were reviewed. Placement indications included history of DVT or PE, malignancy, hypercoagulability, prolonged immobilization, staged procedures > 5 levels, combined anterior/posterior approaches, iliocaval manipulation during exposure, and anesthesia > 8 hours. Descriptive statistics were used for the analysis of patient characteristics. Non-parametric, frequency statistics (odds ratios, chi-square) were used for analysis of main outcomes.

Results: 219 patients (150F, 69M) were analyzed with mean age of 58.8 years (range 17-86 years). There were two complications from IVCf placement (66 Greenfield and 157 retrievable). Incidence of lower extremity DVT was 18.7% in 36 patients. PE incidence was 3.7% (8/219), and the paradoxical embolus rate was 0.5% (1 patient). Prophylactic IVCf use reduced the odds of developing PE (OR=3.7, $p<0.05$) compared to population controls. Mean follow-up was >2 years. Patients receiving Greenfield filters had significantly higher VTE incidence compared to those receiving retrievable filters (OR=2.8, $p=0.008$). Anesthesia duration longer than 8 hours significantly increases VTE incidence ($p=0.029$). There were 14 deaths, none related to PE or paradoxical embolus.

Conclusion: VTE-related morbidity and

mortality have heightened the awareness within the spine community to the peri-operative management of patients receiving major spinal reconstruction. Prophylactic IVCf placement significantly lowers PE rate.

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Defining the Role of Early Surgical Decompression after Traumatic Spinal Cord Injury: Results of a Canadian Multicenter Study

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Introduction: Although there exists compelling experimental evidence supporting early spinal cord decompression after spinal cord injury (SCI), in practice, the role of surgery remains controversial in the absence of well-designed clinical studies. We present the results of a multicenter Canadian effort evaluating the impact of early vs. late surgical decompression post SCI on neurologic outcome, length of hospital stay and development of complications.
Methods: A prospective cohort study of patients within the Ontario Spinal Cord Injury Rehabilitation (OSCIR) program was performed. Eighty-six ASIA A-D SCI patients, from six Ontario trauma centers were enrolled between 2007 and 2009. Patient information was collected preoperatively, postoperatively, at acute care discharge and at discharge from rehabilitation. A grouped analysis was performed comparing the cohort of patients who received early surgery (<24 hours after SCI) to those receiving late surgery (=24 hours after SCI). Fisher's exact test was used to examine for differences in baseline characteristics and outcomes between early vs. delayed surgery patients.
Results: Of the 86 patients treated surgically there were 69 males and 17 females, with a mean age of 46.3 years. There was a trend towards older age and increased number of co-morbidities within the late surgery group. More patients had a 2 grade or more improvement in their ASIA Impairment Score (AIS) from admission to rehabilitation discharge in the early surgery group ($p<0.05$). This improvement was most marked amongst the early surgery ASIA A subgroup as compared to injury matched patients who underwent late surgery. Early surgery patients also experienced significantly greater improvements in ASIA sensory score over follow-up. The only significant predictor of acute care and overall length of stay was the admission AIS.
Conclusion: The results of this study support the growing body of literature which supports the principle of early intervention in the setting of spinal trauma and SCI.

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Age Related Changes in Neurologically Intact Human Spinal Cords Assessed Using Diffusion Tensor MR Imaging

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Introduction: Diffusion Tensor MR Imaging (DTI) is an important imaging modality that can be useful for monitoring changes in tissue structure in the brain and spinal cord. We present the largest dataset of DTI derived indices in the cervical spinal cord of a cohort of non-myelopathic individuals. The aim of this study was to characterize diffusion characteristics in the human cervical spinal cord at various ages.
Methods: With appropriate IRB approval, twenty-eight neurologically intact age and sex matched subjects, 22 -85 years old, were enrolled in this study. A single-shot, twice-refocused, spin-echo, echoplanar pulse sequence was used to obtain axial images throughout the cervical segments of the spinal cord (C1 - C8) on a 1.5 Tesla Clinical MR imaging Scanner in 45 minutes.
Results: Diffusion images indicated a significant decrease ($p<0.05$) in fractional anisotropy (FA) and an increase in mean diffusivity (MD) after 65 years of age in both male and female subjects. Cervical mean diffusivity averaged 0.98+/- 0.03 x 10(-3) mm(2)/s, fractional anisotropy averaged 0.63+/- 0.02 mm(2)/s.
Conclusion: To date, this is the largest study of DTI indices in a non-myelopathic population. This study provides evidence of changes in diffusion characteristics in the cervical spinal cord after the age of 65 years. Changes in spinal cord diffusion with increasing age likely reflect changes in spinal cord tissue structure. We believe that the definition of the normative values of DTI indices in these individuals will assist in evaluating DTI index differences in patients with spinal cord disease in the future. These significant changes in diffusion characteristics should be accounted for when using DTI to diagnose abnormalities in older patients.

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A Combined Neuroprotective Immuno-modulatory Therapy Mitigates Early Bladder Dysfunction After Experimental Spinal Cord Injury

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Introduction: Traumatic spinal cord injury (SCI) can result in devastating motor and sensory deficits. Of these, impaired bladder function is particularly significant as urinary tract complications rank among leading causes of morbidity and mortality in acute and chronic SCI. Experimental SCI in a rat contusion model demonstrates characteristic bladder dysfunction that parallels clinical SCI including abnormal micturition, urinary retention, and pathologic changes in functional bladder wall compliance. Previously, our group demonstrated that a combined immuno-modulatory strategy of cAMP elevation and peripheral macrophage depletion improves not only late but early hindlimb motor function after SCI. In the present study, we investigated the same combined immuno-modulatory therapy to determine if it confers similar neuroprotective benefit in mitigating early bladder dysfunction after SCI.
Methods: 12 rats were subjected to T8 weight-drop contusion injury. Post-SCI, animals either were treated with combined cAMP elevation + peripheral macrophage depletion (treated=6) or were untreated (control=6). Early bladder dysfunction was assessed using 2 techniques. First, severity of urinary retention was evaluated by measuring residual urine volumes (RUV) after daily timed manual bladder expression. Second, on post-SCI day 7, functional bladder wall compliance was assessed by measuring bladder capacity at micturition during transurethral single cycle filling cystometry (0.125ml/min).
Results: Animals had equivalent initial thoracic SCI (hindlimb BBB score<1, post-SCI day 1) with resulting abnormal micturition. Control animals, however, demonstrated progressively increasing daily RUV signifying worsening urinary retention, whereas treated animals did not ($p<0.05$)(Figure1). On post-SCI day 7, bladder capacity with filling cystometry was significantly increased ($p<0.01$) in control (4.9±0.7ml) compared to treated (3.5±0.6ml) animals, signifying increased disturbance in functional bladder wall compliance among control animals.

Conclusion: Experimental SCI results in early bladder dysfunction characterized by urinary retention and abnormal functional bladder wall compliance. A combined immuno-modulatory strategy reduces these pathophysiologic findings in acute experimental SCI. Clinical translation of this therapy may decrease risk of urinary complications in SCI patients.

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The Role of Nitric Oxide in Secondary Spinal Cord Injury: Insights from a New Transgenic Model

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Introduction: Acute spinal cord injury (SCI) occurs worldwide with an annual incidence of 15-40 cases per million per year. Recent advances have led to better understanding of the pathophysiology of SCI. Alterations in nitric oxide (NO), a neurotransmitter produced by Nitric oxide synthase from L-arginine have been implicated with different isoforms showing distinct temporal patterns. Arginase negatively regulates NO production through competition with NOS for the substrate L-arginie. Our aim is to develop a transgenic mouse model that over-expresses arginase in distinct cell populations to understand their role in NO production after SCI.

Methods: We used standard techniques to develop transgenic mouse models over-expressing the enzyme Arginase exclusively in neurons as well as in astrocytes. Plasmids containing the gene for arginase were cloned under the neuronal specific thy1 promotor as well as the Glial specific GFAP promotor. Transgenic founders were generated by pronuclear injections of the plasmids. Transgenic mice were identified at birth by eye pigmentation and confirmed by PCR using primers specific for Arginase. Western blot analysis, RNA extraction, enzyme essays as well as histology were established in the transgenic models and compared to control animals.

Results: Our transgenic animals show an up to 30 fold over-expression of Arginase with comparable enzyme activity. Arginine and citrulline levels are reduced in plasma of transgenic animals when compared to wild type controls. Despite these physiological discrepancies, our animals sustain normal growth. Under nonstressful conditions, these animals survive comparably to wild type litters, are fertile with offsprings born in mendelian ratio and have no histological abnormalities.

Conclusion: We were able to generate viable and fertile mice overexpressing Arginase specifically in neurons and glial cells. These mice will be a valuable tool to understand the role different cells play in the pathophysiology of acute spinal cord injury.

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The Impact of Weekend Hospital Admission on the Timing of Intervention and Outcomes After Surgery for Acute Spinal Cord Injury in the United States, 2005-2008

Hormuzdiyar H. Dasenbrock, Timothy F. Witham, Daniel M. Sciubba, Ziya L. Gokaslan, Ali Bydon

Introduction: Many studies haves suggested that patients who are admitted on the weekend have inferior outcomes compared to those admitted on a weekday. However, the impact of weekend admission on the timing of intervention and outcomes after surgery for acute spinal cord injury has not been previously evaluated.

Methods: Data from the national inpatient sample (2005-2008) were retrospectively extracted. Patients were included if they had a diagnosis of acute spinal cord injury, underwent spinal decompression with or without fusion and were admitted emergently or urgently. Multivariable logistic regression analyses were conducted to calculate the odds of death, the development of a postoperative complication and the performance of surgery on the day of or day after admission depending on if the hospital admission day was a weekend or a weekday. Logarithmic multivariate regression was used to evaluate the association of admission on a weekend with length of stay and hospital charges. All analyses were adjusted for differences in patient age, gender, co-morbidities, race, primary insurance, admission type and hospital characteristics.

Results: A total of 4,991 admissions were evaluated, of which 35% were on the weekend. Weekend admission was not significantly associated with a higher adjusted odds of in-hospital mortality (OR: 1.00. 95% CI: 0.70. 1.44). Patients admitted on the weekend did not have significantly different adjusted odds of performance of surgery on the day of or day after surgery (OR: 0.91, 95% CI: 0.77, 1.07). Postoperative complications, length of stay and total hospital charges were not significantly different between patients admitted on the weekend or a weekday.

Conclusion: Unlike other surgical diseases, the outcomes of patients admitted in the United States for acute spinal cord injury during the weekend do not differ from those admitted during the week. Nationwide, surgery is not delayed for patients with acute spinal cord injury who present on the weekend.

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Long-term Outcomes of Patients with Multilevel Ossification of the Posterior Longitudinal Ligament after Laminectomy, Laminoplasty and Laminectomy and Fusion: A Meta-Analysis of Observational Studies

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Introduction: Although posterior decompression is preferred for multilevel cervical ossification of the posterior longitudinal ligament (OPLL), few studies have evaluated the long-term outcomes of patients undergoing different posterior techniques. We report a meta-analysis of observational studies comparing the improvement in myelopathy and long-term complications including the development of postoperative kyphosis, the prevalence of axial pain and the progression of OPLL in patients with multilevel disease undergoing laminectomy, laminoplasty and laminectomy and fusion.

Methods: A literature search was performed using MEDLINE of studies indexed between January 1980 and June 2010. Pre-determined study inclusion criteria included reporting outcomes for patients with OPLL separately from other etiologies of myelopathy; studies were excluded if they reported a total of ten or fewer patients. Data on the severity of myelopathy (measured by the Japanese Orthopedic Association (JOA) scale) and long-term complications were extracted and pooled assuming random effects.

Results: 40 studies with a total of 1,549 patients were included of which 8 reported laminectomy, 34 reported laminoplasty and 2 reported laminectomy and fusion. Among studies with a long-term mean follow-up (of at least four years), patients undergoing laminectomy and fusion had a non-significantly higher recovery rate of JOA score 62.5%, compared to 57.2% after laminoplasty and 53.4% after laminectomy. With an intermediate mean follow-up (of at least two years), kyphosis developed in 28.4% after laminectomy, 7.5% after laminoplasty and 0% after laminectomy and fusion. Axial pain was

present in 35% of patients who underwent laminoplasty; progression of OPLL was noted in 70% after laminectomy and 66% after laminoplasty.
Conclusion: Substantial long-term improvement in myelopathy was seen regardless of the posterior technique utilized. However, long-term complications – particularly the development of kyphosis or neck pain and progression of OPLL – were common after laminectomy or laminoplasty. Additional research is needed on the long-term outcomes of patients with OPLL after laminctomy and fusion.

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Assessment of Potential Predictors of Long-Term Outcomes of Surgery for Cervical Spondylotic Myelopathy: Clinical, Demographics and MR imaging Factors

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Introduction: Cervical spondylotic myelopathy (CSM) is the commonest cause of spinal cord dysfunction worldwide, leading to severe neurological impairments and major socio-economical costs. Nevertheless, prospective data on factors which predict surgical outcomes are lacking.
Methods: 65 consecutive patients with CSM were treated at a university-based center. After excluding 4 patients who were lost to follow-up, 61 (follow-up: 94%) were analyzed for prediction of surgical outcomes. There were 42 males and 19 females with mean age of 57 years (range: 32 to 86 years). The mean mJOA score improved from 12.8 ± 2.7 points preoperatively to 15.8 ± 2.3 points at 12 months postoperatively ($p<0.0001$). The modified Japanese Orthopaedic Association Scale (mJOA) was used as the primary outcome measure to quantify functional disability at admission and at 12-months follow-up. Potential predictors of functional outcomes included age, gender, duration of symptoms, severity of myelopathy, number of compressed segments, antero-posterior diameter [AP] and transverse area [TA] of the spinal cord at the site of maximal compression, three patterns of MRI spinal cord signal intensity changes. Data were analyzed using Spearman's rank correlation test, ANOVA and Mann-Whitney test, and stepwise multivariable regression.
Results: Higher baseline mJOA scores were associated with younger age ($p=0.0002$), shorter duration of symptoms ($p=0.03$), fewer compressed segments ($p=0.04$) and less severe cord compression ($p=0.02$). Moreover, better postoperative mJOA scores were associated with younger age ($p<0.0001$) and shorter duration of symptoms ($p=0.07$). Using multivariate analysis, baseline and follow-up mJOA scores were best predicted by age.
Conclusion: The data suggest that functional outcomes can be predicted by age and baseline mJOA scores. Moreover, age negatively affects functional outcomes following surgical treatment.

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The AOSpine North America Cervical Spondylotic Myelopathy Study: Perioperative Complication Rates Associated with Surgical Treatment Based on a Prospective Multicenter Study of 302 Patients

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Introduction: Cervical spondylotic myelopathy (CSM) often warrants surgical treatment. Our objective was to assess complication rates associated with the surgical treatment of CSM based on a prospective multicenter study.
Methods: The AOSpine North America CSM study is a recently completed prospective multicenter study of patients surgically treated for CSM. Standardized forms were used to collect clinical and surgical data. Perioperative complication rates (within 30 days of surgery) were assessed.
Results: A total of 302 patients (178 men/124 women) were enrolled, with a mean age of 57 years (range: 29-86). Surgical approaches included anterior-only (n=176, 58%), posterior-only (n=107, 35%), and combined anterior-posterior (n=19, 6%). Fusion, laminoplasty, and corpectomy were performed in 27%, 13%, and 18% of cases, respectively. Of 332 reported adverse events, 73 were adjudicated to be complications, including 25 major (8%) and 48 minor (16%). The most common complications included: cardiopulmonary events (3.3%), infection (7 superficial/2 deep, overall 3.0%), dysphagia (3.0%), C5 radiculopathy/palsy (1.7%), worsened myelopathy (1.3%), new radiculopathy other than C5 (1.0%), epidural/wound hematoma (1.0%), instrumentation malposition/migration (1.0%), durotomy (1.0%), other neurological deficit (0.7%), renal complications (0.7%), and altered mental status (0.7%). Single cases of death, stroke, re-operation (not otherwise specified), thromboembolism, wound dehiscence, worsened neck pain, and pneumonia were reported. Ten miscellaneous complications were documented.
Conclusion: These data provide benchmark rates for perioperative complications associated with the treatment of CSM and demonstrate a remarkably low rate of neurological complications, with the vast majority complications being treatable and without long-term impact.

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Spinal Injuries in Children and Adolescents

Jan Stulik, Jan Kryl, Michal Barna, Petr Nesnidal

Introduction: In this retrospective study, the effectiveness of conservative and surgical treatment of injured spines in children is evaluated in a 10-year period.
Methods: All patients from birth to the completed 18th year of age treated in our departments between 1996 and 2005 were included in this study. The patients, evaluated in three age categories (0-9, 10-14, 15-18), were allocated to two groups according to the treatment used.
Results: During 1996 through 2005, we treated a total of 15 646 patients with injury to the skeleton, aged 0 to 18 years. The spine was affected in 571 cases, which is 3.6%. We used conservative treatment in 528 (92.5%) and surgery in 43 (7.5%) children. The group of patients treated conservatively consisted of 292 boys (55.3%) and 236 girls (44.7%); 219 (41.5%) were in the 0-9 year category, 251 (47.5%) were between 10 and 14 years old and 58 (11 %) were 15 to 18 years old. In all age categories, injury to the thoracic spine was most frequent (340; 64.4%). Multi-segment injury in 124 patients (23.5%). The thoracolumbar spine was affected in 22 patients (4.2%), and lumbar vertebrae in 28 patients (5.3%), upper cervical spine in 4 (0.8%) and lower cervical spine in 10 (1.9 %) patients. None of the patients showed neurological deficit. The surgically treated group included 29 (67.4%) boys and 14 (32.6%) girls; two (4.7%) children were between 0 and 9 years, nine (20.9%) between 10 and 14 years, and 32 (74.7%) between 15 and 18 years. The upper cervical spine was operated on in 5 (11.6%), lower cervical spine in 8 (18.6%), thoracic spine in 13

(30.2%), thoracolumbar spine in 5 (11.6%) and lumbar vertebrae in 12 (27.9%) patients. Neurological deficit was recorded in 9 (20.9%) patients.
Conclusion: Childhood spinal injuries account for only 2 to 5% of all spinal injuries and for 3.6% of all skeletal injuries in children. Conservative treatment is preferred; surgery before 12 years of age is strictly individual, while after 12 years therapy is similar to that used in adults.

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Diffusion Tensor MR Imaging in Rats with Varying Spinal Contusion Severity

Shekar N. Kurpad, Brian Schmit, Michael Jirjis, Mohammed Ali Jazayeri, John L. Ulmer

Introduction: Diffusion Tensor Imaging (DTI) is a promising novel MRI based technique for spinal cord tractography. We have previously shown that DTI derived indices, including mean diffusivity (MD), fractional anisotropy (FA), lateral and transverse apparent diffusion coefficients (lADC and tADC) correlate with structural and functional changes after SCI in the zone of injury. We present the preliminary results of our recent investigations in the validation of DTI FA as a biomarker for distal changes in the cervical spinal cord after experimental thoracic injuries of varying severity.
Methods: Four groups of rats were used for the experiments. These included animals with sham surgery, mild, moderate and severe thoracic injuries derived from a standard NYU impactor. Animals were imaged in vivo using a 9.4T magnet, and axial diffusion weighted images were collected at a b-value of 500 seconds/mm(2). Average FA values were calculated in axial sections of the cervical spinal cord with five slices representing C2-3/C3-4/C4-5/C5-6 and C6-7 respectively.
Results: In all three injury groups, average FA values showed a progressive decreasing trend in a caudal cephalad direction ranging from 0.69 to 0.59 mm(2)/s in FA. Severely injured rats showed the greatest reduction in FA values (average of 0.9 decrease in FA) with moderate and mild injured animals showing slightly lesser reduction (average of 0.6 and 0.4 mm(2)/s decrease in FA respectively). FA values in the severe injury group were significantly different (analysis of variance [ANOVA], $p > 0.05$) than the other two groups. No significant difference was observed between the mild and moderate groups.
Conclusion: We have demonstrated that FA can be a reliable biomarker for estimating spinal cord structural changes in the cervical spinal cord after thoracic injury. In addition, our studies show that FA changes in the cervical cord can reflect injury severity in the thoracic cord. These observation carry important implications in further refining DTI indices to assess SCI severity.

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CTA Screening for Vertebral Artery Injury in Transverse Foramen Fractures in 320 Patients

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Introduction: Transverse foramen fractures are a common finding after cervical spine trauma. Computed tomography angiography (CTA) is a rapid method to screen for vertebral artery injury in patients who sustain these fractures.
Methods: We reviewed the prospective trauma database of 2084 consecutive cervical spine fractures from 2000 to 2009. We identified 320 patients with transverse foramen fractures and computed tomography angiography. The primary goal is to identify the incidence of vertebral artery injury in this blunt trauma population.
Results: CTA results were obtained on all 320 patients with cervical transverse foramen fractures. In this population, 19% of patients were found to have sustained vertebral artery injury on CTA.
Conclusion: Transverse foramen fractures of the cervical spine should undergo screening with CTA to evaluate for vertebral artery injury. Fracture patterns associated with vascular injury will be discussed. Outcomes of various treatment methods employed will be discussed.

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Dens Fractures in Patients over 65 Years of Age: Anterior Screw Fixation of the Dens vs. Posterior Fixation of C1-C2

Jan Stulik, Jan Kryl, Petr Nesnidal

Introduction: This study is a retrospective evaluation of dens fractures in patients over 65 years of age treated with anterior screw fixation of the dens (ASF) or posterior atlantoaxial fixation and fusion (PF).
Methods: We treated surgically 28 patients older then 65 years with dens fractures, with a mean age of 77.4 years (65-90 years). According to the type of treatment the whole cohort was divided into 2 groups that were subdivided into two age groups of patients 65-74 years old (N=8, mean age 68.5) and older then 75 years (N=20, mean age 81). Neurological deficits were found in three patients, Frankel D type. All patients underwent radiograph examination in two projections, CT scans and in most cases also MRI examination. Based on these examinations, the type of injury was determined and method of treatment indicated. Follow-up was 12 to 78 months after the surgery (mean 31.3 months) with consideration on aetiology and type of injury, neurological finding, method of treatment, union of the fracture lines or C1-C2 fusion, stability of the spine and the final outcome.
Results: There was statistically significant difference in the mortality ($p<0.05$), with 0% in the younger group and 40% in the older group. Mortality within 6 weeks after the injury was 28.6%. Mortality after ASF was 21.4% and mortality after PF was 35.7% ($p>0.05$). Of the 20 surviving patients, 11 were treated with ASF and 9 with PF. We found only one case of nonunion of the dens (9.1%) and one fibrous callus in the region of C1-C2 fusion and the fracture line in the dens (11.1%) ($p>0.05$).
Conclusion: Active surgical treatment conduces the improvement of the quality of life of elderly patients after dens fractures. Mortality is influenced by the age rather than by the surgical technique used. Elderly patients with a neurological deficit mostly die of associated diseases.

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A Pilot Evaluation of the Role of Bracing in Stable Thoracolumbar Burst Fractures

Mohammed F. Shamji, Darren Roffey, Don Chow, Joseph O'Neil, Garth Johnson, Daryl Young, Eugene Wai

Introduction: The management of thoracolumbar burst fractures may depend on clinical presentation of neurological deficit as well as radiographic features of fracture severity suggestive of instability.[1] When patients are neurologically intact and have mild deformity on computed tomography (CT), conservative therapy may be applied, conventionally involving bracing over months to permit fracture stabilization.[2,3] We investigated the utility of bracing vs. no bracing among stable thoracolumbar burst fractures.
Methods: Patients with stable thoracolumbar burst fractures, single level between T12 and L2, without neurological deficit or lower extremity injury were entered into this study.

Randomization was computer-generated in sealed envelopes. Investigated endpoints were at time of presentation and at 6-months follow-up and included radiographic outcomes of kyphotic progression and loss of vertebral height and clinical outcomes of self-reported pain and disability. Continuous variables were analyzed by two-factor ANOVA (time and treatment as factors), at the 0.05 level of significance.

Results: There were no differences between patients treated with or without bracing regarding the level of injury (p=0.18) and initial spine geometry including extent of fragment retropulsion (p=0.97), anterior loss of height (p=0.56), or Cobb angle (p=0.26). Progressive loss of height occurred to by additional 17±4% in both groups (p=0.96) and degree of kyphotic progression was also no different by treatment (brace 6±2, no brace 8±2, p=0.59). Improvements in self-reported pain and disability were observed in both treatment groups, to similar extent regardless of management arm (Figure 1, p=0.40).

Conclusion: Patients with stable thoracolumbar burst fractures treated with or without bracing had similar outcomes at 6 months. Radiographic outcomes of fracture geometry and clinical outcomes of pain and disability scores were no different by treatment type. These patients may benefit from conservative therapy simply involving sequential imaging without brace immobilization, although larger series of patients may be required.

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Clinical Outcome and Risk of Reoperation for Recurrent TCS in 99 Consecutive Children Operated for Tight or Fatty Filum

Lauren Rose Ostling, Karin S. Bierbrauer, Charles Kuntz

Introduction: For operative division of a tight or fatty filum in pediatric patients, the clinical outcome is often assumed to be favorable, while complications and risk of reoperation for recurrent tethered cord syndrome (TCS) are frequently considered negligible.

Methods: In this retrospective study, the authors reviewed the medical records of 99 consecutive children who underwent initial division of the filum terminale at Cincinnati Children's Hospital Medical Center (November 1995 - May 2006) for a tight or fatty filum. Presenting symptoms/signs, MRI findings, complications, postoperative symptoms/signs, and need for reoperation were recorded. Mean follow-up for all patients was 32 months; 79 were followed for greater than or equal to 6 months and 67 were followed for greater than or equal to 12 months.

Results: The most common presenting symptoms were bladder and/or bowel dysfunction, followed by gait abnormality, back pain, and spasticity. At last follow-up, 86 patients were improved or stable, while 11 patients had at least one symptom/sign which had worsened. There were a total of 12 complications in 9 patients including 5 wound infections, 4 CSF leaks, 1 pseudomeningocele, 1 stitch abscess and 1 transient headache. Five children underwent a reoperation for recurrent TCS with further detethering of the spinal cord. Worsening back pain was the most common symptom in those patients requiring reoperation. Mean time to reoperation was 58 months (range 22 - 73 months). Arachnoid adhesions were found to have accounted for the retethering at the time of reoperation in four of the five patients.

Conclusion: Division of a tight or fatty filum, in this consecutive series of pediatric patients, resulted in improved or stable symptoms in 89% of patients. However, the complication rate and 5.1% rate of reoperation for recurrent TCS are not insignificant.

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Determination of the Minimum Improvement in Pain, Disability, and Health State Associated with Cost-effectiveness: Introduction of the Concept of Minimum Cost Effective Difference (MCED)

Scott Parker, Owoicho Adogwa, Brandon J. Davis, Clint Devin, Matthew J. McGirt

Introduction: Spinal surgical outcome studies rely on patient-reported-outcomes (PRO) to assess effect. A shortcoming of these outcome-metrics is that extent of change in numerical scores lack a direct meaning or clinical significance. Hence, the concept of minimum clinical important difference (MCID) was adopted as smallest improvement in PRO needed to achieve treatment-effectiveness. While total cost of <$50,000 per QALY-gained is considered cost-effective for a particular treatment, a measure for smallest improvement in PRO that is associated with cost effectiveness has yet to be introduced. Here we utilize a common MCID-calculation method with a cost-utility threshold-anchor to introduce the concept of minimum cost effective difference (MCED).

Methods: Forty-five patients undergoing trans-foraminal lumbar interbody fusion (TLIF) for degenerative spondylolithesis were included. BP-VAS, LP-VAS, ODI, EQ-5D were administered before and 2-years postoperatively. Cost was calculated from Resource use x Medicare national allowable payment amounts (direct cost) and Missed work x self-reported gross-of-tax wage rate (indirect cost). Total cost per QALY gained was assessed for each patient. The MCED for each PRO was determined using receiver operating characteristic (ROC) curve analysis with <$50,000/QALY as cost-effective anchor and MCID determined with the health transition index (HTI) of the Short Form-36 as anchor.

Results: A significant improvement in all outcome measures was observed two years after TLIF(Figure 1), with a mean two-year gain of 0.86 QALYs per patient. Cost was <$50,000/QALY gained for 27 (60%) patients. MCED was greater than MCID for each PRO: 3.1 vs. 2.1 for VAS-LP, 3.1 vs. 2.1 for VAS-BP, 19 vs. 14 for ODI, and 0.32 vs. 0.15 for EQ-5D,Table 1. For MCED, area under the ROC curve ranged from 0.78-0.98, suggesting the four PRO change scores were accurate predictors of cost-effectiveness. Mean cost per QALY-gained was lower for patients achieving vs. not-achieving MCED in VAS-LP ($43,560 vs. $112,087), VAS-BP ($41,280 vs. $129,440), ODI ($30,954 vs. $121,750), and EQ-5D ($35,800 vs. $189,412).

Conclusion: Minimum cost effective difference serves as the smallest improvement in outcome metric that represents a cost-effective response to surgery. The extent of improvement associated with cost-effectiveness was consistently greater than that associated with patient-reported clinical effectiveness (MCID). MCED following TLIF is 3.1 points for BP-VAS, 3.1 points for LP-VAS, 19 points for ODI, and 0.32 QALYs for EQ-5D.

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Comparative Effectiveness of Minimally Invasive vs. Open Transforaminal Lumbar Interbody Fusion: Two-year Assessment of Narcotic Use, Return to Work, Disability, and Quality of Life

Owoicho Adogwa, Scott Parker, Oran Aaronson, Joseph S. Cheng, Matthew J. McGirt

Introduction: Minimally invasive transforaminal lumbar inter-body fusion (MIS-TLIF) for lumbar spondylolithesis theoretically allows for surgical treatment of back and leg pain while minimizing blood loss and tissue injury. While prior

studies have demonstrated shorter hospital stay and equivocal six and twenty-four month outcomes with MIS- vs. open-TLIF, the effect of MIS techniques on postoperative narcotic use and return to work are poorly understood.
Methods: Forty patients undergoing MIS-TLIF (n=20) or open-TLIF (n=20) for grade I degenerative spondylolithesis-associated back and leg pain were enrolled. Two-year outcomes were prospectively assessed via phone interview and included pain [visual analogue scale (VAS)], low-back disability [Oswestry disability index (ODI)], quality of life [EuroQol (EQ-5D)], occupational disability, and narcotic use.
Results: MIS vs. open-TLIF cohorts were similar at baseline. Median [IQR] length of hospitalization following surgery was significantly less for MIS- vs. open-TLIF (3 [3-3] vs. 5.5 [4-6] days), p=0.001. MIS- vs. open-TLIF patients demonstrated similar two-year improvement in VAS-BP, VAS-LP, ODI, and EQ-5D scores, Figure3. Overall, median [IQR] length of postoperative narcotic use was 3.0 [1.4-4.6] weeks and significantly shorter for MIS- vs. open-TLIF patients (2.0 [1.0-3.0] vs. 4.0 [1.4-4.6] weeks, p=0.008),Figure 1. Overall, median [IQR] time to return to work was 13.9 [2.2-25.5] weeks and significantly shorter for MIS- vs. open-TLIF patients (8.5[4.4-21.4] vs. 17.1 [1.8-35.9] weeks, p=0.02), Figure 2.
Conclusion: Both minimally invasive and open-TLIF provide long-term improvement in pain, disability, and quality of life in patients with back and leg pain from grade I degenerative spondylolithesis. However, MIS-TLIF may allow for shortened hospital stays, reduced postoperative narcotic use, and accelerated return to work, influencing factors associated with direct medical costs and indirect costs of lost work productivity.

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Comparative Analysis of Surgical Site Infection after Minimally Invasive vs. Open Posterior/Transforaminal Lumbar Interbody Fusion: Analysis of Hospital Billing and Discharge Data from 5,328 Patients

Matthew J. McGirt, Scott Parker, Jason Lerner, Luella Engelhart, Michael Y. Wang

Introduction: Surgical site infection (SSI) following posterior or transforaminal interbody fusion (P/TLIF) of the lumbar spine is associated with significant morbidity and medical resource utilization. To date, there have been no studies conducted with sufficient power to compare the incidence of SSI following minimally invasive (MIS) vs. open P/TLIF procedures. We assess the incidence and direct costs of SSI in patients undergoing MIS vs. open P/TLIF from a hospital-system database representing more than 600 hospitals and 5 million discharges per year.
Methods: In a retrospective longitudinal analysis of hospital discharge and billing records from the Premier Perspective™ database, all patients undergoing P/TLIF were identified via International Classification, 9th Revision, Clinical Modification (ICD-9-CM) procedure codes. MIS procedures were identified by instrumentation trade name. SSI was defined as a subsequent diagnosis of postoperative infection or administration of intravenous antibiotics 1-8 weeks postoperatively. Medicare reimbursement rates and commercial payer charge data were used to estimate the direct medical costs of SSI.
Results: 3,793 patients underwent open P/TLIF (1,625 one-level, 2,168 two-level) and 1,535 patients MIS-P/TLIF (882 one-level, 653 two-level). Overall, MIS- vs open-P/TLIF was associated with a reduction in SSI [71 (4.6%) vs 228 (6%), p=0.047], Table 1. Stratified by levels fused, SSI was similar for one-level P/TLIF [41 (4.6%) vs 77 (4.7%), p=0.919], but significantly reduced for two-level MIS-P/TLIF [30 (4.6%) vs. 151 (7.0%), p=0.030], Table 2. The estimated cost of surgically managed SSI was $23,380 and medically managed SSI $12,419. For two-level fusion, estimated SSI-associated cost per 100 P/TLIFs performed was $115,959 for open- and $72,306 for MIS-P/TLIF (cost savings: $43,653 per 100 two-level P/TLIFs performed).
Conclusion: This population-based study of data from over 600 hospitals in the US indicates that MIS- vs. open-P/TLIF was associated with a decreased incidence of postoperative infections after two-level lumbar fusion. Considering the morbidity and costs associated with SSIs, MIS-lumbar fusion may be a valuable tool in reducing hospital infection rates and costs associated with spine care.

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Endoscopic Image-Guided Transcervical Odontoidecomy: Long-Term Outcomes of 15 Patients with Basilar Invagination

Hormuzdiyar H. Dasenbrock, Michelle J. Clarke, Ali Bydon, Daniel M. Sciubba, Timothy F. Witham, Ziya L. Gokaslan, Jean-Paul Wolinsky

Introduction: Ventral decompression with posterior stabilization is the preferred treatment for symptomatic irreducible basilar invagination (BI). However, the standard (and expansile) transoral approaches to the dens can be associated with substantial morbidity. Endoscopic image-guided transcervical odontoidectomy (ETO) may allow for decompression to be performed with less morbidity. We report the largest series with the longest follow-up of patients undergoing odontoidectomy for BI via an endoscopic transcervical approach.
Methods: 15 patients who had a follow-up of at least 9 months were retrospectively reviewed. Intraoperatively, the vertebral body of C2 was removed and the odontoid was resected in a "top-down" manner using endoscopic visualization and frameless stereotactic navigation. Posterior instrumented stabilization was subsequently performed.
Results: The average (± standard deviation) age of the patients was 42.6±24.5 (range 11-72) years; the mean preoperative degree of basilar invagination (measured above the McGregor line) was 12.0±9.9 (range 0-35) mm. Postoperative complications occurred in 6 patients, including a urinary tract infection (n=2), upper airway swelling (n=2), dysphagia (n=2), gastrostomy tube placement (n=1) and an asymptomatic pseudomeningocele (n=1). The average length of hospital stay was 9.1±4.9 (range 2-23) days. With a mean follow-up of 34.9±14.4 months, myelopathy improved in all patients and the mean modified Japanese Orthopedic Association (mJOA) score increased from 11.1±4.0 to 16.0±1.4 (p=0.0001). Patients with a diagnosis other than rheumatoid arthritis (p=0.003) or who a higher preoperative mJOA score (p=0.026) were significantly more likely to have a complete neurological recovery; improvement in neurological function was not significantly associated with preoperative severity of basilar invagination. At the final follow-up, all patients had evidence of solid arthrodesis and resolution of their pre- or postoperative dysphagia. No patients experienced late neurologic deterioration.
Conclusion: ETO may be a valid treatment for patients with symptomatic irreducible basilar invagination that avoids some of the morbidity of transoral surgery and leads to long-term improvement in myelopathy.

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Minimally Invasive Treatment of Adjacent Segment Degeneration via XLIF

Jody A. Rodgers, W.B. Rodgers, 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 with XLIF are presented.

Methods: Of our single-site consecutive series of 932 XLIF patients, 276 were treated for ASD. Clinical and radiographic measures were prospectively collected and evaluated.

Results: Age ranged from 29-91 years (average 61.6 years). 90.6% had one or more comorbidity. 144 patients (52%) were obese or morbidly obese. All but one case included supplemental fixation: 47% unilateral pedicle screws, 4% bilateral pedicle screws, 12% lateral embroidered plate, and 43% 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 1.3 days, with 2 blood transfusions and one wound infection. Complications included intraoperative hardware failure (4, revised during same procedure with no incident), ileus (5), gallstone pancreatitis (1), urinary retention (3), kidney stone (1), peritoneal catheter occlusion (1), pulmonary embolism (1), subcutaneous hematoma (1), delirium (1), atrial fibrillation (3), MI at 6 weeks post-op (1), compression fracture at an adjacent level (5), sacral fracture (1), and postoperative quadriceps weakness (1, resolved within 4 weeks of surgery). Average VAS scores improved by 4.6 points from pre-op to 12 months. Average disk height improved from 6.4 to 10.6 at post-op, settling to 8.7mm at 24 months; slip from 3.5 to 0.6mm. Definitive signs of fusion (Lenke 1-2) were present in 74% at 3 months, 91% at 6 months, 96% at 12 months and 95% at 24 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.

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Comparative Clinical Outcomes Following Minimally Invasive L5-S1 Interbody Fusion, Comparison of TLIF, ALIF, and AxiaLif for Single-level Arthrodesis

Zachary Adam Smith, Larry T. Khoo

Introduction: The development of new minimally invasive spine (MIS) techniques for lumbosacral fusion has provided the spine surgeon multiple methods for fusion at the L5-S1 interbody space. The authors compare clinical and radiographic outcomes from a cohort of prospectively followed patients treated with three modern techniques, MIS-TLIF, ALIF, and AxiaLIF.

Methods: Between June 2003 and January 2009, 58 patients were treated for isolated degenerative disk disease of the L5-S1 segment. All patients presented with back pain with or without radiculopathy and had failed conservative management. The average patient age was 43.34 years. Twenty patients were treated with TLIF, 19 with ALIF, and 19 with AxiaLIF. All patients were prospectively followed with pre- and postoperative visual analog score (VAS) and Oswestry-Disability Index (ODI) scores as well as routine radiographic follow-up.

Results: Clinical outcome with ODI demonstrated a decrease in ODI of -25 with TLIF, -22 with ALIF, and -24 with AxiaLIF. VAS leg scores decrease 92% in patients treated with TLIF, 76% with ALIF and 71% with AxiaLIF. The time of access to the interbody space was most rapid with AxiaLIF (65m) and slightly longer with ALIF (85m) and TLIF (105m). Radiographic outcomes showed that ALIF produced the best distraction of the interbody space (8.6mm); TLIF (6.3mm), AxiaLIF (5.9mm). Fusion with TLIF and ALIF was 95% and AxiaLIF 90%. Subsidence was greatest with AxiaLIF 16% followed by TLIF (12%) and ALIF (9%). Complications included 2 patients with radiculitis following TLIF. There was a single CSF leak (TLIF) and a single lumbar plexus injury (ALIF). There was a single vascular injury (ALIF) and a single visceral injury (AxiaLIF).

Conclusion: MIS-TLIF, ALIF, and AxiaLIF are all modern, MIS-type approaches to the L5-S1 interbody space. Patient outcomes suggest each has unique clinical strengths and specific disadvantages. Complications with each approach is unique and primarily related to anatomy of the access route.

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Cost-utility Analysis of Minimally Invasive vs. Open Multilevel Decompression for Lumbar Stenosis

Owoicho Adogwa, Brandon J. Davis, Erin Fulchiero, Oran Aaronson, Joseph S. Cheng, Clint Devin, Matthew J. McGirt

Introduction: Minimally invasive (MIS) multi-level hemilaminectomy for degenerative lumbar spinal stenosis allows for effective treatment of back and leg pain while theoretically minimizing blood loss, tissue injury, and postoperative recovery. No studies to date have evaluated the comprehensive healthcare costs associated with multilevel laminectomy procedures, nor assessed the cost-effectiveness of MIS vs. open- multilevel laminectomy.

Methods: Fifty-four patients undergoing MIS paramedian tubular (n=27) or open multilevel hemilaminectomy (n=27) for lumbar stenosis associated radiculopathy were prospectively studied. Total back-related medical resource utilization, missed work, and health-state values (quality adjusted life years (QALYs), calculated from EQ-5D with U.S. valuation) were assessed after two-year follow-up. Two-year resource use was multiplied by unit costs based on Medicare national allowable payment amounts (direct cost) and work-day losses were multiplied by the self-reported gross-of-tax wage rate (indirect cost). Difference in mean total cost per QALY gained for MIS- vs. open-laminectomy was assessed as incremental cost-effectiveness ratio (ICER: COSTmis - COSTopen/QALYmis - QALYopen).

Results: MIS vs. open cohorts were similar at baseline, Table 1. Both MIS and open laminectomy were associated with a two-year gain of 0.72 QALYs, Figure 1. Mean direct medical costs ($13,334 vs. $14,291), indirect societal costs ($9,775 vs. $11,130), and total two-year cost ($23,109 vs. $25,420, p=0.21) were similar between MIS- and open-hemilaminectomy, Table 2. MIS was associated with similar total costs and utility, making it a cost equivalent technology compared to the traditional open approach.

Conclusion: MIS- vs. open- multilevel hemilaminectomy was associated with similar cost over two years while providing equivalent improvement in quality adjusted life years. In our experience, MIS- vs. open- multilevel hemilaminectomy is a cost equivalent technology for patients with lumbar stenosis associated radicular pain.

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Minimally Invasive Lateral Access Surgery for Symptomatic Thoracic Disc Herniation: Initial Clinical Experience with Clinical and Radiographic Outcomes

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Introduction: Symptomatic herniated thoracic discs remain a surgical challenge and historically have been associated with high levels of complications. While the neurologic outcomes have improved with the abandonment of the decompressive laminectomy; surgical complications, morbidity and the need for fusion have continued. The purpose of this study is to demonstrate the safety and reproducibility of the minimally invasive lateral thoracic approach for symptomatic thoracic herniated intervertebral discs with clinical and radiological outcomes.

Methods: We retrospectively studied 24 patients to assess the clinical and radiographic results using minimally invasive surgery for the treatment of thoracic herniated discs. All patients underwent a lateral transthoracic approach utilizing an expandable tube retractor. Follow up times were an average of 21 months. The patients were followed with neurologic examination, visual analog score (VAS) and Oswestry disability index (ODI). Postoperative computed tomography was performed to assess the extent of bony resection.

Results: The mean blood loss was 415 ml. The mean visual analog scale score improvement for thoracic pain was 4.1. The Oswestry disability index improved an average of 36%. All discs were successfully removed except in one patient. One case was complicated by durotomy and one case was complicated by worsened myelopathy Asia D to ASIA C. There was no incidence of wrong-level surgery.

Conclusion: Our early experience suggests that the minimally invasive lateral transthoracic approach is safe, reproducible and effective for achieving adequate decompression in thoracic disc herniations in a less invasive manner than traditional surgical treatment options. This surgical technique allows the surgeon to directly visualize and protect the dura prior to visualizing the lesion without the need to collapse the lung. As this technique is advanced, the applicability of minimally invasive surgery will likely be expanded and will afford the opportunity for reduced complications.

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Early Radiographic Outcomes of XLIF in the Minimally Invasive Treatment of Adult Scoliosis: Results from a Prospective Multicenter Non-randomized Study of 107 Patients

Frank M. Phillips, Safdar Khan, Solas Degenerative Study Group

Introduction: Surgical intervention in adult scoliosis patients has traditionally been performed using large open anterior and/or posterior procedures. This report summarizes the early radiographic outcomes of a minimally-invasive approach (XLIF) for the treatment of adult scoliosis, as part of an ongoing prospective, multicenter study.

Methods: 107 patients were treated for adult scoliosis with XLIF at 14 US centers. Radiographs were collected preoperatively and postoperatively at 2 weeks, 3, 6, 12, and 24 months. Radiographic analysis included measures of lumbar lordosis (L1 to S1), coronal Cobb angle, device subsidence, and device migration.

Results: Radiographic follow-up was available for 103 patients who were treated at 310 levels between T11 and L5. Procedures included 1-6 levels. 73.8% of patients were female, average patient age was 67.8 years, BMI was 28.4 kg/m2, and 10.7% were smokers. Supplemental fixation included bilateral pedicle screws (49%), unilateral pedicle screws (26%), and anterolateral plating (7%); the remaining 18% were standalone. At 3 months incidence of migration was 0% and subsidence was 26.2%, none requiring revision. On average, patients had normal lordosis preoperatively, with 33 patients having abnormal lordosis (>-40°) measuring an average of -28.5°. Lordosis was significantly corrected in hypolordotic patients from preoperative to 2 weeks ($p<0.001$) which was maintained at 3 months (average 3 month lordosis = -35.4°). Significant corrections in average coronal Cobb angle were observed from preoperative to 2 weeks ($p<0.001$) and maintained at 3 months. Coronal correction was significantly affected by supplemental fixation ($p=0.027$) with the greatest corrections in patients with bilateral posterior pedicle fixation and the least in patients with no supplemental fixation (average 12.6° vs. 2.6°).

Conclusion: Significant reduction in deformity was observed with respect to coronal Cobb angle and lordosis, and was maintained through the three month evaluation, providing evidence that the XLIF technique can effectively correct deformity in the adult scoliosis population.

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Economic Impact of Minimally Invasive Spine Surgery Open vs. MIS Spinal Fusion Costs in the Perioperative Period (First 45 Days)

Jody A. Rodgers, W.B. Rodgers, John Lucio, Brent Vanconia, Kevin J. DeLuzio

Introduction: Improved clinical and radiographic outcomes have been reported of minimally invasive spinal surgery techniques in comparison to traditional open approaches. We seek to determine if fewer complications, reoperations, additional therapies and diagnostics yields a lower overall cost among minimally invasive patients.

Methods: Hospital costs were retrospectively obtained for all our center's two level spinal fusions from 2005-2008. 101 patients had a traditional open procedure, and 109 underwent a minimally invasive fusion. Patients were not randomized; procedure methods were employed sequentially. After our transition to minimally invasive techniques in late 2006, no further open procedures were performed. Costs obtained include surgical procedure and hospitalization, in addition to ensuing hospital costs occurring in the first 45 days postop.

Results: Average cost of the original procedure and hospitalization was 6% less expensive in the MIS group overall, despite higher implant costs in the MIS group. When combined with all perioperative costs within the first 45 days after surgery, the average procedure cost reduction was 10.4%, a savings of $2,825.37 per procedure.

Conclusion: Results indicate an overall reduction of costs of MIS two level procedures compared to traditional open approaches. Costs of the surgical procedure and hospitalization are lower in the MIS group. Early numbers indicate that cost savings increase as length of time postop increases. The open group, although with longer follow-up, has demonstrated a significantly higher incidence of reoperation than the MIS group comparatively. Thus, our continued cost evaluation into the intermediate and long-term follow-up period may demonstrate an ever-increasing improvement in overall costs.

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Perioperative Outcomes and Complications Following XLIF for the Treatment of Adult Scoliosis: Results of a Prospective, Non-randomized, Multicenter Evaluation

Robert E. Isaacs, Jonathan Hyde, J. Allan Goodrich, W.B. Rodgers, Frank M. Phillips, Solas Degenerative Study Group

Introduction: Combined anterior/posterior instrumented fusion is often performed for the surgical treatment of adult scoliosis. Such procedures have been associated with a high risk of complication, particularly in the elderly patient population. Less invasive surgical approaches to neural decompression and fusion have recently been applied in the treatment of degenerative scoliosis. This report summarizes the perioperative complications following lateral fusion for the correction of degenerative scoliosis.
Methods: In a prospective multicenter observational study of patients who underwent the XLIF procedure for the treatment of degenerative scoliosis, perioperative measures were compiled to identify the short-term outcomes of the procedure. Intraoperative data collection included surgical details, operative time, estimated blood loss, and complications. Postoperative complications, length of hospital stay, and neurological status were recorded.
Results: 107 patients (mean age 68 years; range 45-87) were treated with XLIF. 28% had at least one comorbidity. A mean of 4.4 levels/patient (range 1-9) were treated. Supplemental pedicle screw fixation was used in 75.7% of patients, 5.6% had lateral fixation and 18.7% had standalone XLIF. Mean operative time and blood loss were 178min and 50-100cc. Mean hospital stay was 2.9 days (unstaged), 8.1 days (staged; 16.5%), 3.8 days overall. 5 patients (4.7%) received a transfusion, 3 (2.8%) required ICU admission, 1 (0.9%) required rehabilitation services. Major complications occurred in 13 patients (12.1%): 2 (1.9%) medical, 12 (11.2%) surgical. Of procedures that involved only less invasive techniques (XLIF standalone or with percutaneous instrumentation), 9.0% had one or more major complications. In those with supplemental open posterior instrumentation, 20.7% had one or more major complication. Early reoperations (3, for deep wound infections) were associated with open posterior instrumentation.
Conclusion: The morbidity in adult scoliosis surgery is minimized with less invasive techniques. The rate of major complications in this study (12.1%) compares favorably to reports from other studies of surgery for degenerative deformity.

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Correlation of Preoperative Depression and Somatic Perception Scales with Postoperative Disability and Quality of Life After Lumbar Discectomy

Scott Parker, Kaisorn L. Chaichana, Owoicho Adogwa, Joseph S. Cheng, Matthew J. McGirt

Introduction: Lumbar discectomy is a common surgical procedure performed in the U.S. for patients experiencing back and leg pain. However, patients with certain psychological predispositions may be especially vulnerable to poor clinical outcomes. The goal of this prospective longitudinal study was to determine the role that preoperative depression and somatic anxiety have on long-term back and leg pain, disability, quality of life for patients undergoing single-level lumbar discectomy.
Methods: 67 adults undergoing discectomy for single-level herniated lumbar disc underwent prospective quantitative measurement of leg and back pain (visual analogue scale; VAS), quality of life (Medical Outcomes Short Form-36; SF-36), and disease-specific disability (Oswestry Disability Index; ODI) preoperatively, at 6 weeks, 3, 6, and 12 months after surgery. Degree of preoperative depression and somatization were assessed using Zung Self-Rating Depression Scale and modified somatic perception questionnaire (MSPQ). Multivariate regression analyses were performed to assess associations between Zung and MSPQ scores with achievement of a minimum clinical important difference (MCID) in each outcome measure by 12 months postoperatively.
Results: Overall, a significant improvement in VAS-leg, VAS-back, ODI, and SF-36 PCS was observed by 6 weeks after surgery and maintained throughout 12-months follow-up. Increasing preoperative depression (Zung score) was associated with a decreased likelihood of achieving MCID in disability (p=0.006) and quality of life (p=0.04) but was not associated with leg (p=0.96) or back pain (p=0.85) by 12 months, Fig1&Table 1. Increasing preoperative somatic anxiety (MSPQ score) was associated with decreased likelihood of achieving MCID in disability (p=0.002) and quality of life (p=0.03) but was not associated with leg (p=0.64) or back pain (p=0.77) by 12 months, Fig1&Table 1.
Conclusion: Zung and MSPQ are valuable tools at preoperatively risk stratifying patients who may not experience clinically relevant improvement in disability and quality of life after discectomy. Efforts to address these confounding and underlying contributors of depression and heightened somatic anxiety may improve overall outcomes after lumbar discectomy.

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Microdiscectomy Improves Pain-associated Depression, Somatic Anxiety, and Mental Well-being in Patients with Herniated Lumbar Disc

Scott Parker, Richard L. Lebow, Owoicho Adogwa, Adam S. Reig, Joseph S. Cheng, Matthew J. McGirt

Introduction: In a multicenter, prospective, longitudinal outcome study, we assessed the prevalence of preoperative depression, somatization, and mental well-being in patients with herniated lumbar discs and the effect that microdiskectomy had on these psychological disturbances.
Methods: Patients undergoing surgical discectomy at five medical institutions for a single-level, herniated lumbar disc were prospectively assessed preoperatively, at 6 weeks, 3, 6, and 12 months after surgery for visual analog scale for low back pain (BP-VAS) and leg pain (LP-VAS), depression via Zung Self-Rating Depression Scale, heightened anxiety somatic perception via the Modified Somatic Perception Questionnaire (MSPQ), and mental well-being via the SF-36 mental component summary (MCS).
Results: 100 patients were available for 1-year follow-up. Mean BP-VAS and LP-VAS was significantly improved at 6 weeks and remained improved at 3, 6, 9, and 12 months postoperatively,Figure 1. A significant improvement in SF-36 MCS was also observed by 6 weeks after surgery (42±14 vs. 48.2±12, p<0.01), and it continued to improve over 12-months, Figure2. A significant improvement in MSPQ score was not observed until 3 months after surgery (9±7 vs. 6.6±6.9, p<0.05). A significant improvement in ZUNG depression score was not observed until 12 months after surgery (19±11 vs. 14.4±10.9, p<0.05). 67% of somatasized patients (MSPQ>12) became non-somatsized one year post-surgery. 70% of

clinically depressed patients (ZUNG>33) became non-depressed one year post-surgery. Improvement in SF-36 MCS, ZUNG, and MSPQ each significantly correlated ($p<0.001$) with improvement in BP-VAS and LP-VAS.

Conclusion: The majority of patients defined as somatized and depressed preoperatively returned to good mental well-being following surgery. Improvement in pain and overall mental well-being were seen acutely after microdiskectomy, while improvement in somatic anxiety and depression occurred months later. Microdiskectomy significantly improves pain-associated depression, somatic anxiety, and mental well-being in patients with a herniated lumbar disc. In addition, future comparative effectiveness research on surgical vs. nonoperative treatment of disc herniation should include mental well being as an outcome measure.

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Management of Degenerative Lumbar Stenosis Related to Meyerding Grade I Spondylolisthesis: The Reappraisal of Unilateral Laminotomy

Mario Ganau, Enrico De Micheli, Massimo Gerosa

Introduction: The management of degenerative lumbar stenosis related to Meyerding Grade I sponsylolisthesis is still a matter of debate: both laminectomy and laminotomy have been advocated, but sometimes fusion may represent an overtreatment. A prospective trial was conducted in 38 patients to evaluate the impact of unilateral laminotomy for bilateral decompression of the lumbar canal in such cases.

Methods: On admission, patients (fatio F:M = 27:11; mean age 69y) underwent clinical evaluation using the Beaujon Scoring System (BSS) and VAS scale. Segmental instability detected on dynamic x-rays were considered exclusion criteria. CT and/or MRI studies of the lumbar spine were performed in all cases preoperatively 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 the MacNab classification (grade I-excellent, II-good, III fair, IV-poor).

Results: At discharge, clinical improvement assessed by BSS and VAS scales was significant in all patients; but more interestingly it was sustained even at long-term follow-up (mean 40 months): 81% of the patients were still in excellent conditions according to MacNab classification. Following surgery the lumbar spinal canal diameters (anteroposterior, transpedicular, interapophyseal) were significantly larger than the preoperative measurements, and no cases of vertebral instability were found.

Conclusion: The results of our study indicate that, whenever evidence of spinal instability is ruled out, unilateral laminotomy is a valid surgical option in the treatment of degenerative lumbar stenosis related to Meyerding Grade I spondylolisthesis.

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Determination of Minimum Clinically Important Difference (MCID) in Pain, Disability, and Health State Utility After Transforaminal Lumbar Interbody Fusion (TLIF) for Degenerative Lumbar Spondylolithesis

Scott Parker, Owoicho Adogwa, Alexandra Paul, Bill Anderson, Oran Aaronson, Joseph S. Cheng, Matthew J. McGirt

Introduction: Spinal surgical outcome studies rely on patient reported outcomes (PRO) to assess treatment effect. Commonly used health-related quality-of-life questionnaires include pain scales for back and leg pain (Visual Analog Scale), the Oswestry Disability Index (ODI), and the EuroQol-5D health survey (EQ-5D). A shortcoming of these questionnaires is that their numerical scores lack a direct meaning or clinical significance. Hense, the concept of minimum clinical important difference (MCID) has been put forth as a measure for the critical threshold needed to achieve treatment effectiveness. By this measure, treatment effects reaching the MCID threshold value imply clinical significance and justification for implementation into clinical practice.

Methods: In 45 patients undergoing trans-foraminal lumbar interbody fusion (TLIF) for low-grade degenerative lumbar spondylolithesis associated back and leg pain, PRO measures of BP-VAS, LP-VAS, ODI, and EQ-5D were administered preoperatively and 2-years postoperatively and 2-year change scores calculated. Four established anchor-based MCID calculation methods were utilized to calculate MCID (1. average change, 2. minimum detectable change (MDC), 3. change difference, 4. receiver operating characteristic curve analysis) for two separate anchors (health transition index (HTI) of the Short Form-36 and satisfaction index).

Results: The mean±SD two-year improvement in BP-VAS, LP-VAS, ODI, and EQ-5D were 4.3±2.9, 3.8±3.4, 19.5±11.3, and 0.43±0.44, respectively(Figure 1). The four MCID calculation methods generated a range of MCID values for each of the PROs(BP-VAS:2.1-5.3, LP-VAS:2.1-4.7, ODI:11-22.9, EQ-5D:0.15-0.54),Table 1. The mean area under the ROC curve (AUC) from the four PRO-specific calculations was greater for the HTI vs. satisfaction anchor (HTI AUC: 0.73 vs. satisfaction AUC: 0.69), suggesting HTI as a more accurate anchor.

Conclusion: TLIF specific MCID is highly variable based on calculation technique. The MDC approach with SF-36 HTI anchor appears to be most appropriate for calculating MCID because it provided a threshold above of the 95% confidence interval of the un-improved cohort (greater than the measurement error), was closest to the mean change score reported by improved and satisfied patients, and was least affected by the choice of anchor. Based on MCD method with HTI anchor, MCID following TLIF are 2.4 points for BP-VAS, 2.5 points for LP-VAS, 15.6 points for ODI, and 0.40 QALYs for EQ-5D.

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Attenuating Experimental Spinal Cord Injury by Hyperbaric Oxygen: Stimulating Production of Vasculoendothelial and Glial Cell Lines Derived Neurotrophic Growth Factors and Interleukin-10

Po-An Tai, Chen-Kuei Chang, Ko-Chi Niu, Mao-Tsun Lin, Chien-Min Lin, Wen-Ta Chiu

Introduction: The present study was to further examine the mechanisms underlying the beneficial effects of hyperbaric oxygen (HBO2) on experimental spinal cord injury (SCI).
Methods: Rats were divided into three major groups: (1) sham operation (laminectomy only); (2) laminectomy + SCI+ normobaric air (NBA; 21% O2 at 1 ATA); and (3) laminectomy + SCI + HBO2 (100% O2 at 2.5 ATA for 2 hours). Spinal cord injury was induced by compressing the spinal cord for 1 minute with an aneurysm clip calibrated to a closing pressure of 55 g. HBO2 therapy was adopted immediately after SCI. Behavioral tests of hind limb motor function measured by Basso, Beattie, Bresnahan locomotor scale was conducted at day 1 to 7 after SCI. The triphenyltetrazolium chloride staining and terminal deoxynucleotidyl transferase-mediated deoxyuridine triphosphate biotin nick end labeling assay were also conducted after SCI to evaluate spinal cord infarction and apoptosis respectively. Both glial cell lines derived neurotrophic nerve growth factor (GDNF) and vascular endothelial growth factor (VEGF) positive cells and cytokines in the injured spinal cord were assayed by immunofluorescence and commercial kits, respectively.
Results: It was found that HBO2 therapy significantly attenuated the SCI-induced hind limb dysfunction, spinal cord infarction and apoptosis, and overproduction of spinal cord interleukin-1ß and tumor necrosis factor-a. In contrast, the numbers of both GDNF-positive and VEGF-positive cells and production of spinal cord interleukin-10 during SCI were all significantly increased by HBO2.
Conclusion: These data suggested that HBO2 may attenuate experimental SCI by stimulating production of GDNF, VEGF and interleukin-10.

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FDA IDE Clinical Outcomes for 110 Symptomatic Lumbar Stenosis Patients Treated with ACADIA™ at 16 Centers

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Introduction: Decompression with fusion is often indicated for patients with lumbar radiculopathy and/or neurogenic claudication especially in cases of pre-existing or iatrogenic instability. Alterations in lumbar biomechanics due to arthrodesis have the potential to accelerate degenerative changes at neighboring levels. Placing ACADIA™ as an alternative to fusion may provide the required stability while preserving adjacent level biomechanics, potentially reducing the risk of accelerated degenerative changes. An FDA IDE clinical study has been undertaken to determine the safety and efficacy of this new treatment option.
Methods: Perioperative data, Oswestry Disability Index (ODI) scores, Zurich Claudication Questionnaire (ZCQ) scores, and Visual Analog Scale (VAS) pain scores were recorded. Patient evaluations were conducted at baseline, 6 weeks, 3, 6, 12 and 24 months.
Results: Enrollment has reached 110 patients with 99, 60 and 20 out to 6, 12 and 24 months, respectively. The mean age, BMI, operative time, blood loss and hospital stay were 61, 30kg/m2, 186 minutes, 407mL, and 3.0 days, respectively. The L3/4, L4/5 and L5/S1 levels accounted for 7.3%, 87.3% and 5.5% of the cases, respectively. The percent improvement in mean ODI score at 24 months was 75%. The percent improvements in mean VAS back and leg pain at 24 months were 82% and 83%, respectively. The mean ZCQ Symptom Severity and Physical Function points improved at 12 months were 1.82 and 1.24, respectively. The mean ZCQ patient satisfaction score was 1.37 at 12 months.
Conclusion: This new treatment may represent a clinically viable alternative to fusion. Improvements in functional and pain outcome measures were seen at all postoperative time points and a high level of patient satisfaction has been documented. The clinical safety and efficacy of this procedure will be demined at the conclusion of the ongoing prospective randomized FDA IDE pivotal trial.

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Direct Vertebral Body Derotation: How Much Correction of the Rib Deformity Can Be Expected?

Amer F. Samdani, Steven Wei-Hung Hwang, Baron Lonner, Peter Newton, Michelle Marks, Tracey Bastrom, Randal Betz, Patrick Cahill

Introduction: Direct vertebral body derotation (DVBD) is a powerful tool in the surgical correction of rotational spine deformity and has decreased the use of thoracoplasty for rib deformity correction. In this study, we sought to determine the extent of rib deformity correction which can be expected with DVBD and factors which may correlate with improved correction.
Methods: A prospective, longitudinal database was queried to identify AIS patients who underwent a posterior spinal fusion with 2-year follow-up and Lenke 1-3 curves. All patients had undergone DVBD maneuvers (en-bloc, segmental or both) during their surgery. Patients having undergone concurrent thoracoplasty were excluded from the study. The absolute change and percent change from preoperative inclinometer readings were correlated with preoperative clinical and radiographic data using a Pearson correlation.
Results: 148 patients were identified who fulfilled the inclusion criteria. The mean age was 14.8 ± 2.0 years with a mean primary thoracic curve of 55.3 ± 9.3º. The primary thoracic curve reduced to 28.1 ± 12.0º on bending radiographs translating to a flexibility of 49%. The mean preoperative inclinometer reading was 14.9 ± 4.5° which reduced to 7.5 ± 4.0° post-op for a 50% improvement. We attempted to correlate 23 of the most commonly used pre-op radiographic measures. Interestingly, none correlated with rib deformity correction including: preoperative rib deformity (p=0.16), thoracic curve flexibility (p=0.71), and thoracic curve magnitude (p=0.78). An additional 80 patients had apical vertebral rotation measured using the apical vertebral body-rib ratio. Neither the initial ratio (p=0.52), nor the change in ratio during bending radiographs (p=0.45) correlated with inclinometer results.

Conclusion: Utilizing DVBD, the surgeon can expect a 50% reduction in the rib deformity as assessed by inclinometer. This is irrespective of the pre-op inclinometer reading, thoracic curve flexibility, and degree of apical rotation on standing and bending x-rays.

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Age Increases the Risk of Postoperative Dysphagia and Aspiration After Anterior Odontoid Screw Fixation

Jonathan A. Grossberg, Heather Spader, Adetokunbo A. Oyelese

Introduction: Type II odontoid fractures are the most common spinal fracture in the elderly population and may be managed with halo immobilization, posterior fusion, and anterior odontoid screw fixation. Anterior odontoid screw fixation has several advantages over posterior fusion, including: reduced surgical time, decreased postoperative pain, preserved range of motion, earlier mobilization, and decreased postoperative narcotic requirement. We review our experience using anterior odontoid screw fixation in Type II odontoid fractures in the elderly and non-elderly populations.

Methods: Demographic and outcome data were retrospectively collected in 30 consecutive patients with type II odontoid fractures treated with anterior odontoid screw fixation.

Results: Mean patient age was 70.7 (Range: 20-92); eighteen of the patients were male and twelve were female. All patients had successful placement of a single anterior odontoid screw without intraoperative complication. Complications included pneumonia in nine patients (30%), gastrostomy tube placement due to patient failing swallow evaluation in thirteen patients (43%), and vocal cord paralysis in one patient (3.3%). Patients over the age of seventy-five accounted for twelve of the thirteen (92%) gastrostomy tube placements and eight of the nine (88.9%) pneumonias respectively. The difference in rates of gastrostomy tube placement and pneumonia for the older patients were both found to be statistically significant with a P of <.0001 for gastrostomy tubes and a P<.0.02 for pneumonias.

Conclusion: Anterior odontoid screw fixation is an effective treatment option for patients with Type II odontoid fractures. In the elderly population, however, the benefits of the procedure must be weighed against the risks of postoperative dysphagia requiring gastrostomy and pneumonia.

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Disc Herniation Induces 55% Increase in Multifidus Load in Axial Rotation

Bruce Robie, Sebastian Dendorfer, Soren Torholm, John Rasmussen

Introduction: The multifidus is a key stabilizer of the spine[1], especially in axial rotation[2]. Its loss of size has been shown in patients with symptomatic herniations[3]. Cadaver testing has shown that herniations significantly decrease the segment stiffness in axial rotation[4]. We hypothesize that this loss of segment stiffness results in an overload of the multifidus, leading to muscle atrophy. The purpose of this study is to examine the mechanical effect of a lumbar disc herniation, via the loss of segmental stiffness in axial rotation, on the force required by the different branches of the multifidus.

Methods: We used the AnyBody Modeling System™, a validated model[5,6] consisting of more than 1000 individual muscle branches to analyze flexion-extension, lateral bending and axial rotation motion of a standing adult under the influence of gravity (Fig. 1). Simulations were run using segment stiffness at L5-S1 from cadaver test data for normals and for herniated segments[4]. The analyzed parameters were the forces in all branches of the multifidus muscles of the model on the right side of the spine.

Results: The herniation did result in significant increases in the force in the multifidus. The greatest impact was in axial rotation, where there was a 55% increase in force in a multifidus branch crossing the effected segment (Fig. 2). Lesser impact was seen in flexion-extension (maximum 33% increase), and a small decrease was seen in lateral bending.

Conclusion: The mechanical effect of the herniation on the multifidus was greatest in axial rotation, significantly increasing the peak load required by branches of the multifidus crossing the herniated level. This overload may be a cause of muscle atrophy in patients with herniations. Limiting motion in axial rotation may be required to protect the multifidus from atrophy in patients with herniations.

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Neurovascular Complications of Cervical Pedicle Screw Fixation in the Cervical Pathologies

Kadir Kotil

Introduction: Retrospective study of a prospectively followed cohort. Using to cervical transpedicular fixation (CPF) technique is very low in the routine practice, as the pedicle is thin and risk of neurovascular damage is high. In this study, we emphasized the neurovascular complications of cervical transpedicular fixation in the different cervical pathologies.

Methods: Postoperative neurovascular injury of the transpedicular screws of the 210 pedicles of the 45 patients we operated due to traumatic and nontraumatic cases in the cervical region, were investigated. Fixation was performed between C3 and C7, and iliac wing and lamina were used as autografts for fusion.

Results: In postoperative computed tomography (CT) scan, the applied screw was observed to have directly penetrated into the vertebral foramen in only two (0.9 %) pedicle during the fixation process; however, the blood circulation appeared normal in angiography. In terms of screw-pedicle relations, the screws were at their correct places in 174 pedicles (82.8%), while non-critical lateral orientation was detected in 14 (6.6%), and medial orientation in another 16 pedicles (7.3%). Fusion ratio was 100%. There was no morbidity or mortality. The average length of the screws used 32 mm for C3-7. A total of 204 (92.3%) pedicles of this series had an intrapedicular width of 3.2 mm or less. The cases were followed up for a total of 17 to 34 months (25.7).

Conclusion: Use of the CPF provides a very strong three column stabilization but also carries a high risk of pedicle perforation without neurovascular injury. No mortality or morbidity. Free hand technique with experienced surgeon is acceptable for CPF in the different cervical pathologies.

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Posterior Approach for Thoracolumbar Corpectomies with Expandable Cage Placement and Circumferential Arthrodesis: A Multicenter Case Series of 67 Patients

Christoph Hofstetter, Dean Chou, Benjamin Newman, Henry E. Aryan, Federico Girardi, Roger Hartl

Introduction: Multicenter trial investigating outcome and durability of single-stage thoracolumbar corpectomy using expandable cages via a posterior approach.

Methods: Retrospective chart review of 67 consecutive patients following single-stage thoracolumbar corpectomies with circumferential reconstruction for oncologic, traumatic and osteomyelitic pathologies. Circumferential

reconstruction was accomplished by using expandable cages with posterior instrumentation and fusion. Correction of sagittal deformity, ASIA score and complications were recorded.
Results: Single-stage thoracolumbar corpectomies resulted in an average correction of sagittal deformity by 6.2 degrees at a mean follow-period of 20.5 months. At last follow-up, we observed a fusion rate of 68% for traumatic and osteomyelitic fractures. Approximately half of the patients remained neurologically stable. Improvement of neurological function was seen in 23 patients (38%) while 7 patients (11%) suffered from a decrease of lower extremity motor function. Deterioration of neurological function was due to progression of metastatic disease in 5 patients. A total of 5 constructs (7%) failed. Three of these constructs were placed for traumatic fractures, one for a pathologic and one for an osteomyelitic fracture. Other complications included epidural hematomas in 3 patients and pleural effusions in 2 patients.
Conclusion: Single-stage posterior corpectomy and circumferential reconstruction was performed in multiple centers with consistent outcome over a wide range of pathologies. Correction of sagittal deformity was sustained and the neurological outcome was good in the majority of patients. 18% of acute traumatic fractures, however, required revision of the construct.

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Why Lumbar Artificial Disc Replacements (ADR) Fail

Kenneth Pettine, Christian Schlicht

Introduction: To determine why ADR's fail. Ninety-one patients undergoing ADR. at one IDE site were evaluated for clinical success.
Methods: Failure was defined as less than 50% improvement in ODI and VAS or any additional surgery at index or adjacent spine motion segment. Three ADR's were evaluated: Maverick™ (M) 25 patients, Charité™ (C) 31 patients, Kineflex™ (K) 35 patients. All procedures were one level performed at L4-5 or L5-S1. Demographics and inclusion/exclusion criteria were similar and will be discussed. Facet pain was diagnosed by facet block and significant clinical improvement after facet rhizotomy.
Results: Overall clinical failure occurred in 26%, (24 of 91 patients) (M) 28%, (7 of 25 patients); (C) 39%, (12 of 31 patients); (K) 14%, (5 of 35 patients) at two-year follow-up. The type of A.D.R. makes a difference. Causes of failure included: facet pathology 46% of failure patients, (11 of 24). Implant complications occurred in 6% of the total patients and 25% of the failure patients, (6 of 24). Patients with additional orthopedic or medical pathology or disability/narcotic issues occurred in 29% (7 of 24), of the failure group. Despite the fact these patients were considered failures based on ODI and VAS, they reported a 92% satisfaction with the ADR and would repeat the surgery for the same result. Interestingly, ADR patients are often either a clinical success at three-month follow-up or a possible failure. Only five patients went from a success to failure after three months. One was an infection one year after ADR and four patients developed additional pathology unrelated to their ADR. Only one patient went from a failure to success after a facet rhizotomy one year after ADR.
Conclusion: These results indicate overall clinical success can be improved most by patient selection and implant type.

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Association of Surgical Resection and Survival in Patients with Malignant Primary Osseous Spinal Neoplasms from the Surveillance, Epidemiology, and End Results (SEER) Database

Matthew J. McGirt, Kaisorn L. Chaichana, Debraj Mukherjee, Scott Parker, Owoicho Adogwa, Joseph S. Cheng, Oran Aaronson, Ziya L. Gokaslan

Introduction: While surgical resection has been shown to improve short-term local disease control, it remains debated whether surgical resection is associated with improved overall survival in patients with malignant primary osseous spinal neoplasms. We reviewed survival data from a U.S. cancer registry spanning 30 years to determine if surgical resection was independently associated with overall survival.
Methods: The SEER registry (1973-2003) was queried to identify cases of histologically confirmed primary spinal chordoma, chondrosarcoma, osteosarcoma, or Ewing's sarcoma of the mobile spine and pelvis via ICD-O-2 coding. Patients with systemic metastasis were excluded. Age, gender, race, tumor location, and primary treatments were identified. Extent of local tumor invasion was classified as confined within periosteum vs. extension beyond periosteum to surrounding tissues. The association of surgical resection with overall survival was assessed via Cox proportional-hazards regression analysis adjusting for age, radiotherapy, and tumor invasiveness.
Results: 827 patients were identified with non-metastatic primary osseous spinal neoplasms (215 chordoma, 282 chondrosarcoma, 158 osteosarcoma, 172 Ewing's sarcoma), Table 1. Overall median survival was histology specific (chordoma: 96 months, Ewing's sarcoma: 90 months, chondrosarcoma 88 months, osteosarcoma 18 months). Adjusting for age, radiation therapy, and extent of local tumor invasion in patients with isolated (non-metastatic) spine tumors, surgical resection was independently associated with significantly improved survival for chordoma [Hazard Ratio (95% Confidence Interval; 0.617 (0.25-0.98)], chondrosarcoma [HR (95%CI); 0.153 (0.07-0.36)], osteosarcoma [HR (95%CI); 0.382 (0.21-0.69)], and Ewing's sarcoma [HR (95%CI); 0.494 (0.26-0.96)]. Figures 1-3.
Conclusion: In our analysis of a 30-year U.S. population based cancer registry (SEER), patients undergoing surgical resection of primary spinal chordoma, chondrosarcoma, Ewing's sarcoma, or osteosarcoma demonstrated prolonged overall survival independent of patient age, extent of local invasion, or location. Surgical resection may play a role in prolonging survival in the multi-modality treatment of patients with these malignant primary osseous spinal neoplasms.

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Development of a Novel Intravertebral Human Prostate Adenocarcinoma Rat Model for the Study of Intravertebral Metastatic Spine Disease

Rachel Sarabia-Estrada, Camilo A. Molina, Guergana Panayotova, Clinton Jung, Ziya L. Gokaslan, Timothy F. Witham, Jean-Paul Wolinsky, Ali Bydon, Daniel M. Sciubba

Introduction: Prostate carcinoma is the most commonly diagnosed malignancy and second most common cause of cancer-related death in US men. The majority of these patients suffer from bone metastases, with the spine as the most common osseous site. Nevertheless, a practical and reproducible model of spinal metastatic disease using human prostate cancer tissue has not been reported. We report the first animal model of metastatic epidural spinal cord compression using human prostate cancer.
Methods: Human prostate cancer cell line (PC-3) was injected subcutaneously into the flank of athymic male rats.

Following in situ growth, tumor was removed for spine transplant. Group 1 (n=6) rats underwent a transperitoneal approach followed by implantation of tumor tissue into the L6 vertebra. Group 2 (n=6) rats were subjected to the same procedures but no tumor was implanted. Animals were functionally assessed daily via a kinematic analysis of locomotion. Pathological growth of tumor was assessed grossly, histologically, and via computed-tomography (CT) imaging 23 days after tumor implantation.

Results: Microscopic morphology of PC3 tumor was confirmed by histological analysis with H&E. In Group 1, the PC3 tumor was successfully established in the L6 vertebrae body, as confirmed histologically and via CT imaging. Kinematic analysis of locomotion in Group 1 showed decline in coordination, balance, and leg swing at 15 days, consistent with epidural compression, while locomotion was unchanged in Group 2.

Conclusion: This study demonstrates a novel model of metastatic spine disease using a human prostate cancer cell line. Functional, radiographic, and histopathologic data provide evidence of the practicality and reliability of the model as the basis for future experiments on human prostate spine tumors.

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Postoperative Infection After Minimally Invasive vs. Open Transforaminal Lumbar Interbody Fusion (TLIF): Literature Review and Cost Analysis

Scott Parker, Owoicho Adogwa, Oran Aaronson, Joseph S. Cheng, Matthew J. McGirt

Introduction: Surgical site infection (SSI) in the setting of lumbar fusion is associated with significant morbidity and medical resource utilization. To date, there have been no studies conducted with sufficient power to directly compare the incidence of SSI following minimally invasive (MIS) vs. open TLIF procedures. Furthermore, studies are lacking that quantify the direct medical cost of SSI following fusion procedures. We set out to determine the incidence of SSI in patients undergoing MIS vs. open TLIF reported in the literature and to determine the direct hospital cost associated with the treatment of SSI following TLIF at our institution.

Methods: A systematic Medline search was performed to identify all published studies assessing SSI after MIS or open TLIF. The cumulative incidence of SSI was calculated from all reported cohorts and compared between MIS vs. open TLIF. In order to determine the direct hospital costs associated with the treatment of SSI following TLIF, we retrospectively reviewed 120 consecutive TLIFs performed at our institution, assessed the incidence of SSI, and calculated the SSI-related hospital costs from accounting and billing records.

Results: To date, there have been 10 MIS-TLIF cohorts (362 patients) and 20 open-TLIF cohorts (1133 patients) reporting incidence of SSI. The cumulative incidence of reported SSI was significantly lower for MIS vs. open-TLIF (0.6% vs. 4.0%, p=0.0005). In our experience with 120 open TLIF procedures, SSI occurred in 6 (5.0%) patients. The mean hospital cost associated with the treatment of SSI following TLIF was $29,110 in these six cases. The 3.4% decrease in reported incidence of SSI for MIS vs. open-TLIF corresponds to a direct cost-savings of $98,974 per 100 MIS-TLIF procedures performed.

Conclusion: Postoperative wound infections following TLIF are costly complications. MIS vs. open TLIF is associated with a decreased reported incidence of SSI in the literature and may be a valuable tool in reducing hospital costs associated with spine care.

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Utilization of Spinal Fusion for Isolated Lumbar Degenerative Disc Disease and Long-term Development of Associated Spinal Pathologies: A Population-based Study

Matthew J. McGirt, Owoicho Adogwa, Jim Lesko, Terra Slaton, Jason Lerner, Luella Engelhart, Michael Y. Wang

Introduction: The optimal management of lumbar degenerative disc disease (DDD) in the setting of isolated mechanical back pain remains debated. To date, no nationally representative population-based studies have explored the relative prevalence of fusion procedures for lumbar DDD. Furthermore, limited information is available on the long-term progression of segmental spinal degeneration in patients with medically managed isolated lumbar DDD. We assess the prevalence of fusion procedures and the long-term development of associated degenerative spine diagnoses in patients with isolated lumbar DDD from a national claims database representing more than 25 million patients per year.

Methods: The MarketScan® Commercial Claims and Encounters and The Medicare Supplemental and Coordination of Benefits databases (2003-2008) were queried to identify all patients with a new diagnosis of isolated lumbar DDD utilizing ICD-9-CM codes. Kaplan-Meier survivorship analysis was used to assess the five-year cumulative incidence of surgical intervention and new diagnoses of associated spinal pathologies.

Results: 3,066 patients were identified with a new diagnosis of isolated lumbar DDD (mean age: 59±13 years, female:1,832 (60%)). Over a five-year follow-up period, the cumulative incidence of lumbar fusion was 2.19% (95%CI: 1.72-2.77%), Figure 1. For patients with medically managed DDD, 21.58% developed a later diagnosis of radiculopathy or stenosis, Figure 2. Surgical decompression (laminectomy/discectomy) for ensuing radiculopathy/stenosis was performed in only 2.94% of patients, Figure 3. By five years, only 1.44% of patients had received a new diagnosis of spondylolithesis, Figure 4.

Conclusion: This population-based study of a national claims database suggests that the vast majority of patients with isolated lumbar DDD in the United States are non-surgically managed. By five years after diagnosis, one-fifth of patients with conservatively managed lumbar DDD were subsequently diagnosed with symptomatic nerve root compression. Subsequent nerve root compression was medically managed in the majority of cases. This study suggests that in the United States fusion procedures for lumbar DDD are performed in a small minority of patients and that medically managed patients should be monitored for progressive lumbar degeneration.

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Cost Effectiveness of Minimally Invasive vs. Open Transforaminal Lumbar Interbody Fusion (TLIF) for Degenerative Spondylolithesis Associated Low-back and Leg Pain Over Two-years

Scott Parker, Owoicho Adogwa, Brandon J. Davis, Joseph S. Cheng, Oran Aaronson, Matthew J. McGirt

Introduction: Minimally invasive transforaminal lumbar inter-body fusion (MIS-TLIF) for lumbar spondylolithesis allows for surgical treatment of back and leg pain while theoretically minimizing tissue injury and accelerating overall recovery. While prior studies have demonstrated shorter length of hospital stay and reduced blood loss with MIS- vs. open-TLIF, short- and long-term outcomes have been equivocal. No studies to date have evaluated the comprehensive healthcare costs associated with TLIF procedures nor assessed the cost-utility of MIS vs. open-TLIF.

Methods: Forty patients undergoing MIS-TLIF (n=20) or open-TLIF (n=20) for grade I degenerative spondylolithesis associated back and leg pain were prospectively studied. Total back-related medical resource utilization, missed work, and health-state values (quality adjusted life years (QALYs), calculated from EQ-5D with U.S. valuation) were assessed after two year follow-up. Two-year resource use was multiplied by unit costs based on Medicare national allowable payment amounts (direct cost) and work-day losses were multiplied by the self-reported gross-of-tax wage rate (indirect cost). Difference in mean total cost per QALY gained for MIS- vs. open-TLIF was assessed as incremental cost-effectiveness ratio (ICER: COSTmis COSTopen/QALYmis - QALYopen).

Results: MIS vs. open-TLIF cohorts were similar at baseline(Table1). By two-years postoperatively, patients undergoing MIS-TLIF reported a mean QALYs gained of 0.50, and open-TLIF patients reported 0.41 QALYs gained (0.50 vs. 0.41, p=0.23), Figure 1. Mean total two-year cost of MIS- and open-TLIF was $35,996 and $44,727, respectively(Table 2). MIS- vs. open-TLIF was associated with a mean two-year cost savings of $8,731 per patient while providing equivalent QALYs gained (ICER).

Conclusion: Both MIS- and open-TLIF significantly improved quality of life, however, the MIS approach was associated with decreased total costs, making it a cost effective advancement in the surgical technique of TLIF for spondylolithesis-associated back and leg pain.

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Endonasal vs. Transoral Odontoid Resection: A Systematic Meta-Analysis of Outcomes

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Introduction: Odontoid resection may be indicated in ventral cervicomedullary compression. Surgical approaches have traditionally utilized a transoral technique, which may carry significant morbidity. Endonasal odontoid resection represents a new technique that provides direct, minimal access to the odontoid process with maximal preservation of anatomic structures. Limited evidence-based data exists to guide clinical decisions.

Methods: We performed a MEDLINE (1950-2010) database search to identify relevant studies. Comparisons were made between endonasal and transoral cohorts for patient and tumor characteristics and postoperative complications. Clinical outcomes were classified into 'improved', 'stable', or 'deteriorated' groups. Statistical analyses of categorical variables were carried out using Mann Whitney U, Chi-square and Fisher's exact tests.

Results: 40 studies, involving 764 patients, were included. The endonasal cohort had a significantly lower rate of soft palate incision (0.0% vs. 33.6%, p=0.005). There was no difference in complete odontoid resection between cohorts. In the endonasal cohort, there were no cases of postoperative soft palate repair, atlanto-occipital instability, wound dehiscence, CSF leak or meningitis. Patients in the endonasal group had a shorter time to extubation (p<0.0001) and oral feeding (p=0.0025). There was a significantly higher percentage of patients with improved outcome in the endonasal cohort (100% vs. 73.3%, p=0.009).

Conclusion: Our systematic meta-analysis provides evidence-based support

for the endonasal approach as a safe and effective alternative to traditional transoral surgery for odontoid lesions. Indeed, results in appropriately selected cases appear to be superior for a variety of outcome measures. Further investigations comparing cost and length of stay are warranted.

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Skin Derived Precursor Cells (SKPs) Promote Return of Electrophysiological Function in the Rat Tibial Nerve Model of Adriamycin Induced Demyelination

Joey Kevin Grochmal, Rajiv Midha, Sundeep Dhaliwal

Introduction: Skin derived precursor cells (SKPs) can mimic the phenotypic appearance of Schwann cells when predifferentiated in vitro (SKP-SCs), and are a reliable autologous source of Schwann cells that survive in considerable numbers when micro-injected into nerve grafts and denervated nerve. Our hypothesis is that SKP-SCs can produce morphologically and electrophysiologically functional myelin as they ensheath axons. We are testing this hypothesis in a model of focal demyelination of the rat tibial nerve.

Methods: We unilaterally injected 500,000 GFP-L4 labeled SKP-SCs into the tibial nerves of 10 adult Lewis rats, while a second group of 10 received 500,000 GFP-L4 labelled Schwann cells in the same paradigm. A third group (n=10) receives media alone. This was done 9 days after a demyelinating tibial nerve lesion was created using a 30ul injection of 12.5ug/ml Adriamycin (1). Baseline electrophysiology was performed on all animals prior to adriamycin injection, and all animals are being followed with nerve conduction studies and for compound motor action potentials (CMAPs) every 3 days until 42 days post-initial injection. Animals from each group are being periodically sacrificed for morphological and immunohistochemical analysis, using anti-voltage gated sodium channel, anti-voltage gated potassium channel, as well as anti-CASPAR antibodies.

Results: Preliminary results (n=5/group) indicate that the animals which received cell-injection therapy demonstrate a significant earlier return of CMAPs, suggesting quicker reversal of demyelination conduction block than the control media injection group. The SKP-SC group also demonstrates superior recovery than the SC group (figure 1).

Conclusion: We anticipate the SKP-SC group will continue this trend, on par with or better than the Schwann cell group. We also predict that SKP-SCs will participate in functional nodes of Ranvier formation, as demonstrated by confocal microscopy.

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Comparative Effectiveness of Anterior Cervical Diskectomy and Fusion with Minimally Invasive Posterior Cervical Foraminotomy for Cervical Radiculopathy

Jeffrey A. Steinberg, John W. German

Introduction: Patients with cervical radiculopathy are often treated with either anterior cervical diskectomy and fusion (ACDF) or more recently minimally invasive posterior cervical foraminotomy (miPCF). To date the comparative effectiveness of these procedures has rarely been reported in the literature. Traditional surgical dictum has suggested that patients with axial pain may benefit from fusion.

Methods: A retrospective review was undertaken of 48 patients undergoing either a miPCF (n=28) or ACDF (n=20) for the treatment of cervical radiculopathy. Medical records were abstracted for demographic information, medical history, surgical details, and complications. Clinical outcomes were assessed by patient derived neck and arm visual analog scores (VAS), neck disability index (NDI), SF-12, and patient satisfaction index (PSI). Outcomes were analyzed using both a threshold method in which outcomes were classified as success (NDI<40; VAS<4.0) or failure (NDI>40; VAS>4.0) as well as the peri-operative change in which outcomes were classified as success (NDI=-15; VAS=-2.0), or failure (ODI<-15; VAS<-2.0). Statistical analyses included a t-test for continuous variables and a Chi square test for categorical variables with significance set at $p<0.05$.

Results: The groups did not differ at baseline with respect to neck VAS, arm VAS, neck to arm VAS ratio, NDI, or SF-12 PCS, while the baseline SF-12 MCS (miPCF: 47.21 ± 13.50; ACDF: 36.75 ± 10.95; $p<0.05$) did differ. At last follow-up the mean peri-operative changes were not significantly different for neck VAS, arm VAS, NDI, SF-12 PCS or SF-12 MCS. At last follow-up the per cent of patients with a successful outcome as defined by threshold criteria was significantly higher in the miPCF group than the ACDF group for neck VAS, arm VAS, and NDI.

Conclusion: In this small retrospective analysis miPCD is associated with a similar degree of neck pain and disability than that of ACDF. This conclusion runs counter to that suggested by traditional dictum.

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Accuracy of Percutaneous Pedicle Screw Placement Using the O-ARM Multidimensional Surgical Imaging System Compared with Fluoroscopy

John K. Houten, Rani Nasser, Nrupen Baxi, Michael Schiraldi, Adesh Tandon

Introduction: Increasing popularity of minimally invasive surgery (MIS) for lumbar fusion has led to dependence upon intraoperative fluoroscopy for pedicle screw placement, as limited muscle dissection does not fully expose the bony anatomy necessary for traditional, freehand techniques nor for the registration steps in image-guidance techniques based upon preoperative CT scans. This has raised concerns about the cumulative level of radiation exposure for both surgeon and OR staff, especially for surgeons who perform MIS frequently. The recent introduction of the O-ARM Multidimensional Surgical Imaging System promises to allow superior accuracy of pedicle screw placement without the need for fluoroscopy. We present the first clinical series of wholly percutaneous screw placement using the O-ARM without fluoroscopy and compare the results with placement with fluoroscopy.

Methods: A retrospective review of a 14-month period identified 76 consecutive patients that underwent minimally invasive lumbar fusion surgery by a single surgeon. Indications for fusion were spondylolisthesis, recurrent disc herniation and/or severe facet arthropathy. The O-ARM was introduced in the middle of this period and was used for all subsequent patients. There were no training cases. Accuracy of screw placement was assessed by examination of axial computed tomography.

Results: The fluoroscopy group included 113 screws in 31 patients, and the O-ARM group included 158 in 45 patients The perforation rate involving medial pedicle wall was 1.9% in the O-ARM group and 10.6% in the fluoroscopy group ($p<0.025$). The overall pedicle perforation rate was 12.7% verses 19.5%, with 86% of perforations under 2mm. No reoperations were necessary.

Conclusion: Percutaneous pedicle screw placement with the O-ARM Multidimensional Intraoperative Imaging System is a safe and effective technique that limits radiation exposure to surgeon and OR staff. Use of the O-ARM resulted in fewer medial wall breaches compared

with conventional fluoroscopic techniques in this single-surgeon series.

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Longterm Outcome After Unilateral Approach for Bilateral Decompression of Lumbar Spinal Stenosis: 9-Year Prospective Study

Yunus Aydin, Halit Çavusoglu, Ahmet Murat Müslüman, Okan Kahyaoglu, Osman Nuri Türkmenoglu

Introduction: The aim of our study is to evaluate the results and effectiveness of bilateral decompression via a unilateral approach in the treatment of degenerative lumbar spinal stenosis.

Methods: We have conducted a prospective study to compare the midterm outcome of unilateral laminotomy with unilateral laminectomy. One hundred patients with 269 levels of lumbar stenosis without instability were randomized to two treatment groups: unilateral laminectomy (Group 1), and laminotomy (Group 2). Clinical outcomes were assessed with the Oswestry Disability Index (ODI) and Short Form 36 Health Survey (SF-36). Spinal canal size was measured pre- and postoperatively.

Results: The spinal canal was increased to 4 6.1-fold (mean 5.1 ± SD0.8-fold) the preoperative size in Group 1, and 3.3 5.9-fold (mean 4.7 ± SD 1.1-fold) the preoperative size in Group 2. If the anteroposterior diameter of the spinal canal (APD) (defined bone structure) was normal, laminotomies provided adequate decompression. If the APD was reduced, laminectomies provided more adequate decompression. If the transverse diameter and APD were normal, removing the hypertrophic ligamentum flavum alone provided adequate decompression. The mean follow-up time was 9 years (range 7 10 years). The ODI scores decreased significantly in both early and late follow-up evaluations and the SF-36 scores demonstrated significant improvement in late follow-up results in our series. Analysis of clinical outcome showed no statistical differences between two groups.

Conclusion: For degenerative lumbar spinal stenosis unilateral approaches allowed sufficient and safe decompression of the neural structures and adequate preservation of vertebral stability, resulted in a highly significant reduction of symptoms and disability, and improved health-related quality of life.

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Neurological Outcome Following Nerve-Sparing Resection of Benign Pre-Sacral Neurogenic Tumors

Marie-Noëlle Hébert-Blouin, Daniel Leonard, Eric J. Dozois, Robert J. Spinner

Introduction: Nerve sheath tumors represent 5 to 10% of presacral tumors. The majority of these tumors are benign, slow growing, and cause minimal or ill-defined symptoms. As a result, diagnosis is often delayed; tumors may reach considerable size, and may involve surrounding structures/organs making their management complex. Data regarding the surgical management and outcomes of pelvic neurogenic tumors are limited. The aim of this study was to evaluate the occurrence of postoperative neurological deficit and/or clinical symptoms of urogenital or anorectal dysfunction after surgical nerve-sparing resection of benign presacral neurogenic tumors.

Methods: A retrospective review was performed of patients who underwent nerve-sparing resection of benign neurogenic presacral tumors between 2004 and 2010 by the same experienced team of colorectal and peripheral nerve surgeons. Clinical, imaging and operative data as well as postoperative functional outcome (neurological, urogenital and anorectal) were analyzed.

Results: Eighteen patients (16 - 71 years of age) were included in the study. Twelve of these tumors were schwannomas and 6, neurofibromas. The tumor size was between 3.4 and 13.4 cm (largest diameter). Thirteen patients presented with symptoms, 9 of these with motor, sensory, urogenital and/or anorectal dysfunction. All underwent an intracapsular nerve-sparing approach. There was no intraoperative complication apart from blood loss (100cc to 3000cc, median of 600cc). Postoperatively, one patient developed a prolonged ileus, ARDS, and an extensive DVT and another patient a significant foot drop which improved to normal within a few months. Fourteen patients had improvement or resolution of their preoperative symptoms or remained without symptoms, 1 had persistence of the preoperative symptom, 2 had new symptoms, and 1 did not have adequate follow-up.

Conclusion: A nerve-sparing approach by an experienced team of surgeons allows safe resection with high rate of preservation of the neurological function even in large tumors.

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Spinal Cord Intramedullary Pressure Increases in Thoracic Kyphotic Deformity: A Cadaveric Study

Chad W. Farley, Bradford Curt, David B. Pettigrew, Jeffrey R. Holtz, Charles Kuntz, IV

Introduction: Previous studies reveal thoracic T4-T12 kyphosis ranges from +14 to +69 degrees for 98.5% of the asymptomatic adult population. We sought to determine if spinal cord intramedullary pressure (IMP) changes in response to increasing thoracic kyphosis.

Methods: In eight fresh-frozen cadavers, a progressive kyphotic deformity was created. Cadavers were positioned, sitting with skull clamp, and segmentally instrumented from occiput to L2. The T3 lamina was removed, dura opened, and 3 pressure sensors were advanced caudally to T4/T5, T7/T8 and T11/T12 within the cord parenchyma. A step-wise kyphotic deformity was induced by sequentially releasing and retightening the skull clamp while distracting posterior short segment rods and closing anterior segmental osteotomies. Lateral radiographic T4-T12 Cobb angles and IMP measurements were obtained.

Results: Minor IMP increases of 2-5 mm Hg were observed at one or more spinal cord levels in 1 of 8 cadavers when the Cobb angle <+51° and in 4 of 8 cadavers when >+51° and <+65°. At Cobb angles exceeding +65°, IMP progressively increased at one or more levels in 7 of 8 cadavers. There was no statistically significant correlation between vertebral canal diameter and IMP at maximum kyphosis suggesting canal diameter is unlikely to explain IMP variance. For Cobb angles >+51° and <+65°, statistically significant minor increases in IMP were detected at the T7/T8 level only ($p = 0.02$). For Cobb angles >+65°, statistically significant increases in IMP were detected at all three spinal cord levels ($p < 0.005$).

Conclusion: Thoracic kyphosis less than +51° resulted in no meaningful increase in IMP while kyphosis measuring +51° to +65° resulted in minor 2-5 mm Hg increases. As the thoracic kyphotic deformity exceeded +65°, IMP increased significantly. IMP may help explain the wide range of "normal" thoracic alignment and further define thoracic kyphotic deformity.

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MIS TLIF Reduces Adjacent Segment Degeneration

Sanjay S. Dhall, Praveen V. Mummaneni

Introduction: In comparison with traditional Open TLIF, minimally invasive TLIF's limit muscle and facet exposure. Does such a limited exposure decrease adjacent segment disease? No prior study has examined this issue. We retrospectively compared our mini-open TLIF with our open TLIF patients focusing on the incidence of adjacent segment disease.

Methods: From 2003-2006, 39 patients underwent TLIF for DDD or spondylolisthesis. 18 patients underwent mini-open TLIF and 21 patients underwent open TLIF. The mean age in each group was 54 years, and there was no statistically significant difference in ages between the groups (p=0.98). Mid-term follow-up was conducted to determine the rate of symptomatic adjacent segment disease in each group. Modified Prolo Scores (MPS) were recorded.

Results: No patients were lost to follow-up, and mean follow-up was 3 years. All patients in both groups had successful fusion confirmed by dynamic radiographs. In the open group, 3 patients (14%) developed adjacent segment disease requiring revision fusion surgery. None of the mini-open patients required revision surgery.

Conclusion: Mini-open TLIF allows for more muscle and facet sparing than open TLIF and may be associated with a lower rate of surgical adjacent segment disease at three years.

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Supplement of High Magnesium Diets Promote Nerve Regeneration by Down-Regulated Inflammatory Response

Hung-Chuan Pan

Introduction: Supplement of magnesium either pre-injury or post-injury significantly improved functional recovery in various neurological disorders. However, the essential benefits of magnesium supplement in peripheral nerve disorders have not been elucidated yet. In this study, we investigate the effect and mechanism of magnesium supplement on peripheral nerve regeneration in a sciatic nerve crush injury model.

Methods: Peripheral nerve injury was induced in ICR mouse by crushing left sciatic nerve using a vessel clamp. Before animals subjected to nerve injury, the animals were supplemented with diet either of basal, low and high magnesium diets for 3 weeks. After injury, the animals were supplemented with the same diets for another 4 weeks. Neurobehavior, electrophysiological and regeneration marker were conducted to assess nerve regeneration. The deposits of inflammation cells, the associated pro-inflammatory cytokines and genes expression, and cell apoptosis markers were used to investigate the mechanism of magnesium supplement.

Results: Magnesium supplement significantly increased the concentration of magnesium in the plasma as well as in nerve tissue and Mg depletion produced the reciprocal effect. The most significantly improved neurobehavior and electrophysiology study were observed in group treated with high magnesium diet. The escalated regeneration demonstrated either in neurofilament or S-100 expression also showed the same trends. Increased regeneration paralleled the reduced deposits of inflammatory cells, expression of inflammatory cytokines, and associated macrophage migration genes. Furthermore, reduced Schwann cells apoptosis were in line with significant expression of bcl-2, bcl-XL and down-regulated the expression of caspase -3 and cytochrome C.

Conclusion: Administration of high Mg diet before and continuously after injury rescued Schwann cells from apoptosis by suppressing the inflammatory response. These anti-inflammatory effects paralleled the significant improvement in neurological function.

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Fusion Results Using DBM and BMA in eXtreme Lateral Interbody Fusion (XLIF)

W.B. Rodgers, Edward J. Gerber, Jody A. Rodgers

Introduction: This study determines the viability of a graft composite composed of demineralized bone matrix (DBM) coupled with bone marrow aspirate (BMA) and local bone (LB) in use with the XLIF procedure.

Methods: 91 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: 56 patients (24M; 32F; Avg 61.6 yrs; Avg BMI 29.9; 44 1LVL; 11 2LVL, 1 3LVL; LOS 1.68 days; 0 infections) were available for follow-up 12 months after surgery. VAS pain scores improved from 8.50 to 1.82. Disk height improved from 6.4 preop to 10.3mm postoperatively and was 9.2 mm at 12 months. Listhesis (34 pts) improved from 4.21 preop to 0.64 mm at 12 months. Modified Lenke scores were 2.1 (3 mos), 1.2 (6 mos), 1.1 (12 mos). 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 56/56 patients at 12 months postoperatively. 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.

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Comparison of Clinical and Radiological Findings in Adjacent Segment Disease After Lumbar Fusion with Total Laminectomy and Subtotal Laminectomy

Kyoung Suok Cho, Sang Bok Lee, Pil Woo Huh, Do Sung Yoo, Tae Gyu Lee, Chun Kun Park

Introduction: Fusion has become the standard of care for numerous pathologic conditions of the spine over the past 50 years. The development of pathology at the mobile segment next to a lumbar or lumbosacral spinal fusion has been termed adjacent segment disease. Initially reported to occur rarely, it is now considered a potential late complication of spinal fusion. The purpose of this retrospective clinical study was to compare the incidence and radiological findings of adjacent segment disease (ASD) after lumbar fusion with upper lumbar total laminectomy or subtotal laminectomy.

Methods: Over a 12-year period, we performed posterior lumbar fusion with total laminectomy (Group I) in 81 patients and lumbar fusion with subtotal laminectomy in 80 patients. Patients were followed a minimum of 5 years (mean 7.5 years). Radiographic changes in the disc height and vertebral slip range of motion were measured. On magnetic resonance imaging (MRI), postoperative progression of the disc degeneration and spinal canal stenosis were evaluated.

Results: Significant posterior intervertebral instability (> 3mm) on

radiograph was more frequent in the Group I (16.3 % vs. 6.3%, P <0.05). MRI images demonstrated more significant aggravation of disc degeneration (36.5% vs. 16.6%, P <0.001) and progression of adjacent stenosis (19.85 vs. 10%, P <0.01), at fusion upper disc level in the Group I.
Conclusion: These results demonstrated an effect of fusion upper level sound interspinous ligament and subtotal laminectomy for the prevention of transition syndrome in lumbar spine fusion.

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Outcomes Following Minimally Invasive Posterior Cervical Decompression for Myelopathy

Jeffrey A. Steinberg, John W. German
Introduction: To date a comparative analysis of clinical outcomes following a minimally invasive posterior cervical approach (miPC) for myelopathy has not been compared to that of an anterior cervical diskectomy or corpectomy with interbody fusion (ACDF).
Methods: A retrospective review was undertaken of 64 patients undergoing either a miPCD (n=32) or ACDF (n=32) for treatment of myelopathy. Medical records were abstracted for demographic information, medical history, surgical details, and complications. Clinical outcomes were assessed by patient derived neck and arm visual analog scores (VAS), neck disability index (NDI), and patient satisfaction index (PSI). Modified Japanese Orthopedic Association (mJOA) myelopathy scores and Nurick (N) scores were classified as improved (mJOA +3; N+1), same (mJOA +2 to -2; N 0), or worse (mJOA -3; N-1). Neck pain and disability outcomes were analyzed using a threshold in which outcomes were classified as success (NDI=40; VAS=4.0) and failure (NDI>40; VAS>4.0) as well as the peri-operative change in which outcomes were classified as success (?NDI=-15; ?VAS=-2.0), and failure (?NDI<-15; ?VAS<-2.0). Statistical analyses included t-test for continuous variables and Chi square for categorical with significance set at a p<0.05.
Results: At last follow-up a successful outcome based on change criteria favored miPCD for mJOA (miPCD: 45%; ACDF: 17%; p<0.05), N (miPCD: 50%; ACDF: 30%; p<0.05), and NDI (miPCD: 39%; ACDF: 17%; p<0.05) while neck VAS, right arm VAS, and left arm VAS did not differ between the groups. At last follow-up the percent of patients obtaining a successful outcome based on threshold criteria did not differ with respect to: neck VAS, right arm VAS, left arm VAS, or NDI. The PSI for both procedures was high (miPC: 4.00 ± 1.19; ACDF: 3.76 ± 1.30; NS).
Conclusion: In this small retrospective analysis miPCD is associated with similar outcomes to that of ACDF. Further comparative effectiveness study of these techniques is warranted.

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Minimally Invasive Tumor Decompression for Spinal Metastases

Harshpal Singh, Scott A. Meyer, Zachariah Maliakal George, Arthur L. Jenkins, III
Introduction: Patients deemed poor operative candidates for open surgery due to age, comorbidities, metastatic burden, or limited life expectancy with neurologic compromise may benefit from a palliative decompression through a minimally invasive transpedicular approach.
Methods: An IRB approved retrospective review of 24 consecutive minimally invasive tumor decompressions on 14 adult patients with symptomatic epidural compression during a 5-year period from 2003 to 2008 was performed. Inclusion criteria were patients with symptomatic epidural metastatic compression deemed not appropriate for open surgery because of age, burden of metastatic disease, or life expectancy of less than 1 year based on Tokuhashi scores. Exclusion criteria included patients with significant spinal deformity or evidence of instability, life expectancy greater than 1 year, and highly radiosensitive tumors. Medical records and radiographic studies of the patients were reviewed retrospectively. Patients were characterized according to their age, gender, histopathology, radiographic findings, and treatment outcomes. Neurologic outcome was graded by preoperative and postoperative Karnofsky scores and ambulation scores. Changes in ambulation scores and Karnofsky scores were assessed using the Wilcoxon Signed Rank test on the differences between the pre-op and post-op scores for each surgical procedure.
Results: Karnofsky performance status scores improved from a preoperative mean of 57.1 to a postoperative mean of 73.8, leaving a mean improvement of 16.6 points. The median change (difference = postop - preop) was 15 and the Inter-Quartile Range (IQR) for the changes was 5 - 20. This difference was significant (p=0.0001). Mean ambulation scores improved 1.1 points from a mean preoperative score of 2.8 to a mean postoperative score of 3.9. The median change (difference = postop - preop) was 1 and the IQR for the changes was 0 - 2. This difference was significant (p=0.0001).
Conclusion: Minimally invasive transpedicular tumor decompression can improve neurologic outcomes in patients deemed to be poor surgical candidates.

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Predictors of Back Pain and Disability Following Minimally Invasive Surgery for Lumbar Radiculopathy

Anthony G. Conte, John W. German
Introduction: Persistent back pain and disability limits clinical outcome following surgery for lumbar radiculopathy. Identification of the risk factors associated with a poor outcome may help improving outcome.
Methods: A retrospective review was undertaken of 140 patients undergoing surgery for lumbar radiculopathy. Medical records were reviewed and data was abstracted for demographics, past medical, past surgical, co-morbidities, anatomic factors, and intraoperative factors. Six month outcomes were available for patient derived outcomes including Oswestry disability index (ODI) and back visual analog score (VAS). Outcomes were analyzed using the peri-operative change in which outcomes were classified as success (ODI>-15; VAS>-2.0) or failure (ODI<-15; VAS<-2.0) as well as a threshold method in which outcomes were classified as success (ODI<40; VAS<4.0) or failure (ODI>40; VAS>4.0).
Results: Using the change method the per cent of patients who were classified as failures was 44.6% for ODI and 48.5% for back VAS while the threshold method classified treatment failures in 46.2% for ODI and 35.8% for back VAS. A bivariate analysis of the ODI perioperative change method identified the following risk factors for failure: depression, anxiety, absence of sequestrectomy, absence of annulotomy, and absence of PLL incision. Bivariate analysis of the ODI threshold method identified the following risk factors for failure: depression, anxiety, neurologic co-morbidity, foraminotomy, absence of annulotomy, and worker's compensation. Bivariate analysis of the back VAS threshold method identified the following risk factors for failure: female sex, depression, anxiety, neurological comorbidity, higher estimated blood loss, absence of sequestrectomy, and absence of annulotomy. Bivariate analysis of the back VAS perioperative change method

suggests identified the following risk factors for failure: depression, foraminotomy, and absence of sequestrectomy.
Conclusion: The common risk factors for persistent back disability identified by these analyses are: depression, anxiety, and absence of annulotomy. The common risk factors for persistent back pain are depression and absence of sequestrectomy.

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Idiopathic Spinal Cord Herniation

Ulrich Batzdorf, Langston T. Holly

Introduction: Idiopathic Spinal Cord Herniation (ISCH) is a relatively rare but treatable cause of neurological dysfunction.
Methods: Ten patients with ISCH were treated by the authors between 1986 and 2010. Patient age ranged from 23 to 57 years, with a mean of 51.5 years. The cord herniation was situated in the upper thoracic spine, between T3 and T7, and was ventral or ventro-lateral in all patients. Lower extremity sensory impairment and weakness with or without spasticity, were the most common clinical presentations. The diagnosis was established by magnetic resonance imaging or computerized tomographic scanning following myelography in all patients. All patients were treated surgically. In some patients the cord herniation was noted to extend beyond the margins of the dural defect, necessitating enlargement of the dural opening to release the cord. Using either bovine pericardium or synthetic material, a ventral sling was placed between the cord and the dural defect. The sling was then anchored to the patient's dura and an expansile duraplasty was performed in 5 patients. This technique was used in all but the first of the ten patients. We did not resect any of the herniated cord tissue.
Results: All patients improved after surgery, but one patient developed neuropathic pain requiring medical treatment. Lower extremity weakness showed most improvement, sensory symptoms improved in half of the patients, spasticity tended to remain unchanged. Aside from 2 patients treated within the last year, the mean follow-up time was 5 years.
Conclusion: Although uncommon, the diagnosis if ISCH is still frequently overlooked by both neurosurgeons and radiologists, resulting in delay of definitive treatment. In most patients the appearance of ISCH on imaging studies is sufficiently characteristic to establish the diagnosis. The cause of this disorder is currently not known.

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Application of in Vivo Bioluminescence to Monitor Spine Tumor Volume in a Rodent Model of Spine Tumor

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Introduction: Animal models of metastatic spinal tumors (ST) are used to determine efficacy of spine surgery, radiation, and chemotherapeutics in preclinical studies. Although tumor volume (TV) can be measured via pathological analysis, there is currently not a highly specific imaging modality that can correlate neurological function with TV in rodents while are still alive. We introduce the application of a bioluminescence imaging (BLI) whereby tumor volume can be non-invasively measured and correlated with neurological function in a rat model of metastatic epidural spinal cord compression.
Methods: Human prostate cancer cell line (PC-3) that express luciferase; were injected subcutaneously into the flank of six athymic male rats to evaluate the development of tumors. Luciferin was injected at (40 mg/kg), and bioluminescence was imaged in the flank. The size was monitored every 3 days. When the tumor reached a size of 12x12 mm, it was removed and implanted into the L6 vertebral body (7 x 7 mm piece) via a transperitoneal approach. Tumor-implanted animals were functionally assessed daily via a kinematic analysis of locomotion, and dysfunction was correlated with computed tomography (CT) and bioluminescence imaging.
Results: 15 days after the cell injection the rats develop tumors that reached a size of 12x12 mm, and BLI showed proliferative activity of PC3 cells in the rat flank. The morphology of the PC3 tumor was confirmed by histological analysis. ST was then detected by CT 23 days after tumor implantation. Kinematic analysis of locomotion was correlated with tumor growth.
Conclusion: This study involves the application of a non-invasive in vivo imaging modality of TV in a rat model of ST. As CT does not adequately image soft tissue and magnetic resonance imaging (MRI) is not cost effective, this technique shows reliable and accurate assessment of TV correlated with both neurological decline and postmortem pathological analysis.

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Cost Effectiveness of Transforaminal Lumbar Inter-body Fusion (TLIF) for Grade I Degenerative Spondylolithesis

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Introduction: Transforaminal lumbar inter-body fusion (TLIF) for spondylolithesis-associated back- and leg-pain is associated with improvement in pain, disability, and quality of life. However, given the rising healthcare costs associated with spinal fusion procedures, the cost-effectiveness of TLIF has recently been questioned. In a single cohort cross-over study, we set out to prospectively assess the comprehensive costs of TLIF, to determine its relative utility compared to the preceding 6-12 months of conservative therapy, and determine its cost-effectiveness in the treatment of degenerative spondylolithesis.
Methods: Forty-five patients undergoing TLIF for grade I degenerative spondylolithesis-associated back- and leg-pain after 6-12 months of conservative therapy were included. Two-year total back-related medical resource utilization, missed work, and health-state values [quality adjusted life years (QALYs), calculated from EQ-5D with U.S. valuation] were assessed,Table 1. Two-year resource use was multiplied by unit costs based on Medicare national allowable payment amounts (direct cost). Patient and care-giver work-day losses were multiplied by self-reported gross-of-tax wage rate (indirect cost). Total cost per QALY gained after TLIF was assessed as incremental cost-effectiveness ratio (ICER: COSTSurg/QALYSurg - QALYMed).
Results: Compared to health states reported after 6-12 months of medical management, a significant improvement in all outcome measures was observed two years after TLIF(Figure 1), mean two-year gain of 0.86 QALYs per patient. Post-TLIF resource utilization is given in Table 1. Mean±SD total two-year cost of TLIF was $36,835±11,800 (Surgery cost: $21,311±2,800; Outpatient resource utilization cost: $3,940±2,720; Indirect cost: $11,584±11,363), Table 2. When compared to utility gained after 6-12 months of medical management, TLIF was associated with a mean two-year ICER of $42,854 per QALY gained.
Conclusion: TLIF improved pain, disability, and quality of life in patients with degenerative spondylolithesis-

associated back and leg pain. When compared to the preceding 6-12 month period of medical management, the ICER of TLIF was <$50,000 per QALY. This suggests that TLIF is a cost effective treatment of lumbar spondylolithesis when evaluated with medicare costs. These results support the need for healthcare policy and resource allocation in favor of spinal fusion procedures.

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Ten-Year Experience with the Dakota Knife Carpal Tunnel Release

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Introduction: The Dakota Knife is a refinement of the traditional open technique for carpal tunnel release. We describe the Dakota Knife technique and report more than ten years' experience.
Methods: The procedure is performed under local or regional anesthesia. Loupe magnification is used. A 1.5cm mid-palmar incision is made. Retraction of the palmaris fibers allows for layer-by-layer incision through the transverse ligament until a small portion of the median nerve is exposed. The Dakota Knife is passed once distally and once proximally. Full release is verified visually and with palpation. Wound closure is done with absorbable or monofilament nylon sutures. A small wrap is applied. Splints or casting is not necessary. We undertook a retrospective chart review on all patients undergoing carpal tunnel release using the Dakota Knife. Patients were followed from preoperatively to 30 months following surgery. Patient questionnaires were used for data collection at 1, 3, 6, 18, and 30 months.
Results: 461 procedures were performed on 328 patients from March 1998 to August 2010. Clinical findings were reported for all patients. Preoperative clinical data is presented in tables 1 and 2. Clinical results are reported in table 3. Numbness, whether residual or increased was reported in 8.3% of patients. Satisfaction is reported for 215 patients who returned surveys at 18 and/or 30 months. Results are reported in table 4.
Conclusion: In the current group of reported patients we experienced no recurrent nerve injuries, and there were no surgical issues due to instrument failure. No hemostasis issues were encountered. The patient outcomes reported were acceptable and consistent with recently reported outcomes(1). The Dakota Knife (figures 1 and 2) is designed to cut the ligament as the instrument is passed, thereby greatly reducing or eliminating the volume of instrument beneath the ligament and by extension, the amount of pressure exerted on the already compromised median nerve. The technique is easily learned with a minimal learning curve and a few simple nuances in technique.

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Location Dictates Major Surgical Complications for Intradural Extramedullary Spinal Tumors

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Introduction: Intradural extramedullary (IDEM) neoplasms can pose a challenge for surgical resection. Numerous factors affect the resectability and ultimately the outcome for these lesions. We report our institutional experience with surgical resection of intradural extramedullary neoplasms, focusing on the effect of location on surgical outcomes.
Methods: We performed a retrospective review of 98 consecutive patients ranging from 7 to 87 years old (mean age 49.9 years) who presented with an intradural extramedullary spine tumor in the cervical and/or thoracic regions and underwent resection between February 2000 and July 2009. All patients had magnetic resonance imaging (MRI) and the axial location of the tumor was categorized as anterior, posterior, or lateral. Additionally, the spinal cord at the respective level of resection was analyzed. Postoperative complications were assessed, as well as the neurologic status at the patient's last follow-up clinic visit.
Results: Surgery related complication rates amongst patients with IDEM spinal tumors based on axial spinal cord location was found to be 41.6% of all anterior tumors (n=12), 4.4% of all lateral tumors (n=69), and 0% of all posterior located tumors (n=17). Although no statistical difference was noted in the frequency of tumors occurring at any particular level in the spine (p=0.98), major surgery related complications were 4.5% at O- C3 (n=22) , 0% at C4 -C7 (n=16), 23.7% at T1-T4 (n=21), 5% at T5-T8 (n=20), and 0% at T9-T12 (n=20). Complication included CSF leak requiring lumbar drainage, reexploration for epidural hematoma, and major postoperative neurological deficits. Major postoperative neurological deficits were seen in 3 patients, all had anterior located tumors. All major neurological deficits occurred from T1-T5, where 2 of 21 patients or 9.5% with T1-T4 tumors and 1 of 20 or 5% of those with T5-T8 tumors experienced a complication.
Conclusion: Spinal intradural extramedullary (IDEM) tumors that are anteriorly located in the upper thoracic spine were found to have the highest rate of surgery related major complications. This finding might be associated with the unforgiving anatomy of the upper thoracic spine with a higher cord to canal ratio, as well as the tenuous vascular supply to that region of the spinal cord.

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Interpedicular Travel in the Human Lumbar Spine Instrumented with Rigid and Semi-Rigid Rods: Implications for Dynamic Fusion

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Introduction: Posterior dynamic fusion conceptually provides adequate stabilization of an instrumented functional spinal unit while allowing sufficient motion to facilitate arthrodesis. The Scientx Isobar TTL Evolution is a dynamic posterior fusion system that when used in conjunction with an anterior column interbody fusion graft intentionally allows for greater anterior/posterior column load sharing and axial distraction with bending.
Methods: The biomechanical properties of the Isobar system were tested utilizing instrumented cadaveric lumbar spines placed in a six degree-of-freedom testing apparatus. Pedicle displacement between adjacent instrumented vertebrae, defined as interpedicular travel (IPT), was ascertained in three different Isobar configurations (low, middle, and high) as well as with a rigid rod under flexion/extension, lateral bending, axial torsion and compression loads. Axial rod displacement was used as a proxy for IPT and was determined by the attachment of 4 LED mounted flags to the superior and inferior aspects of each rod. Displacement of the LEDs was measured in all three axes using an opto-electronic array.
Results: With the Isobar damper in the middle position, there was a statistically significant increase in IPT in flexion and extension compared to the rigid rod. The mean difference of displacement was found to be 0.080mm, 95% CI of 0.018 to 0.142 (p=0.017). There was a statistically significant increase in IPT in lateral bending with the Isobar damper in the high position compared to the rigid rod. A mean difference of displacement was 0.342mm, 95% CI of 0.039 to 0.645 (p=0.030). Data analysis included one-

way repeated measures ANOVA and bonferroni post hoc test. Statistical significance was set to $p<0.05$.
Conclusion: The Isobar damper in the middle position allowed for greater change in rod length with flexion and extension than the rigid rod. In the high position, the Isobar damper allowed greater lateral bending compared to the rigid rod.

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Single Level Lumbar Fusion at L5-S1: A Comparison of MIS TLIF and AxiaLIF

W.B. Rodgers, Edward J. Gerber, Jody A. Rodgers

Introduction: Results of the MIS-T/PLIF procedure were compared with AxiaLIF procedure to contrast safety and effectiveness of each minimally invasive transsacral fusion alternative.
Methods: Data were collected on the first 50 patients (25MIS-T/PLIF, 25AxiaLIF) treated by a single center for single-level fusion at the LS junction using two alternative MIS techniques. The first 25 patients (11M, 14F, age 48.9 yrs, BMI 30.3) were treated with MIS-T/PLIF and the second 25 (13M,12F; age51.4 yrs, BMI 31.4) with AxiaLIF. Outcomes are reported, including 12 and 24 month postop data (MIS-T/PLIF group n=19,5; AxiaLIF group n=17,5.
Results: In the MIS T/PLIF group, OR time averaged 102.8 minutes, hemoglobin change 2.10g, and length of stay 1.69 days. Disk height increased 3.0mm from preop to postop with 1.1 mm settling at 12 and 24 months; listhesis (10 pts) decreased 1.8mm from preop to postop with maintenance of reduction at 12 and 24 months; Lenke scores measured 2.9 at 3 months, 1.6 at 12 months, and 1.3 at 24 months. VAS improved from 8.1 to 3.0 postop and was 3.0 and 0.8 by 12 and 24 months. There were four complications in this group: one deep infection, one broken instrument (radial disk cutter) requiring anterior removal, one neuropraxia, and one transfusion. One patient died of unrelated causes at 3 months postop. In the AxiaLIF group, OR time averaged 68.8 minutes, hemoglobin change 1.74g, and LOS 0.92 days. Disk height increased to 7.6mm at postop with 0.8mm settling by 12 months and 24 months; listhesis (17 pts) decreased 2.2mm with loss of reduction of 0.6mm at 12 months and 0.8mm at 24 months; Lenke scores measured 2.9 at 3 months, 2.1 at 12 months, and 1.8 at 24 months. VAS improved from 8.7 to 3.7 at 3 months, 2.7 at 12 months, but declined to 4.4 at 24 months. There were no complications in this group.
Conclusion: We saw similar clinical and radiographic outcomes but different OR times, blood loss, and length of stay. The prevalence of complications in the MIS-T/PLIF group led us adopt the AxiaLIF as fusion method of choice at L5-S1 interval.

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Extreme Lateral Interbody Fusion (XLIF) in the Morbidly Obese

W.B. Rodgers, Edward J. Gerber, Jody A. Rodgers

Introduction: Minimally invasive procedures are challenging in obese patients whose body habitus may decrease the accessibility of the spine to the instruments necessary to perform these procedures. The XLIF procedure, however, is performed in the lateral decubitus position, minimizing the difficulty of the pannus as it falls away from the exposure.
Methods: In our single-site prospective series of 941 XLIF patients, 479 were identified as obese (BMI>30) and 160 of those were morbidly obese (BMI>38). Comorbidities, surgical details, hospital stay, complications, pain scores, changes in disk height and alignment, and fusion were assessed.
Results: In all our XLIF patients, no surgery could not be successfully completed due to body habitus. The heaviest patient to date weighed 427 lbs. (193.7 kgs); the largest BMI was 61.8 (avg 43.6, range 38.0-61.8). Age ranged from 22-78 years. Comorbidities included smoking (30%), prior spine surgery (43%), diabetes (30%), CAD (42%), COPD (4%). 586 levels were treated in these 479 patients: 386 1-levels, 80 2-levels, 12 3-levels and 1 4-level; the majority at L4-5. All but 2 surgeries included supplemental fixation. There was three transfusions and one infection. Complications included 2 MI's at 4 and 6wks, one atrial fibrillation, pneumonia requiring intubation for 5 days, one other respiratory distress requiring re-intubation, one pulmonary embolism, one posterior hardware failure/rod fracture at 6 months, and one fracture of vertebral osteophytes requiring reoperation. Hospital stay averaged 1.29 days. From pre-op to 24 month follow-up: disk height increased an average 2.6mm; slip decreased an average 3.2mm in spondylolisthesis patients; and VAS pain scores decreased from 8.7 preop to 2.7 at 24 months. Lenke scores were 2.1 at 3 months, 1.2 at 12 months, and 1.1 at 24 months.
Conclusion: Our results demonstrate the usefulness and safety of the XLIF technique in treating morbidly obese patients minimally invasively. Complications are minimal, procedures timely, and outcomes similar to non-obese patients.

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Impact of Multi-modality Intraoperative Monitoring During Correction of Symptomatic Cervical or Cervicothoracic Kyphosis

Paul Park, Anthony C. Wang, Shawn Hervey-Jumper, Frank La Marca

Introduction: Surgical correction of symptomatic cervical or cervicothoracic kyphosis involves the potential for significant neurologic complications. Intraoperative monitoring (IOM) has been shown to reduce the risk of neurologic injury in scoliosis surgery. IOM has not been well-evaluated during surgery for cervical or cervicothoracic kyphosis. In this article, we review a cohort of patients who underwent kyphosis correction with multi-modality intraoperative monitoring (MIOM).
Methods: Twenty-nine patients were included in this study. Preoperative and postoperative Cobb angles were measured to determine extent of correction. MIOM consisted of somatosensory evoked potentials (SSEPs), transcranial motor evoked potentials (TcMEPs), and electromyography (EMG). Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were assessed for each monitoring modality.
Results: Mean patient age was 58.0 years, and 20 patients were female. Mean preoperative and postoperative sagittal Cobb angles were 41.3° and 7.3°, respectively. A total of 8 intraoperative monitoring alerts were observed. TcMEPs yielded a sensitivity of 75%, specificity of 84%, PPV of 43%, and NPV of 95%. SSEPs had sensitivity of 25%, specificity of 96%, PPV of 50%, and NPV of 88%. EMG resulted in sensitivity of 0%, specificity of 93%, PPV of 0%, and NPV of 96%. Changes in TcMEP led to successful intervention in 2 cases. There was one case where a C8 palsy occurred without any changes in MIOM.
Conclusion: Specificity and NPV were generally high in all 3 monitoring modalities in contrast to sensitivity and PPV. Both false positive and false negative results occurred. TcMEP monitoring was the most useful modality and appeared to allow successful intervention in certain cases. Larger prospective, comparative

studies are necessary to determine whether MIOM truly decreases the rate of neurologic complication and is therefore worth the added economic cost and intraoperative time.

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Comparison of Three-Dimensional Fluoroscopy vs. Postoperative Computed Tomography for the Assessment of Accurate Screw Placement After Instrumented Spine Surgery

Sarah T. Garber, Erica Bisson, Meic Schmidt

Introduction: Three-dimensional (3-D) fluoroscopy performed intraoperatively has been used increasingly as a means to evaluate screw placement during spinal instrumentation. While 3-D fluoroscopy does not possess the resolution and image quality of a computed tomography (CT) scan, it may provide adequate information about screw placement that can guide both intra- and postoperative decision making. The goal of this research project is to compare the accuracy of visualization of proper screw placement determined intraoperatively using 3-D fluoroscopy with postoperative CT.
Methods: A retrospective review of all spinal instrumentation procedures done at the University of Utah by the senior authors using the O-arm was completed. Cases in which no postoperative CT was done were excluded. All screws were assessed for placement on both the O-arm and CT images using the previously described method by Rao, et al.
Results: Twenty cases were identified that had both post-instrumentation O-arm images and postoperative CT images. These included 8 cervical, 4 cervicothoracic, 2 thoracic, 3 thoracolumbar, and 3 lumbosacral cases. Forty-five, thirty-six, and twenty-two screws were placed in the cervical, thoracic, and lumbosacral spine, respectively. The O-arm identified a total of 13 breaches (11-grade 1, 2-grade 2), and the CT identified 14 breaches (10-grade 1, 3-grade 2, 1-grade 3).
Conclusion: The results of our study show that intraoperative three-dimensional fluoroscopy is highly accurate in the evaluation of screw placement during neurosurgical spine procedures. These results should lead to a decreased frequency of postoperative CT scans and therefore help to minimize both cost and radiation exposure in patients who require spinal instrumentation.

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Axial Rotation Requires Greatest Load in Multifidus Muscle: Potential Association with Low Back Pain?

Bruce Robie, Sebastian Dendorfer, John Rasmussen, Soren Torholm

Introduction: The multifidus muscle is a key stabilizer of the spine[1]. Its atrophy has been shown in patients with low back pain[2] and those with herniations[3], possibly due to overload. Motions and loads that could induce overload are not well understood. The AnyBody Modeling System™ simulation software enables muscle force analysis and contains more than 1000 individual muscle branches, and includes a validated lumbar spine model[4,5] (Fig. 1). The purpose of this study is to examine the force required by the different branches of the multifidus for each of the principal motions.
Methods: Flexion-extension, lateral bending and axial rotation of the lumbar spine using a model of a standing human under influence of gravity was assessed. The stiffness of each lumbar spinal segment was based on published cadaver measurements. The analyzed parameters were the forces in all branches of the multifidus muscles on the right side of the spine.
Results: The peak force in a multifidus branch occurred during axial rotation (53N), with lesser forces in flexion/extension (20N) and lateral bending (17N). The multifidus force peaked at the limit of axial rotation (12° of lumbar spine rotation) and diminished towards zero in the opposite direction (Fig. 2), while a maximum force was seen at full flexion with a lesser peak at extension and reduced forces at neutral position.
Conclusion: Axial rotation motion induced the largest force in the multifidus, which is a key stabilizing muscle of the posterior spine. This result is consistent with previous work showing that axial rotation motion induces the greatest load on the facets[6] and excessive axial rotation motion occurs in patients with low back pain[7]. The current study is limited to an analysis of normal behavior; further study of the multifidus in disease states is warranted.

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Evaluation of Neurological Dysfunction in Rat Animal Models of Spine Tumors

Rachel Sarabia-Estrada, Camilo A. Molina, Ismael Jimenez-Estrada, Ziya L. Gokaslan, Timothy F. Witham, Jean-Paul Wolinsky, Ali Bydon, Daniel M. Sciubba

Introduction: Animal models of spinal tumors serve as the foundation for many preclinical studies regarding efficacy of spine surgery, radiation, and chemotherapeutics. The standard evaluation of neurological spinal cord dysfunction in rodents is the BBB (Basso, Beattie, Bresnahan) scale. Unfortunately, this scale is complex and requires significant personnel training to obtain reliable grading. We introduce the application of a video-assisted kinematic system to evaluate gait impairment in a rat model of metastatic epidural spinal cord compression.
Methods: 12 Fisher rats (Group 1) were implanted with CRL-1666 tumor in the L6 vertebral body. 6 rats (Group 2) underwent sham surgical procedures with no placement of tumor. All animals were functionally assessed daily via a kinematic analysis of locomotion. The iliac crest, hip, knee, ankle, and the fifth metatarsal phalangeal joints were marked with ink. Unrestrained gaits of both sham and experimental animals were recorded with a digital video camera on a transparent acrylic passageway. Limb coordinates consisting of 3 to 4 step cycles were analyzed frame by frame using the Image J software. Locomotion kinematics was studied and evaluated using the software "walking rats".
Results: Line drawings were constructed between articulation joints to illustrate the spatio-temporal sequences of hindlimb movements during gait. Swing and stance phases were identified from each step cycle. Swing and stance phase duration and both length and stride speeds were determined for both groups.
Conclusion: This study involves the application of an objective and quantitative evaluation of progressively paretic rats using video analysis of gait kinematics through a transparent walkway. Complication of datasets has allowed standardization of gait in normal animals and progressively paretic animals that can be applied to spine tumor and other spinal cord injury models in rodents.

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A Role for Motor and Somatosensory Evoked Potentials During Anterior Cervical Discectomy and Fusion for Patients Without Myelopathy: Analysis of 57 Consecutive Cases

Risheng Xu, Eva Ritzl, Matthew J. McGirt, Daniel M. Sciubba, Jean-Paul Wolinsky, Timothy F. Witham, Ziya L. Gokaslan, Ali Bydon

Introduction: Although the usage of combined motor and sensory

intraoperative monitoring has been increasing and has been shown to improve the surgical outcome of patients with cervical myelopathy or myeloradiculopathy, the role of transcranial electric motor evoked potentials (tceMEP) used in conjunction with somatosensory evoked potentials (SSEP) in patients presenting with radiculopathy but without myelopathy has been less clear.

Methods: We retrospectively reviewed all patients (n=57) with radiculopathy but without myelopathy undergoing anterior cervical decompression and fusion at a single institution over the past 3 years who had intraoperative monitoring with both tceMEPs and SSEPs. The data were analyzed with regards to intraoperative SEP or tceMEP changes, as well as intra, peri, or postoperative clinically significant events and outcomes.

Results: 57 (100%) patients presented with radiculopathy, 53 (93.0%) with mechanical neck pain, 35 (61.4%) with motor dysfunction, and 29 (50.9%) with sensory deficits. 30 (52.6%) were male, and the average age was 47.6±11.1. An average of 1.65 vertebral levels (range 1-3) was fused. Intraoperatively, 3 (5.3%) patients experienced decreases in SSEP signal amplitudes, and four (6.9%) had tceMEP signal changes. There were three instances where a change in neuromonitoring signal required intraoperative alteration of the surgical procedure: these were deemed clinically significant events/true positives. SSEP monitoring showed 2 false positives and 2 false negatives, whereas tceMEP monitoring only had one false positive and no false negatives. Thus, tceMEP monitoring exhibited higher sensitivity (33.3% to 100%), specificity (95.6% to 98.1%), positive predictive value (33.3% to 75.0%), negative predictive value (97.7% to 100%), and efficiency (91.7% to 98.2%) compared to SSEP monitoring.

Conclusion: Although recent studies have presented evidence to support the use of tceMEP monitoring along with SSEPs in high risk patients with central cord compromise, none have systematically examined the utility of using tceMEP/SSEPs in patients without myelopathy. Here, we present a series of 57 patients undergoing anterior cervical decompression and fusion for radiculopathy without myelopathy, where combined tceMEP/SSEP monitoring resulted in an intraoperative change in surgical procedure in 3 (5.8%) patients, likely preventing irreversible neurologic damage.

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Single Level Lumbar Fusion for a Grade I and II Spondylolisthesis Correction Using the AxiaLIF Rod Sysyem

W.B. Rodgers, Edward J. Gerber, Jody A. Rodgers

Introduction: AxiaLIF offers 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 as an alternative to conventional lumbar fusion. To our knowledge, this represents the first report of the use of this technique in spondylolisthesis.

Methods: 85 patients (36 M, 49 F, age 54.5 yrs, BMI 32.0) were treated with AxiaLIF fusion at L5-S1 for either a Grade I (n=69) or Grade II or greater (n=15) spondylolisthesis. The VAS scores, disc heights, and improvement in slip and complications are presented.

Results: VAS improved by 65% over the first year; disk height increased 3.6 mm from preop to postop (with some settling (1.34 mm) by 24 months); listhesis was reduced by 3.6 mm at postop, but settled by 2.7 mm at 24 months. There were no neural or visceral injuries, or hardware failures. Two patients had mild gapping of coccygeal incisions that were treated with local dressings and resolved, two patients had graft herniations requiring laminotomy, one patient had pneumonia treated with IV antibiotics, one patient had delirium, one patient had an infection, one patient required transfusion, and two patients developed a nonunion that was revised at 13 and 24 months respectively.

Conclusion: A transsacral MIS approach using the AxiaLIF fixation system at L5-S1 for a Grade I or Grade II spondylolisthesis offers a safe, reproducible alternative to traditional open procedures. This approach provides adequate reduction of a Grade I or II spondylolisthesis. The intermediate results demonstrate encouraging clinical outcomes with an acceptable complication rate. However, the areas of graft herniation, disc height settling, listhesis settling, and fusion rates bear watching. Of greatest concern is the difficulty assessing fusion status (>45% are not definitely fused) and the loss of disk height (29.5%) and listhesis reduction (19.2%) noted 12 months after surgery.

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A Retrospective Clinical Study of "Hybrid" Anterior 3- or 4-level Cervical Decompression and Fusion Technique To Address Multi-level Cervical Spondylotic Myelopathy and/or Radiculopathy

Paul K. Edwards, Kelli Bunton, Aditya Ancha, John M. Small

Introduction: A retrospective clinical study to assess fusion and outcomes of patients undergoing a "hybrid" anterior cervical 3- or 4-level decompression and fusion technique to address multi-level cervical spondylotic myelopathy or radiculopathy. This technique consists of a single-level anterior corpectomy with PEEK (polyetheretherketone) or titanium cage placement and adjacent 1- or 2-level discectomy with PEEK interbody cage reconstruction and anterior cervical plating.

Methods: From 2004 - 2009, fifty patients were treated with the "hybrid" technique. Cervical flexion/extension radiographs were reviewed to assess fusion (mean 37 months). Lordosis correction was measured by C2-C7 cobb angles on the pre- and postoperative lateral radiographs. Pre- and postoperative VAS and SF-36 scores were recorded. The corpectomy provided local bone graft and was supplemented with DBM if needed. No patient required harvest of iliac crest bone.

Results: Two patients (4%) had symptomatic non-unions and had posterior fusion with instrumentation at the involved level(s). Mean pre- and postoperative C2-C7 sagittal angle were 2.6 and 13 degrees of lordosis, respectively. Mean 10.4 degrees of lordotic correction obtained. 37% of patients had a preoperative kyphotic sagittal plane deformity. VAS and SF-36 (both PCS & MCS component) scores improved an average of 3.4 and 8 points, respectively.

Conclusion: Using the "hybrid" technique to address multi-level cervical spondylotic myeloradiculopathy provides reliable fusion rates (96%), eliminates the morbidity associated with posterior supplemental fixation, and demonstrates a low revision rate (4%). Another benefit to this technique is the substantial amount of autograft available with corpectomy, subsequently eliminating the need for iliac crest bone graft. In addition to these benefits, the anterior reconstruction allows for excellent correction, as well as maintenance, of cervical lordosis. This technique also showed improvement in both SF-36

components (MCS & PCS) and VAS outcome scores similar to those seen using other accepted techniques.

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Is Facet Fusion Biomechanically Equivalent to Posterolateral Onlay Fusion?

Kevin T. Foley, Jeffrey M. Toth, Lawrence Lenke, Mei Wang, Howard B. Seim, III, A. Simon Turner

Introduction: Clinically, a facet fusion is less invasive, requires less bone graft harvest, and is associated with less morbidity than a posterolateral fusion (PLF) using autograft. However, it is not known if the biomechanical stiffness of a facet fusion is equivalent to the biomechanical stiffness of a PLF.

Methods: In order to evaluate fusion efficacy in the instrumented ovine lumbar spine model, eight sheep had 10 cc/side of iliac crest bone graft (ICBG) for PLF at L2-L3. 0.5 cc/side ICBG was placed for facet fusion at L3-L4. 0.5 cc/side rhBMP-2/ACS (0.43 mg/mL) was placed for facet fusion at L4-L5. Sheep were euthanized at six months. Unconstrained biomechanical testing was performed in a non-destructive manner on the L2-L3 and L4-L5 levels. All spinal levels were analyzed using undecalcified histology.

Results: As seen in the graph, the PL fusion with ICBG and the rhBMP-2 facet fusion treatment groups demonstrated similar stiffness, with the rhBMP-2 facet fusion group having on average slightly higher stiffness in all six loading directions. The only difference between rhBMP-2_Facet and the ICBG_PLF that reached the level of statistical significance was the stiffness in extension ($p<0.01$, Bonferroni/Dunn test). All eight levels in the rhBMP-2/ACS facet fusion treatment group and all eight levels in the autograft facet fusion treatment group demonstrated bilateral histologic fusion. Six of sixteen rhBMP-2/ACS treated facet defects demonstrated small intraosseous hematomas or seromas. 4/8 levels in the autograft PLF treatment group demonstrated a bilateral histologic fusion. 1/8 demonstrated a bilateral histologic non-fusion. 3/8 showed a unilateral fusion.

Conclusion: Both rhBMP-2/ACS and autograft demonstrated 100% efficacy when used for facet fusion in this ovine model. Biomechanically, the PL fusion with ICBG and the rhBMP-2 facet fusion treatment groups demonstrated similar stiffness in all six loading directions, with the rhBMP-2 facet fusion group having on average slightly higher stiffness in all directions.

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Measurement of Anterior Column Load Sharing in Posterior Dynamic Fusion Devices

Alexander Kwong-Tak Yu, Joseph Kyle Hobbs, Zachary G. Wright, Daniel Cook, Jonathan B. Bellotte, Donald M. Whiting, Boyle C. Cheng

Introduction: Posterior dynamic fusion devices have become of interest because they not only stabilize the pathologic functional spinal unit, but may facilitate arthrodesis more than traditional rigid rod devices. Wolff's law states that normal physiologic loads facilitate bone growth via mechanotransduction, an adaptive process which translates physiologic stress into effector-cell responses by osteoblasts, resulting in bone formation. We compared anterior column load sharing between dynamic and rigid rod fusion devices under physiologic biomechanical forces with the presumption that anterior column load sharing can translate into facilitated arthrodesis.

Methods: Six fresh frozen human lumbar cadaveric specimens were stripped of soft tissue except for osteoligamentous structures. Anterior column load sharing was tested at the L3-L4 level using a modified transforaminal lumbar interbody fusion (TLIF) cage spacer with an integrated load cell. Load sharing was tested under axial compression (0N to 150N), flexion-extension bending, lateral bending and axial torsion (± 7.5 Nm). Treatment modalities compared include: destabilized spine (no instrumentation, left facetectomy), rigid rod stabilization, and dynamic stabilization using Isobar TTL Evolution.

Results: Under axial compression, the dynamic stabilization treatment with the dampener between pedicles showed a statistically significant increase in anterior column load sharing (69.2N, 19.6 SD) when compared to the rigid rod (40.6N, 23.3 SD) stabilization ($p=0.024$). The destabilized spine treatment showed a statistically significant increase in anterior column load sharing (83.9N, 10.6 SD) when compared to rigid rod treatment ($p=0.018$). No significant differences were noted among the other modalities and load types.

Conclusion: Under axial compression, the load experienced by the anterior column appears to be greater utilizing dynamic fusion systems than traditional rigid rod systems. This increased load may translate into improved and faster rates of arthrodesis of the pathologic functional spinal unit in the clinical setting.

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DBM Use in 2-Level PLIFS: Fusion Comparison of Smokers and Non-smokers

W.B. Rodgers, Edward J. Gerber, Jody A. Rodgers

Introduction: Of our single-site consecutive series of 110 two-level PLIF patients, 47 smoked at the time of surgery. Clinical and radiographic measures were prospectively collected and evaluated to assess comorbidities, complications, and fusion results at 12 and 24 months postop.

Methods: 110 instrumented, 2-level PLIF procedures were performed by a single surgeon using a graft composite were 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 allograft spacers (to achieve interbody fusion) and along the intertransverse membrane (to achieve posterolateral fusion). Anteroposterior and lateral flexion and extension radiographs, obtained at three-, six-, and twelve-months, were evaluated utilizing Lenke's criteria for intertransverse fusion and modified Lenke criteria of interbody fusion. Global fusion was defined as either: Lenke or modified Lenke score of 1; or Lenke score 2+modified Lenke score 2.

Results: 46 smokers and 62 non-smokers, ranging in age from 33-85 years (average age= 57.42 years) presented for 12-month follow-up. Intertransverse/interbody scores for smokers=1.89/1.20 and for non-smokers=1.69/1.25. To date, 32 smokers and 40 non-smokers have presented for 24 month follow-up. Lenke scores for smokers at 24 months postop were 1.81/1.25; non smokers 1.63/1.18. Similar complication rates were observed in both groups; 6 re-operations were performed for adjacent segment disease.

Conclusion: Smoking is often identified as a contributing factor to increased pseudarthrosis (non-union) rates in spinal fusion surgeries. The fusion rates for smokers and non-smokers were 97.8% and 98.4% at 12 months respectively, and 97% and 97.5% at 24 months; no significant difference was shown between the two groups. Slightly better (intertransverse) Lenke scores were noted in the nonsmokers.

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Rate of Fusion of Interbody Constructs in Two-Level PLIFs Using a Commercially Available DBM

W.B. Rodgers, Edward J. Gerber, Jody A. Rodgers

Introduction: In our single-site prospective series of xxx two-level PLIF patients, 56 had the PEEK interbody device, and 46 had the Allograft device. Clinical and radiographic measures were evaluated to assess complications and fusion at 12 and 24 months postoperatively.

Methods: 110 patients underwent 2-level instrumented PLIFs. Patients were assigned to one of two treatment arms that included a composite of DBM + BMA + LBt hat was placed in the aperture of polyethyletherketone (PEEK) spacers (n=56) or the medullary canal of machined fibular allograft wedges (n=46) 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: 107 of 110 patients, with average age of 57.6 years (range from 32 to 85 years) presented for follow-up at 12 months. 98.3% of PEEK patients and 94.3% of allograft patients were considered fused. Of the 72 patients who have presented for 24 month follow-up to date, 100% of PEEK patients and 93.9% of the Allograft group 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 and 24-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.

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A Comparison of Two-Level Lumbar Fusions Using Minimally Invasive (XLIF) vs. Open (PLIF)

W.B. Rodgers, Edward J. Gerber, Jody A. Rodgers

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 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 and alignment restoration, and indirect decompression.

Methods: In our single-site consecutive series of 941 XLIF patients, 155 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 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 1.42; 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 89% of XLIF patients with 12-month follow-up was 1, compared with 79% of PLIF patients at 12 months. While reoperation rate among XLIF patients was 8% (10/117), there was a 19% 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.

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Long-term Prospective Analysis of Minimally Invasive Transforaminal Lumbar Interbody Fusion and Percutaneous Pedicle Screw Placement

Mick J. Perez-Cruet, Girish K. Hiremath, Ramiro Perez de la Torre, David Cooley, Sophia Lang-Perez

Introduction: Minimally invasive transforaminal lumbar interbody fusion (MITLIF) reduces approach related morbidity. Long-term prospective patient outcomes, progression of adjacent level disease and re-operation rates are lacking.

Methods: 94 patients underwent MITLIF were followed prospectively for over 5 years. Outcomes included: Visual Analog Scale (VAS), Oswestry Disability Index (ODI) and Short Form-36 (SF36) preoperatively and at postoperative intervals.

Results: Patients included 62 females and 32 males average age 58 years treated for DDD with (n = 23) or without (n = 24) stenosis or spondylolisthesis with (n = 31) or without (n=16) stenosis. Levels fused included: L5-S1 (n = 36), L4-5 (n = 40), L3-4 (n = 6), L2-3 (n = 4), or 2 level fusion (n = 8). Mean estimated blood loss and hospital stay duration were 177 cc and 3.3 days, respectively. Mean ODI score declined from 50.9% preoperatively to 34.9% at 5 year follow-up ($p < 0.003$). Mean VAS score decreased from 7.4 preoperatively to 3.0 at 5 year follow-up ($p < 0.003$). Dynamic radiographics revealed 98% fusion rate after 1 year. No patients had worsening of neurological deficit. Surgical site infection rate was 1%. Clinically significant adjacent level degeneration requiring fusion was seen in 1 patients (1%) with previous open laminectomy. No patients with primary MITLIF required extension of fusion construct over the 5-year follow-up period.

Conclusion: MITLIF maintained excellent outcomes with low long-term re-operative rates and adjacent level disease. The majority of patients only required singe level (91%) fusion to achieve significant clinical improvements.

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Occipitocervical Fixation: Long-Term Follow-up in Fifty-Seven Patients

Jan Stulik, Zdenek Klezl, Jan Kryl, Petr Nesnidal

Introduction: Occipitocervical fixation and spondylodesis is indicated in various cases of occipitocervical instability.

Methods: Between 1997 and 2007, a total of 57 patients underwent occipitocervical fixation (OC) there were 25 men and 32 women, from 4 to 77 years of age. 2 groups, group one - tying wires or cables and group two - screw-rod or screw-plate systems. Indications included trauma in 15, rheumatoid arthritis (RA) in 28, destruction due to psoriasis in one, tumor in eight, and congenital anomalies in five patients. The patients were evaluated at a final follow-up ranging between 12 and 132 months after the primary surgery (average, 42.7 months). Indications for surgery and the method and extent of instrumentation were recorded. The

evaluation included pain and neurological deficit assessment, radiographic evidence of the stability of fixation and bone union and intraoperative and early and late postoperative complications.
Results: Of the 57 patients, bone fusion was the aim of surgery in 52. Five patients died of associated injuries or serious medical complications shortly after the operation. Of the remaining 47, bone union was achieved in 44 patients (93.6%). Pseudoarthrosis developed in three patients who. In terms of bone union, there was no difference between a short (C0-C2) and a long (C0-CX or C-T) fixation. No differences among fixation materials were found. The differences in percent bone union after spondylodesis between the tying-wire and screw-rod fixation systems were not statistically significant ($p>0.05$). In the patients treated for RA, psoriasis or congenital anomaly, the Nurick scale score significantly improved at 2 years after surgery ($p<0.05$). In comparison with the others, the RA patients had a significantly higher number of complications ($p<0.05$). The patients treated for tumor showed a significant difference between the pre- and postoperative VAS values ($p<0.05$).
Conclusion: Rigid OC fixation is a very effective method for the treatment of craniocervical junction instability. The currently used implants allow us to achieve high stability and efficiency of bone union. Regardless of the instrumentation used, fusion is achieved in more than 90%, and clinical improvement in more than 80% of the patients.

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A Biomechanics Study Comparing the Subsidence of Three Different Designs of Carbon Fiber Lumbar Interbody Cages Under Direct Compression Loading in Human Cadaveric Spines

Fred Chiu-lai Lam, Ronald Alkalay, Michael W. Groff

Introduction: Unilateral transforaminal and direct lateral approaches are gaining popularity compared to the traditional bilateral posterolateral lumbar interbody fusion technique. The posterolateral corners of the endplates have been shown to be stronger than the anterior and central regions. We hypothesize that single carbon fiber cages placed anteriorly or centrally may lead to more subsidence compared to bilateral cages placed in the posterolateral quadrants under direct compression.
Methods: The caudad surface of 28 human cadaveric spine segments from L3 to L5 were potted in methymethacrylate. The superior endplates was exposed and the segment was mounted in a hydraulic material testing system. Specimens were equally divided between four testing groups: three styles of carbon fiber cages, one placed anteriorly, one placed obliquely, and two placed posterolaterally, as well as two titanium mesh cages placed centrally. Specimens were subjected to compression until failure of the endplate was observed. Force-displacement curves were generated and regression analysis was performed to compare subsidence across cage designs as well as failure and stiffness characteristics of the intervertebral cage-bone interface.
Results: There were no differences between bone density across the test groups. Each cage design demonstrated a pre-failure response followed by subsidence within the endplate and later into the vertebral body. The posterolateral carbon fiber cages demonstrated the highest yield and ultimate loads as well as pre-yield stiffness and subsidence stiffness, which was significant compared to the titanium mesh cages and the oblique carbon fibre cage. The titanium mesh cages showed the highest degree of subsidence, compared to the carbon fiber cages. None of the carbon fiber cage designs showed significant differences in subsidence compared to each other.
Conclusion: Positioning on the endplate does not seem to significantly effect subsidence for carbon fiber cages compared to centrally placed titanium mesh cages.

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Patient Satisfaction with Spine Surgery: A Systematic Review

Robert Partlow Naftel, Beverly C. Walters, Barton L. Guthrie, Mark N. Hadley

Introduction: Patient satisfaction is a measurement reflecting patients' perception of outcome of care and has been considered for use in future reimbursement schemes. A multidimensional, disease-specific patient satisfaction instrument could guide changes in surgical practice for quality improvement. No consensus on patient satisfaction instruments exists in spine surgery. The goals of this review are to establish how patient satisfaction with spine surgery has been previously measured, determine if there is a disease-specific, comprehensive instrument to measure patient satisfaction, and to define the dimensions of care that determine patient satisfaction in spine surgery.
Methods: A systematic search of three online databases, unpublished sources, and citations was undertaken to identify 85 empirical studies reporting patient satisfaction with spine surgery. The manuscripts were reviewed for patient satisfaction instrument used; instruments were categorized by content and method axes as described previously in the literature. A taxonomy of patient satisfaction with spine surgery identified the major characteristics of providers and medical care influencing patient satisfaction and acted as a structure to categorically define the dimensions of patient satisfaction in spine surgery. Validity and reliability of each instrument was assessed.
Results: Studies used predominantly global (66/85), rather than multidimensional (15/85), satisfaction instruments (4 did not specify). The most commonly used multidimensional instrument was the Brigham Spinal Stenosis Questionnaire (9/85). Most studies (92%) reported satisfaction with outcome rather than care. Seven dimensions of patient status, outcome and care experience affecting patient satisfaction were identified: pain, function, patient expectations/preference, specific patient health characteristics, caregiver interpersonal manner, efficacy/clinical outcomes, and postoperative care/therapy.
Conclusion: At present, no patient satisfaction instrument exists that is disease-specific and covers all dimensions of patient satisfaction in spine surgery. For quality improvement, such a disease-specific, comprehensive patient satisfaction instrument should be designed, tested for reliability and validity, and widely implemented.

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Minimally Invasive Transforaminal Lumbar Interbody Fusion for Spondylolisthesis in Significantly Obese Patients

Darryl Lau, Paul Park

Introduction: It has been shown that obese patients undergoing traditional open spinal fusion for degenerative conditions tend to have significant increased risk of complications. In addition blood loss can be significantly increased as larger incisions are required in obese patients. Minimally invasive spinal fusion in overweight and obese patients has been suggested to be safe and may offer potential benefits. This

study examines minimally invasive transforaminal lumbar interbody fusion (MI-TLIF) for treatment of spondylolisthesis in significantly obese adults (BMI>35) compared to normal adults (BMI<25).
Methods: Between 2006 and 2009, patients with a BMI>35 or BMI<25 undergoing elective TLIF for spondylolisthesis were identified. Using Student t-tests and Fisher's exact tests, we assessed the relation of blood loss, complications, hospital stay, and postoperative outcomes (visual analogue scale (VAS) for pain and oswestry disability index (OSW)) between the two groups.
Results: Seventeen (17) patients fit the set criteria: 9 patients in the obese group (mean BMI of 37.4) and 8 patients in the normal group (mean BMI of 23.4). There were no significant differences in blood loss (p=0.341), complications (p=0.999), and hospital stay (p=0.579) between the two groups. Mean follow-up for the obese and normal groups were 14.4 months and 17.1 months, respectively. Both groups had significant improvements in VAS (obese, p=0.002, and normal, p=0.004) and OSW (obese, p=0.002 and normal, p<0.001) at follow up after undergoing surgery. There were no significant differences in postoperative VAS (p=0.717) and OSW (p=0.996) scores between the two groups.
Conclusion: With MI-TLIF, outcomes were comparable with the advantage that there did not appear to be an increased rate of complications, blood loss, or hospital stay in obese patients compared to non-obese.

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The Effect of Minimally Invasive Posterior Cervical Approaches vs. Open Anterior Approaches on Neck Pain and Disability

Jeffrey A. Steinberg, John W. German

Introduction: Traditional surgical dictum suggests that patients with myelopathy or radiculopathy and significant axial pain should be treated with an anterior interbody fusion as a posterior decompression alone may exacerbate their neck pain. To date the effect of a minimally invasive posterior cervical approach (miPC) on neck pain has not been compared to that of an anterior cervical diskectomy or corpectomy with interbody fusion (ACF).
Methods: A retrospective review was undertaken of 89 patients undergoing either a miPCD (n=49) or ACF (n=40) for the treatment of myelopathy or radiculopathy. Medical records were abstracted for demographic information, medical history, surgical details, and complications. Clinical outcomes were assessed by patient derived neck visual analog scores (VAS) and neck disability index (NDI). Outcomes were analyzed using: 1) a threshold in which outcomes were classified as success (NDI<40; VAS<4.0) or failure (NDI>40; VAS>4.0) and 2) the peri-operative change in which outcomes were classified as success (?NDI=-15; ?VAS=-2.0), and failure (?ODI<-15; ?VAS<-2.0). Groups were compared using Chi square tests with significance taken at p<0.05.
Results: At last follow-up the percent of patients classified as successful using the threshold criteria were as follows: neck VAS (miPC: 75%; ACDF: 70%; NS) and NDI (miPC: 71%; ACDF: 58%; NS). The percent of patients classified as successful using the peri-operative change criteria were as follows: neck VAS (miPC: 55%; ACDF: 56%; NS) and NDI (miPC: 42%; ACDF: 23%; p<0.05).
Conclusion: In this small retrospective analysis miPCD is associated with similiar neck pain and disability than that of ACF. Given the avoidance of cervical instrumentation and interbody fusion in the miPCD these results suggest that further comparative effectiveness study is warranted.

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In Vivo Model of Cauda Equina Ventral Root Injury

Samuel J. Mackenzie, Igor Smirnov, Blair Calancie

Introduction: Considering the high incidence of cauda equina damage among cases of traumatic spinal injury (12-20%) and the absence of effective treatments, the cauda equina requires distinct study when it comes to motor injury and repair. Model: We have developed a model of cauda equina injury in the rat that meets the following requirements: 1) level-specific and repeatable identification of motor nerve roots enabling surgical axotomy; 2) exclusion of pre-existing innervation and local sprouting from intact (i.e. uninjured) motor neurons as causes of recovery, and 3) quantification of functional deficits and recovery.
Methods: Twenty-four female Sprague-Dawley rats were used in this set of experiments. Ventral nerve roots were identified using a method previously described by our lab, involving stimulus-evoked EMG in the proximal, middle, and distal tail muscles. Ventral roots were then cut bilaterally at the third and fourth sacral levels and the first coccygeal level. All rats were tested in a minimum of three follow-up sessions that involved stimulus-evoked EMG recording upon stimulation of the caudales nerves and video analysis. Retrograde staining with Fluoro-Gold was performed directly after the final follow-up session. Rats were perfused five days later prior to spinal cord sectioning and microscopy.
Results: During initial surgery, 5.5±1.2 cuts were made. Electrophysiological and behavioral follow-up testing successfully identified cases where axotomy was either complete or incomplete, as verified by Fluoro-Gold staining. In cases where bilateral axotomy was complete, we observed straight, flaccid paralysis of the middle and distal tail and an absence of motor neuron staining at the spinal levels innervating those myotomes.
Conclusion: We have developed a novel model of cauda equina injury in the rat. Future studies will examine motor nerve root repair using a multi-faceted strategy involving conduits and mediators of cellular injury. Preliminary data related to conduit-only repair are presented.

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Safety and Efficacy of rhBMP2 in Posterior Cervical Spinal Fusion for Subaxial Degenerative Spine Disease: Analysis of Outcomes in 204 Patients

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Introduction: Currently, many studies offer excellent demonstration of BMP's ability to enhance fusion rates in anterior as well as posterior lumbar surgery. More recently, BMP has also been shown to increase arthrodesis rates in anterior cervical surgery, albeit with an increase in complication rates. To date, few studies have investigated the safety and efficacy of BMP use in cervical surgeries approached posteriorly.
Methods: We retrospectively reviewed 204 consecutive patients with degenerative cervical spinal conditions necessitating posterior cervical fusion at a single institution over the past 4 years. The incidence of postoperative mechanical neck pain, fusion rates, as well as neurologic outcomes were compared between patients who received BMP vs. no BMP intraoperatively.
Results: 134 (65.7%) patients presented with mechanical neck pain, 82 (40.6%) with radiculopathy, 157 (77.7%) with motor weakness, 110 (54.5%) with sensory deficits, and 44 (21.9%) with bladder dysfunction. There were no

significant differences in preoperative variables between the non-BMP vs BMP cohorts. Non-BMP patients were more likely to receive demineralized bone matrix (p<0.0001) and allograft (p<0.0001), and BMP patients were more likely to receive hydroxyapatite crystals (p<0.0001) for fusion. There were no significant differences in intraoperative blood loss, vertebral levels fused, or rates of incidental durotomy. Over an average follow-up of 24.2 months, there were no significant differences between the two cohorts in hospitalization length, CSF leakage, DVT, PE, hyperostosis, infection, pneumonia, hematoma, C5 palsy, wound dehicense, reoperation rates, or Nurick/ASIA scores. 11 (7.1%) patients in the non-BMP group experienced instrumentation failure vs. none in the BMP group. This approached but did not reach statistical significance (p=0.06). Patients receiving BMP had a significantly increased rate of fusion both via Chi-squared (p=0.01) and log-rank tests (p=0.02). However, patients receiving BMP also had the highest rates of recurrent/persistent neck pain via Chi-squared (p=0.003) and log-rank tests (p=0.01).

Conclusion: We show that BMP usage in the posterior cervical spine does not increase complication rates, significantly increases arthrodesis rates, but also may increase the rate of recurrent/persistent neck.

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Adjacent Level Stress Following Long Segment Posterior Cervical Decompression and Fixation: An In-Vitro Human Cadaveric Model

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Introduction: This study investigated changes in adjacent level stress following posterior cervical decompression and fixation in order to define ideal instrumentation stopping points in the surgical management of cervical spondylotic myelopathy.

Methods: Eight human cervicothoracic spines were evaluated under the following conditions: 1) intact spine, 2) C3-C6 laminectomy alone and in combination with: 3) C3-C6 vs. 4) C3-C7 fixation; 5) C3-C7 laminectomy alone and in combination with: 6) C3-C7, 7) C2-C7, 8) C3-T2, vs. 9) C2-T2 fixation. Multi-directional flexibility testing utilized the Panjabi Hybrid Testing Protocol. Intact moments of ±2.0Nm were used for flexion-extension, axial rotation, and lateral bending, with quantification of adjacent level range of motion (ROM) over three motion segments (C2-C3, C6-C7, and C7-T1) normalized to the intact spine (100%). Intradiscal pressures (IPs)were also measured at each level and are reported in PSI.

Results: For the C3-C6 laminectomy subgroup, there were no significant differences in flexion-extension ROM or IP at C2-C3 or C7-T1 when comparing C3-C6 vs. C3-C7 fixation (p>0.05). The extension of instrumentation to include C7 provided a significant decrease in C6-C7 ROM (p<0.05). Following C3-C7 laminectomy and sequential reconstruction, the most significant increase in C2-C3 flexion-extension ROM and IP was found in the C3-T2 subgroup [ROM: 348% of intact (p<0.05); IP: 319±243 vs. 65±41 PSI intact condition (p<0.05)]. At C7-T1, the largest increase in flexion-extension ROM and IP was noted following C2-C7 fixation [ROM: 531% of intact (p<0.05); IP: 152±83 vs. 21±14 PSI intact condition (p<0.05)].

Conclusion: For a C3-C6 laminectomy, construct extension to C7 significantly decreases flexion-extension ROM/IP at C6-C7 without a significant increase in ROM/IP at C2-C3 or C7-T1. For a C3-C7 laminectomy, C3-T2 and C2-C7 instrumentation resulted in the most adjacent level ROM/IP at C2-C3 and C7-T1, respectively, so consideration should be given to including both C2 and T2 within these constructs.

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Subaxial Cervical Synovial Cysts: Report of 35 Histologically Confirmed Surgically Treated Cases and Review of the Literature

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Introduction: Intraspinal extradural synovial cysts are found ventral to the ligamentum flavum and arise from the facet joint. These lesions are also reported in the literature as juxtafacet cysts 1-7, ganglion cysts 1,8-19 , articular cysts20, intraosseous cysts21, epidural cysts22 and ligamentum flavum cysts.23 Some authors have argued that the term juxtafacet cyst be preferred over synovial or ganglion cyst18, while others have argued the opposite.1 In addition, some reports distinguish between synovial cysts (which are lined with pseudostratified columnar cells containing clear fluid) vs. ganglion cysts (which have a connective tissue capsule without a mesothelial lining).3,24,25 The most common term in the literature for these lesions is synovial cyst.

Methods: Between 1993 and 2009, 35 patients with histologically confirmed cervical subaxial synovial cysts underwent surgical resection. We evaluated the clinical presenting symptoms, neuroimaging studies, location of the synovial cyst, surgical treatment and outcomes of the patient based upon a retrospective review of patient charts. The patient characteristics are summarized in Table 1. There were 24 males and 11 females. The mean age at presentation was 69 years old (range 33-82). Twenty-two of the 35 patients presented with cervical radiculopathy as their initial complaint and 13 presented with myelopathy symptoms. The most common location of the synovial cyst was at C7/T1 (17), followed by C4/C5 (8); C3/C4 (5); C5/C6 (3); and C2/C3 (2).

Results: Preoperative and postoperative neurological assessments were done by staff neurologists independent of the operating surgeon. The mean follow-up time was 49 months (range 12-134). Surgical outcomes were determined using the Modified Rankin Score (Table 2).79 Twelve patients were scored 0 (no symptoms); 17 patients were scored 1 (performs all usual activities despite some symptoms); 4 patients were scored 2 (slight disability); and 2 patients were scored 3 (moderate disability).

Conclusion: This series of 35 patients with subaxial cervical synovial cysts surgically treated over a period of 17 years illustrates the relative rarity of these lesions. Patients presenting with cervical radicular or myelopathic symptoms may occasionally be harboring a synovial cyst. Surgical resection and decompression of the neural structures is the optimal treatment.

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Effect of Lumbar Disc Replacement on Lumbosacral Lordosis in Patients with Degenerative Disc Disease

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Introduction: Lumbar fusion is one of the most common surgeries performed by spine surgeons. There has been a growing interest in total disc replacement for back pain with the rising concern of adjacent segment degeneration. Fusion surgery has been shown to lead to decrease in the sacral tilt and lumbar lordosis which can account for post fusion pain resulting in less acceptable clinical outcome even after successful fusion. Lumbar disc replacement (LDR) has recently emerged

as an alternative treatment for back pain. There have been very few studies reporting changes in lumbar sagittal outcome after LDR. The present study reports the effect of LDR on global and segmental lumbar lordosis in group of seventeen patients who underwent LDR at the author's institution.
Methods: Retrospective study of radiographic data of 17 patients who underwent LDR for single level degenerative disc disease at the author's institution was performed. Study included measurement of pre and post operative segmental and global lumbar lordosis and angle of lordosis. Inclusion criteria was a single level LDR surgery and availability of pre and post op lateral upright x ray of the lumbar spine in all the patients.
Results: Patients age varied from 19 to 54 (mean, 35) years. The mean segmental and global lumbar lordosis before surgery was 17.3 and 49.7 degrees which increased to 21.6 and 54 degrees after surgery ($p< 0.001$ and 0.03 respectively).
Conclusion: The effect of LDR on sagittal balance appears favorable with an increase in global and segmental lumbar lordosis after single level LDR for degenerative disc disease. The degree of post operative angle of lordosis was not affected by the angle of implant chosen at the operated level and varied independently of the implant angle.

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Contact Pressure in the Cervical Facet Joint During Physiologic Sagittal Bending of the Spine

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Introduction: The spinal facet joint is integral to the normal function of the spine and can also contribute to the spine's instability after trauma and/or surgery. The contact pressure between the joint's articular surfaces provides a measure of local joint mechanics and the loading environment to cartilage. Yet, presently there is limited data, largely from computational models, defining cervical facet pressures during spinal loading.
Methods: Cadaveric C2-T1 human spines (n=6) underwent 2.7Nm of flexion and 2.4Nm of extension bending, acquisition of vertebral motions and facet pressures during bending were measured synchronously. Contact pressure was measured continuously during application of the bending moment with a tip-mounted pressure probe inserted into the C5/C6 facet joint via the C5 lateral mass, using a technique that preserves the joint capsule's mechanical integrity.
Results: There were no differences between flexion and extension for the global cervical spine (9.5±1.6 degrees) and C5/C6 segmental (1.4±0.6 degrees) rotations. Initial contact pressures in the facet joint were similar in extension (1.4±0.9 psi) and flexion (1.5±2.1 psi). However, the change in pressure established over the application of moment was significantly greater ($p=0.002$) in extension (9.8±3.9 psi) than in flexion (-1.5±1.4 psi). Pressure changes had a greater linear correlation with applied moment than with C5-6 motion, and with extension more than with flexion.
Conclusion: This study is the first to define contact pressures in the human cervical facet joint for physiologic loading. Results support the hypothesis that contact pressure increases during extension as the joint closes and is relieved with its opening during flexion. A negative change in pressure measured for flexion likely represents the relief of minimal initial contact to complete loss of contact. The small pressure changes during these physiologic bending scenarios suggest this joint may be very sensitive to even subtle changes in its loading environment. Support provided by Synthes, NREF, and the Catharine Sharpe Foundation.

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Objective Quantification of Shoulder Kinematics: Implications for Peripheral Nerve Compression Syndromes

Justin M. Brown, William E. Janes, Jack Engsberg

Introduction: Postural abnormalities including neck protraction, "rounded shoulders" and slumped thorax have all been found in association with upper extremity compression neuropathies, particularly when multiple sites of compression exist. Clinical observations suggest that upper extremity movement patterns are altered as well. Competing explanations exist for the causal relationship between kinematics and multi-level nerve compression (MLNC) syndromes. That proximal nerve compressions resulting from altered postures and dynamics may predispose to development of distal neuropathies has been proposed. Conversely, distal nerve compression may have central effects which lead to altered proximal postures and kinematics. The relationship cannot be elucidated without defining these changes. With the support of the 2009 Larson Award, we have developed methods for measuring shoulder kinematics using video motion capture. This solution provides for precise dynamic kinematic evaluation of the thorax, head, scapulae and upper extremity throughout the range of motion.
Methods: Three related investigations have now utilized this method. First, the kinematics of healthy persons and persons with MLNC were compared. In addition, healthy controls were evaluated before and after transient "deafferentation" via either tourniquet-induced ischemia at the level of the humerus or Lidocaine injection at the carpal tunnel.
Results: See Table 1 for results.
Conclusion: We have demonstrated, for the first time, quantifiable alterations in shoulder kinematics associated with MLNC. These results also suggest that transient deafferentation of the distal upper extremity results in altered shoulder kinematics. Although neither intervention is a perfect model for MLNC, this suggests a mechanism whereby the proximal movement patterns described in persons with nerve compressions may be in part a result of, and not only a contributor to, the distal neuropathy. Ongoing research will attempt to further elucidate the effect of distal neuropathy using interventions designed to augment distal afferent input to the spinal cord.

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A DBM, BMA, Local Bone Graft Composite in Multi-level PLIF: Fusion Rates

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Introduction: Data were collected for our single-site consecutive series of 110 two-level PLIF patients. Clinical and radiographic outcomes were evaluated to assess complications and fusion rates at 12 and 24-month follow-up.
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 allograft spacers (to achieve interbody fusion) and along the intertransverse membrane (to achieve posterolateral fusion). Anteroposterior and lateral flexion and extension

radiographs, obtained at three-, six-, and twelve-months, were evaluated utilizing Lenke's criteria for intertransverse fusion and modified Lenke criteria of interbody fusion. Global fusion was defined as either: Lenke or modified Lenke score of 1; or Lenke score 2+modified Lenke score 2.
Results: 107 patients were evaluated at 12 months, and 72 at 24 months to date. Intertransverse (Lenke) scores at 12 months = 1.78 and interbody (modified Lenke) scores = 1.22; at 24 months = 1.71/1.21. Complications included: infections (n=3), wound disruption (n=2), pneumonia (n=1), pulmonary embolus (n=1), dural tear (n=1); 6 re-operations were performed for adjacent segment disease. 105 patients were judged to be fused; there were 2 nonunions.
Conclusion: The DBM-local bone-BMA achieved fusion in 105/107 2-level PLIFs at 12 months postoperatively (70/72 at 24 months). This combination achieved fusion results comparable to earlier literature reports for autograft without the incumbent expense and documented complications of BMP.

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Socioeconomics of Degenerative Cervical Spine Disease in the United States

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Introduction: Degenerative cervical spine disease constitutes a significant source of morbidity in the United States. A limited number of published, peer-reviewed reports detail and quantify the socioeconomic burden of this entity on a national level.
Methods: The Nationwide Inpatient Sample database was queried for the major degenerative cervical spine diagnoses for the year 2007, including: Cervical spondylosis, cervical spondylosis with myelopathy, cervical disc displacement, cervical degenerative disease, cervical disc disease with myelopathy and cervical spinal stenosis. The NIS is maintained by the Agency for Healthcare Research and Quality (AHRQ) and represents a 20% random stratified sample of all discharges from nonfederal hospitals within the United States. It is the largest all-payer inpatient care database in the US and contains data from approximately 8 million hospital stays from 1000 hospitals each year. The NIS is the only national hospital database containing charge information on all patients, regardless of payer, including persons covered by Medicare, Medicaid, private insurance, and the uninsured. Data on demographics, length of stay, charges, discharge patterns and surgical intervention were analyzed.
Results: There were an estimated 164,630 hospitalizations in 2007 for degenerative cervical spine disease in the US. Mean length of stay was 2.3 days and mean hospital charge per admission was $41,562. The total national hospital charges for this entity exceeded 6 billion USD in 2007. The 45-84 age group constituted the majority of the cases (75%) with an equal male:female ratio. 87% of the hospitalizations were associated with routine discharges (a surrogate marker of good outcome). An estimated 36% of all spinal fusions in 2007 were related to degenerative cervical spine pathology.
Conclusion: Degenerative cervical spine disease is not only a major source of morbidity, but also accounts for significant healthcare utilization within the spinal disorders. Efforts to promote research in this area as well as to advance safe and cost-effective treatment modalities need to continue.

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Does Radiographic Location Dictate Pathology of Intradural Extramedullary Spine Tumors?

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Introduction: Intradural extramedullary (IDEM) neoplasms can pose a challenge for spine surgeons. Determining the preoperative pathology through radiographic characteristics provides guidance for operative approach. We report the first systematic correlation of axial location and spinal cord level to tumor pathology for IDEM.
Methods: We performed a retrospective review of 98 consecutive patients ranging from 7 to 87 years old (mean age 49.9 years) who presented with an intradural extramedullary spine tumor in the cervical and/or thoracic regions and underwent resection between February 2000 and July 2009.
Results: Across a combination of all IDEM tumors in the group, similar tumor type were seen at each spinal region (p=0.98). In addition, across all tumors the axial location was predominantly lateral in 70%, compared to 12.5% anterior and 17.7% posterior. Meningiomas were approximately equally distributed axially along 4 quadrants with a roughly equal distribution of arachnoid cap cells and dura. Schwannomas and neurofibromas are lateral in position towards the nerve roots with 83.8% and 88.2% respectively. The pathology of anterior IDEM tumors are predominantly meningiomas with 72.7%, and the rest 27.3% were schwannomas. From analyzing the preoperative films on these anterior schwannomas, it was noted the patients had large growing tumors that started laterally and pushed the spinal cord posteriorly. Neurofibromas occured at a higher frequency rostrally in the spinal column. Schwannomas did not differentiate in incidence based on spinal level.
Conclusion: Preoperative radiographic location from our series of 98 patients suggests a correlation between location and pathology. Meningiomas are traditional thought to occur mostly in a ventral location, in our study meningiomas occurred at a equal prevalence in all four quadrants of the axial spine. Anterior tumors were more likely meningiomas compared to schwannomas with a rate of 3:1. All tumors that were anterior that were not meningiomas had a lateral based component.

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Abnormal Inflammatory Response Metal-on-Metal (MOM) Disc Prostheses

Paul A. Anderson

Introduction: Severe inflammatory responses including large pseudotumors to cobalt-chrome (CoCr) metal on metal (MOM) hip prostheses occur in 2-5% of patients resulting in manufacturer recalls, warnings by regulatory agencies and scientific organizations. The inflammatory response appears to be secondary to wear debris and metal ion release. The purpose of this study is to review six spinal arthroplasty cases with severe inflammatory responses bringing to the attention of neurological surgeons this potential complication.
Methods: Six cases have been reported all requiring revision surgery for severe inflammatory reactions.
Results: Two of these cases were cervical and four lumbar. Five were in patients in clinical trials. All patients had new onset of pain and four developed new onset of clicking. All patients had severe pain and neurologic deficits, including myelopathy in two and cauda equina syndrome in two. Two lumbar cases had DVT and one had renal failure secondary to bilateral ureteral obstruction. Time from surgery to explantation ranged 9 -36 months. Pathology was similar to that seen in MOM hip arthroplasty. Histology revealed

avascular hyaline connective tissue with chronic inflammatory cells. In only one case, third body wear debris was present and one case had obvious severe metallosis, whereas all the others metal wear debris was not seen on standard light microscopy.
Conclusion: The six cases demonstrated that similar pathologic processes to MOM hip arthroplasties will occur in spinal cobalt chrome bearing MOM devices. This problem has not been reported in the stainless-steel device. The tumors were not identifiable on radiographs or MRI and usually required CT myelography. No (Co-Cr) MOM prostheses are approved, but over 1200 have been placed in study patients. Neurosurgeons should be aware of the possibility of severe inflammatory reactions in any patient having pain or neurologic symptoms following a CoCr MOM arthroplasty.

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Low-Pressure Headaches in Adult Patients with Traumatic Brachial Plexus Injury

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Introduction: Brachial plexus injury (BPI) presents with a combination of motor and sensory deficits, pain, but are generally not thought to be associated with headaches. However, it is well known that CSF leaks can occur in BPI patients from nerve root avulsion and that CSF leaks may be associated with low-pressure headaches. In the literature, only a few cases of headaches post BPI are reported. It is unknown if the prevalence of headache in patients with BPI is low, or if they are unrecognized by physicians and/or patients, the focus of care being the affected limb. The aim of this study is to determine the prevalence of low-pressure headache in patients with BPI.
Methods: All patients presenting at our brachial plexus clinic with adult traumatic BPI were asked to complete a questionnaire on the presence and quality of headaches following their injury. The patients' and injury's characteristics were subsequently reviewed.
Results: During the study period (December 2008 to July 2010), 145 patients filled the questionnaire. Of these patients, 22 reported new onset headaches occurring after their injury, seven of these patients having positional headaches. In patients with positional headaches, which are consistent with low-pressure headaches, 6 had a clear preganglionic BPI. Available imaging studies revealed 2 patients with pseudomeningoceles, 1 patient with a pseudomeningocele and evidence of CSF tracking in the soft tissue, and 2 patients with CSF tracking into the pleural space.
Conclusion: In this retrospective study, 15% (22/145) of patients with traumatic BPI suffered from a new-onset headache after their injury, a third of these (7/22) having characteristics of low-pressure headache. These headaches, likely secondary to a CSF leak associated with the BPI, occur in a significant proportion of patients and have been under-recognized.

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The Mechanical Influence of Top Loading and Side Loading Screw Systems on Construct Assembly

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Introduction: This study investigated the pressure and strains imparted upon spinal segments during surgical implantation of side loading (SL) and top loading (TL) pedicle screw systems.
Methods: Porcine spines from T12-sacrum were instrumented with displacement transducers across the lateral aspect of the spinous processes of L2- L3, L3-L4 and L4-L5 in both Anterior-Posterior Shear (APS) and Tension-Compression (TC) directions. Spines were then instrumented with either TL tulip screws or SL posted screws. Prior to rod introduction, pressure film was placed on the anterior spinal surface followed by completion of an L2-L5 construct using pre-curved rods. Displacement transducer data was converted to strain. The Fuji film strip was analyzed using Topaq software with parameters of mean pressure, contact area and compressive force computed. Data between TL and SL screw constructs was compared using an unpaired Student's t-test.
Results: Top loading systems displayed a statistically increased percent compressive strain (relative to initial strain) at L3-L4 in both the APS ($P<0.05$) and TC ($P<0.006$) directions. Other comparisons for individual vertebrae were not statistically significant. Averaging over all levels displayed a statistically significant change in percent strain between the TL and SL systems in both the APS and TC directions ($P<0.003$). TL systems created a compressive strain during set screw tightening; SL systems created a tensile strain. Individual vertebral levels showed no significant pressure differences. However, when averaging over all levels, a significant mean pressure increase for SL systems compared to TL systems ($P<0.01$) was found.
Conclusion: Completing TL constructs created more compressive strain, probably due to the rod reducing method to bring the screw to the rod. Conversely, in SL constructs, the rod is brought to the screw, producing more tensile strain. While some significant changes in strains and pressures were measured, the overall construct assemblies were comparable for both systems.

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Disparities Based on Race, Ethnicity and Insurance Status in the Access to and Outcomes after Surgery for Cervical Spondylotic Myelopathy in the United States, 2005-2008

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Introduction: Differential outcomes based on race, ethnicity and insurance status in the United States are well-documented. However, disparities in the access to and outcomes after surgery for cervical spondylotic myelopathy have not been previously evaluated.
Methods: Data from the national inpatient sample (2005-2008) were retrospectively extracted. Patients were included if they had a diagnosis of cervical spondylotic myelopathy or ossification of the posterior longitudinal ligament and underwent anterior or posterior cervical spine surgery (decompression with or without fusion). Multivariable logistic regression analyses were conducted to calculate the odds of death, non-routine hospital discharge, and treatment at a high-volume hospital for racial or ethnic minorities. Analyses were also performed comparing patients with a lack of or underinsurance (defined as Medicaid or self-pay) to those with private insurance or Medicare. Logarithmic multivariate regression was used to evaluate the association of length of hospital stay and total hospital charges. All analyses were adjusted for differences in patient age, gender, co-morbidities, admission type and hospital characteristics.
Results: A total of 22,600 admissions were evaluated. The odds of in-hospital mortality were not significantly associated with race, ethnicity or insurance status. Length of hospital stay

was 5.0% and 6.7% longer for minority and under- or uninsured patients, respectively (p<0.001); total charges were 3.2% higher for minority patients (p=0.020). Non-Caucasian race or ethnicity (OR: 1.23, 95% CI: 1.08, 1.40) and under- or lack of insurance (OR: 1.29, 95% CI: 1.12, 1.49) were both associated with a significantly higher adjusted odds of non-routine hospital discharge. Minority patients were significantly less likely to be treated at a high-volume hospital (OR: 0.51, 95% CI: 0.32, 0.82).
Conclusion: Minority and under- or uninsured patients have longer hospitalizations and are less likely to have a routine discharge after surgery for cervical spondylotic myelopathy. Disparities also exist in access to high-volume centers for minority patients.

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Prospective Multicenter Evaluation of Percutaneous Lumbar Pedicle Screw Placement Using the Oblique or "Owl's Eye" View

Cary Idler, Melvin Wahl, William R. Taylor

Introduction: Few studies have focused on the oblique technique as a potentially more accurate method of placing percutaneous lumbar pedicle screws without direct visualization. A prospective, randomized, IRB-approved study was undertaken to evaluate the accuracy and safety of the oblique technique using computer assistance to facilitate orienting the C-arm into the oblique view efficiently and accurately.
Methods: After providing informed consent, patients were randomized into one of two groups: one underwent placement of lumbar pedicle screws using the oblique technique with the assistance of Guidance; the other group underwent screw placement per the surgeon's usual technique using fluoroscopy alone (non-Guidance). Fluoro time, screw placement time, and EMG thresholds were recorded intraoperatively for both groups. A neural exam and VAS pain assessment were obtained pre- and immediately post-op. A post-op CT scan was also obtained to determine screw placement accuracy.
Results: A total of 47 patients (27 females and 20 males) have been enrolled to-date. Primary surgeries included instrumented ALIF (9), XLIF (18), and/or TLIF (22). Of the 214 screws evaluated post-op by CT, 11 (5.1%) breaches occurred: 8 (3.7%) medial, 2 (0.9%) lateral, and 1 (0.5%) inferior; 10 of the 11 pedicle breaches were less than 2mm in magnitude, and 1 breach in the non-Guidance group was 2-4mm in magnitude. None of the breached screws required revision, and there were no significant differences in clinical improvements between patients with breached screws (n=7) and those without (n=40). Use of Guidance resulted in a statistically lower fluoro usage per screw (p<0.001) and quicker placement of guidewires (p<0.001). Although there was no statistical difference in the average time it took to place each screw, average times trended lower with the use of Guidance (p=0.059).
Conclusion: The oblique technique for percutaneous pedicle screw placement using NeuroVision Guidance provides feedback on the appropriate targeting of the pedicle and successfully reduces the amount of fluoroscopy used without significantly adding to the time required for placing pedicle screws.

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Clinical Correlation of Unilateral Motor and Sensory Deficits with Magnetic Resonance Diffusion Tensor Imaging and Tractography in Patients with Spinal Cord and Root Lesions

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Introduction: Clinical correlation of traditional magnetic resonance imaging (MRI) of the spinal cord with patient motor and sensory deficits is limited. Diffusion tensor imaging (DTI) and tractography may improve clinical correlation in patients with spinal lesions as they are a more direct measure of spinal cord fiber tracts. We evaluated the application of DTI and tractography in healthy controls and patients with spinal lesions to determine if this measure correlated with clinical status.
Methods: Hospital ethics board approval was obtained for this study. Ten controls and ten patients with spinal lesions that underwent routine MRI (October 2007 to April 2010) with a tractography sequence were obtained from the tractography imaging and clinical database. The tractography sequence was an axial diffusion-weighted single-shot echo planar imaging sequence using Grappa and 12 noncollinear gradient directions. MEDINRIA version 1.0.31 was used to generate the fiber tracking images and fractional anisotropy (FA) and mean diffusivity (MD) were measured in delineated regions of interest corresponding to the corticospinal tract (CST), propriospinal tract (PST) and spinothalamic tract (STT) of the spinal cord bilaterally using dedicated software.
Results: In healthy controls, tract fibers were continuous and FA measure differences between the right and left was less than ¦0.106¦. Analysis could not be performed at instrumented levels. In patients with unilateral sensory or motor deficits, fibers corresponding to the lesioned tract were absent on fiber tracking images and there was a significant decrease (ANOVA, p<0.001) in the FA measurement of the corresponding lesioned tract compared to the intact tract on the contralateral side. These FA measurement differences were not seen if a unilateral deficit was not present or if there was no cord deficit and only a radicular deficit. MD measurements did not correlate with neurological deficits.
Conclusion: Although further clinical correlation with this technique is required, DTI with tractography may improve the MRI detection of unilateral CST, PST, or STT deficits in humans with spinal lesion and may discern cord lesions from radicular lesions. Future work will evaluate whether the fiber continuity changes and FA differences correlate with clinical status over time.

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Theoretical Increase of Thyroid Cancer from Cervical Spine MDCT in Pediatric Trauma Patients

Ryan D. Muchow, Paul A. Anderson, Kelly Egan

Introduction: There has been a dramatic increase in the number of computed tomography (CT) scans performed each year in the United States. Use of CT during cervical spine clearance in pediatric trauma patients enhances diagnostic accuracy but delivers high doses of radiation to the thyroid. The purpose of this study is to calculate the dose of radiation delivered to the thyroid from a cervical spine CT and calculate theoretical thyroid cancer induction rates.
Methods: A retrospective evaluation of an IRB-approved pediatric trauma database was performed at an academic, Level I trauma center. Data was collected by chart review to calculate the amount of radiation absorbed by the thyroid from plain radiographs and CT of the cervical spine during clearance. Patients were separated into age groups 0-6, 7-11, 12-17, to facilitate age-dependent calculations of theoretical thyroid cancer induction.
Results: Six-hundred seventeen patients met the inclusion criteria, 224 receiving plain radiographs and 393 undergoing CT of the cervical spine. The average amount

of radiation absorbed to the thyroid was 0.90 mGy (males) and 0.96 mGy (females) from plain radiographs and 63.6 mGy (males) and 64.2 mGy (females). Average excess relative risk of plain radiographs is 0.24% (males) and 0.51% (females) and for CT is 13.0% (males) and 25.0% (females).
Conclusion: CT cervical spine results in a signicantly higher dose of radiation to the thyroid than plain radiographs. Further, CT has a much greater potential to induce thyroid cancer, particularly in females and younger-aged patients.

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Does Arthroplasty Design Impact Cervical Spine Kinematics: An Analysis of the ProDisc-C, Prestige LP and Synergy Disc

Neil Duggal, Bruno C.R. Lazaro, Kemal Yucesoy, Kasim Zafer Yuksel, Izabela Kowalczyk

Introduction: Cervical total disc replacement (TDR) has emerged as a surgical option to preserve motion and potentially avoid adjacent segment disease (ASD) after anterior cervical discectomy and fusion (ACDF). Recently, much attention has been directed to the ability of a given device to maintain and/or restore normal segmental lordosis. Post-arthroplasty kyphosis can result in increased stresses transmitted to the facet joints, potentially leading to ASD.
Methods: Sixty patients were retrospectively analyzed and divided into three groups, receiving either the ProDisc-C, Prestige LP or Synergy disc. Only single-level arthroplasty cases were included in this study. Lateral dynamic radiographs of the cervical spine were analyzed using Quantitative Measurement Analysis (QMA) software to analyze the kinematics at the index level preoperatively and postoperatively. Several parameters were collected including: range of motion (ROM); disc angles (DA); shell angles (SA); anterior and posterior disc heights (ADH/PDH) and center of rotation (COR). Pre and postoperative data was compared using Student's t-test with a $p<0.05$ level for significance.
Results: Postoperatively, all three device groups maintained adequate ROM at the implanted level. With respect to the SA, the Synergy disc demonstrated the least variability, maintaining 6° lordotic configuration between the device endplates. Both the Prestige LP and ProDisc-C had an unpredictable impact on SA. All three discs significantly increased ADH and PDH ($p<0.01$). There was an anterior shift in COR X with the ProDisc-C and Synergy disc ($p<0.05$) and a superior shift of COR Y with the Prestige and Synergy disc ($p<0.05$).
Conclusion: The goal for motion preservation at the implanted level was achieved with all devices. Synergy disc was unique in its ability to alter the device angulation by 6° of lordosis.

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Implications of Number of Fused Levels in the Outcome of Patients with Degenerative Diseases

Asdrubal Falavigna, Orlando Righesso, Alisson Teles

Introduction: The objective was to evaluate the clinical and functional outcome of patients with lumbar degenerative disease submitted to spinal fusion according with the number of the vertebral levels to be fused.
Methods: A prospective comparative study in patients with degenerative diseases that were submitted to fusion of one (G1), two (G2) or three or more (G3) levels with a 6-month follow-up. The patients were evaluated in the preoperative, 30 days and in 6 months postoperatively with validated instruments (Numerial Rating Scale, NRS; Oswestry Disability Index, ODI; Hospitalar anxiety and depression scale, HADS). The analyses were conducted with SPSS. Comparisons among the groups were done with ANOVA en chi-square tests. The Post-Hoc analyses were conducted with Bonferroni's test.
Results: 65 patients (G1 = 21; G2 = 25; G3 = 19) were included in the study.The general characteristics of the groups, the mean age was greater in G1 and lower in G3 (G1 = 45.4 ±13.1; G2 = 50.8 ± 11.8; G3 = 55.9 ± 9.93; P = 0.024). There was no difference among the groups in relation to the gender, previous surgery, evolution of the symptoms and work compensation. The duration of surgery and bleeding were larger in G3 ($P<0.05$). The incidence of postoperative complications was higher in G3, comparing with G1 and G2 (P = 0.022). No statistically significant difference was detected concerning hospital stay and transoperative complications among the groups. The intensity of pain was higher in G3 in the postoperative evaluation of 30 days, but that difference disappears in 6 months postoperative. There was no differences in relation to disability (ODI) (G1 = 18.3 ± 13.0; G2 = 23.8 ± 13.6; G3 = 27.81 ± 11.7; P = 0.206), depression and anxiety (HADS) (G1 = 8.71 ± 4.73; G2 = 12.72 ± 8.77; G3 = 14.58 ± 7.84; P = 0.127) and satisfaction among the groups (P = 0.140).
Conclusion: There was no difference in relation with the pain, disability, depression and anxiety and postoperative satisfaction among the groups. The patients with 3 or more fused levels presented higher age and postoperative complication rates.

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Multilevel Anterior Cervical Discectomy and Fusion without Supplemental Posterior Instrumentation for Cervical Spondylotic Myelopathy

Edwin Andrew Stevens, Robert A. Marsh, Thomas A. Sweasey

Introduction: Anterior cervical discectomy and fusion (ACDF) is a widely accepted intervention for cervical spondylotic myelopathy (CSM). Despite numerous potential benefits, some consider pathology at 3 or more levels a relative contraindication to an anterior-only surgical approach for multilevel cervical pathology. Potential disadvantages of multilevel ACDF are increased risks of approach and fusion-related complications. The purpose of this study was to review complication rates and neurological outcomes using ACDF alone at 3 or more levels in the management of multilevel CSM.
Methods: A retrospective chart review was performed on patients with CSM who underwent ACDF at 3 or more levels without supplemental posterior fixation. Choice of instrumentation was consistent througout the series.(Fig.1) The variables reviewed included perioperative complications, hospital length of stay, and hardware/fusion related complications. Pre- and postoperative Nurick scores were used to assess neurological outcomes.
Results: A total of 82 patients underwent a 3-level (n=41), 4-level (n=39), or 5-level (n=2) ACDF without posterior stabilization. Mean follow-up was 16 months (range, 0-47). A significant improvement in pre- and postoperative Nurick grades from 1.98 to 0.49 was observed ($p=<0.0001$). An overall complication rate of 40.2% was observed. The most common complications were dysphagia (19.5%), dysphonia (6%), non-union and/or hardware failure (7.3%). The postoperative symptoms of dysphagia and dysphonia were transient in all except one case. Re-operation was performed in 3 patients for symptomatic pseudoarthrosis and/or hardware failure.
Conclusion: The present review supports the safety and efficacy of anterior-only

ACDF at 3 or more levels in the surgical management of CSM. Favorable early neurological outcomes were suggested by significant improvement in Nurick myelopathy grades. Approach and fusion-related complication rates using the described technique compare favorably to previously published studies of multilevel ACDF as well as circumferential fusion procedures.

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Lateral Transthoracic Minimally Invasive Approach for Central Thoracic Disc Herniation: Initial Experience in Seven Cases

Manish K. Kasliwal, Harel Deutsch

Introduction: Various surgical approaches exist for management of thoracic disc herniations. Though the posterolateral approaches have become the preferred approach for thoracic disc herniation especially with the application of minimally invasive techniques in the recent years; it remains true that lateral or anterior approaches provides superior exposure for removal of central disc herniations as compared to posterolateral approaches; though at the cost of added morbidity due to the surgery itself. The authors describe their initial experience in treating central thoracic disc herniations through a novel minimally invasive lateral approach.

Methods: Seven patients with central disc herniation were managed with minimally invasive lateral transthoracic approach from 2007 - 2010. Surgical technique consisted of a lateral position followed by transthoracic exposure through tubular retractor system without the need of intraoperative lung collapse or post operative chest tube placement. Clinical details including age, sex, clinical presentation, surgical details, complications and outcome at last follow-up was analyzed.

Results: Patients ranged in age from 30 to 70 years (mean 52 years). The duration of symptoms ranged from 4 days to 3 years. Central thoracic disc herniations were identified at the following levels: T6-7 (one patient), T7-8 (two patients), T8-9 (two patients), T9-10 (two patients) and T10-11 (one patient). One patient had two disc herniations. The average length of stay in the hospital was 2.6 days (range, 1 to 4 d). Follow-up was available for all the patients. All patients improved after surgery. Degree of preoperative deficit as assessed by Nurick's grading was important as patients with higher Nurick's grade (4-5) had little recovery at last follow up as compared to those with lower Nurick's grade (0-3). No patient deteriorated after surgery.

Conclusion: Minimally invasive lateral transthoracic approach surgery using tubular retractor system for central thoracic disc herniation is safe, effective, and provides a minimally invasive alternative without the morbidity associated with traditional transthoracic approaches.

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Radiographic Outcomes in Two-level ACDFs: Comparison of Smokers and Non-smokers at 1- Year Follow-up

W.B. Rodgers, Edward J. Gerber, Jody A. Rodgers

Introduction: Of our single-site consecutive series of 184 two-level ACDF patients, 62 smoked at the time of surgery. Two-level ACDF results in smokers are presented to show the safety and utility of the procedure in this population.

Methods: 184 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 184 patients, 62 were smokers (22M, 40F; age 52.8 yrs) and 122 nonsmokers (45M, 77F; age 57.5 yrs). Average 12-month Lenke score across all subsets was 1.07 (smokers 1.08; nonsmokers 1.07). At 24 months, average Lenke score across all subsets was 1.03 (smokers 1.00, non smokers 1.02). 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 in similar fusion rates (> 97%) for both smokers and nonsmokers at 12 months and 24 months postoperatively.

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Graft Extrusion in AxiaLIF®

W.B. Rodgers, William Douglas Smith, Kyle Malone, Edward J. Gerber, Jody A. Rodgers

Introduction: The AxiaLIF® L5-S1 fusion is performed while leaving the annulous and ligamentous structures intact. When the annulous has been compromised, graft extrusion from the disc space is possible.

Methods: Review of a combination of 456 AxiaLIFs® by 2 surgeons.

Results: 5 patients (1.1%) experienced graft extrusion, 4 of which were revised. Case 1: A 64-year-old with a transitional anatomy at L4-5 was scheduled to undergo an L4-5 XLIF® and L5-S1 AxiaLIF®. When a lateral corridor for approach could not be accessed, the XLIF® was aborted and the patient underwent a two-level L4-S1 AxiaLIF®. Shortly after, the patient developed an infection in the aborted XLIF® incision site. A CT showed the graft material had extruded anteriorly from the L4-5 disc space (Figure 1). The patient was asymptomatic and did not require revision. Case 2: A 30-year-old underwent an AxiaLIF®. The patient readmitted to the hospital POD4 complaining of pain and neurological deficits in the back and legs. A CT revealed graft extrusion posteriorly into the intradural space, and an operation was performed to remove the dura (Figure 2). Case 3, 4, and 5: A 53-year-old female with DDD and instability at L5-S1, a 62-year-old female with several degenerative spine conditions, and a 37-year-old woman with a disk herniation at L5-S1, all underwent an AxiaLIFs. All 3 patients had prior annular tears, and all 3 patients experienced a recurrence of symptoms at 6 weeks postop AxiaLIF. MRIs revealed graft material herniations through prior annular tears (Figure 3), and all underwent laminotomy and removal of graft material. All 3 report residual symptoms. One was revised at 12 months for pseudarthrosis.

Conclusion: Compromises in the annulous, could lead to graft extrusion, as this system uses graft as a disc distracting agent, thus greatly increasing intra-annular pressure.

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Disparities Based on Race and Ethnicity in the Timing of Surgery for Acute Spinal Cord Injury in the United States, 2005-2008

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Introduction: While disparities in the American healthcare system are well-established, the impact of race and ethnicity on the outcomes after surgery for acute spinal cord injury has not been examined before. Moreover, although the early intervention after acute spinal cord injury is generally preferred, the effect of race and ethnicity on the timing of surgery has not been previously evaluated.

Methods: Data from the national inpatient sample (2005-2008) were retrospectively extracted. Patients were included if they had a diagnosis of acute spinal cord injury, underwent spinal decompression with or without fusion and were admitted emergently or urgently. Multivariable logistic regression analyses were conducted to calculate the odds of death, the performance of surgery on the day of or day after admission and treatment at a high-volume center for racial or ethnic minorities (defined as a race or ethnicity other than Caucasian). Logarithmic multivariate regression was utilized to determine the association of race or ethnicity with length of hospital stay and total hospital charges. All analyses were adjusted for differences in patient age, gender, co-morbidities, primary insurance payer and hospital characteristics.

Results: A total of 4,991 admissions were evaluated. Adjusted odds of in-hospital mortality were not significantly different between Caucasian and minority patients. However, minority patients were significantly less likely to have surgery performed on the day of or day after admission (OR: 0.68, 95% CI: 0.54, 0.84). Non-Caucasian race or ethnicity was significantly associated with a lower odds of treatment at a high-volume hospital (OR: 0.52, 95% CI: 0.31, 0.90). Length of hospital stay was 2.6% longer for minority patients (p=0.028), but there was no significant difference in total hospital charges.

Conclusion: Recent nationwide data show that racial and ethnic minority patients with acute spinal cord injury are less likely to receive early intervention after hospital admission when compared to Caucasian patients.

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Dynamic EMG Testing for the Placement of Lumbar Pedicle Screws

Antoine Tohmeh, Robert Bazzano

Introduction: Evoked EMG has been shown to be a sensitive tool for assessing pedicle integrity after the placement of pedicle screws. This post-hoc "Basic" testing allows for identification of breach intraoperatively and repositioning of screws if necessary, but with additional time, trauma, and limited correction ability. A prospective, IRB-approved study was undertaken to evaluate the effectiveness of "Dynamic" EMG testing, which enables active monitoring during pedicle preparation and screw insertion, enabling changes in pedicle trajectory to be made before a breach occurs.

Methods: Lumbar pedicle screws were placed using Dynamic testing where EMG feedback was provided to the surgeon on a randomized basis among screws in each patient. EMG thresholds were collected during cannulation, tapping, and placement of each screw. Final screw positioning was confirmed with a Basic screw test after placement. Intraoperative redirections based on EMG feedback were documented. A neural exam and VAS pain assessment were performed pre-op, post-op, and 4-6 weeks after surgery. A post-op CT scan was obtained and was evaluated for screw placement accuracy by an independent spine surgeon.

Results: A total of 44 levels were treated with instrumented XLIF and/or TLIF with 137 screws placed. 8 (6%) breaches were identified by post-op CT: 6 (4%) medial, 1 (1%) lateral, and 1 (1%) inferior. All breached the pedicle by less than 2mm, were without sequelae, and no revisions were required. Low EMG thresholds during pilot hole formation led to a significant number of redirections (p=0.014) with no correlation to incidence of breach. There was a significant correlation between thresholds during tapping and screw placement and incidence of breach (p<0.001), suggesting that once a redirection was made and threshold values continued to be low, the surgeon was less likely to redirect and more likely to breach, or that pedicle wall integrity had already been compromised and screw path could not be changed once prepared.

Conclusion: Dynamic EMG testing provides safe, real-time predictive feedback during pilot hole formation and placement of pedicle screws. Earlier warning of low thresholds provides greater opportunity for redirection.

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An Injectable Thiol-acrylate Poly(ethylene glycol) Hydrogel for Sustained Release of Methylprednisolone Sodium Succinate for Treatment of Spinal Cord Injury and in Neurosurgical Applications

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Introduction: Systemic administration of high-dose methylprednisolone (MP) has become controversial as a clinical treatment option for spinal cord injury (SCI) due to its potential serious adverse side effects. Alternatively, the use of a biomaterial to locally deliver this steroid could avoid increased risk of infection, delayed wound healing, pneumonia and sepsis while still providing an anti-inflammatory effect to the site of injury. We developed an injectable poly(ethylene glycol) (PEG)-based hydrogel with controlled gelation that exhibits ideal physical properties for controlled release of MP.

Methods: Gelation was monitored by dynamic rheology and Fourier transform infrared spectroscopy (FT-IR). Mechanical properties were also characterized using tensile specimen testing and analysis of sol/gel properties and equilibration behavior. Release kinetics of methylprednisolone sodium succinate (MPSS) from the hydrogel was analyzed using high performance liquid chromatography (HPLC).

Results: Gelation from a liquid state was achieved under physiological conditions in 7.7 minutes. Mechanical testing revealed properties similar to soft human tissues, with an elastic modulus of 189.8 kPa. The hydrogel exhibited syneresis upon equilibration at 37 degrees Celsius, reducing from 25 wt.% to 39 wt.% polymer. The drug release profile was first-order over a period of over 10 days and independent of the initial drug concentration.

Conclusion: This rationally designed hydrogel is a potential candidate for local controlled release of MP in the intraparenchymal and peridural spaces of the spinal cord. Drug dosage for local administration could be individually tailored without affecting the release time period or hydrogel volume. Syneresis may ensure that no pressure is exerted by the hydrogel upon equilibration to avoid

compression of neural elements, making it a potentially useful candidate in neurosurgical applications.

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Gait Analysis in Idiopathic Scoliosis Patients in the Preoperative and Post-Operative Period

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Introduction: The surgical correction and stabilization is inevitable for the progressive scoliosis patients despite the conservative treatment while preserving mobility as much as possible and a proper gait and balance. In this study we present 22 idiopathic scoliosis patients' preoperative and postoperative gait analysis comparison results that were operated in our clinic.

Methods: We had operated 22 idiopathic scoliosis patients during the period between August 2009 and September 2010 at our clinic. The patients were 13 girls and 9 boys who ranged in age from 10 to 17 years (median age, 13.7). We had performed 7 to 14 levels of posterior instrumentation. The radiological evaluation was performed before, early postoperative, and 6 months after the surgery. In addition to that gait analysis was performed before and 6 months after the surgery.

Results: According to gait analysis the first sign of reversal of the center of gravity to normal was seen at the distal muscle groups. Physical treatment's contribution to reversal process was enormous. Recovery of hyperflexion of the pelvis, hip and knee in the mid-stance phase was seen. Hyperactivity of the gastocnemius and soleus muscles in the plantar/dorsal flexion of the ankle was reversed to normal limits as first signs of normalization of gait in these patients.

Conclusion: Gait analysis is an important and objective tool in evaluating the balance and posture of scoliosis patients in pre and postoperative period in clinical practice and directs the physical therapy after the surgery.

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Anterior Cervical Foraminotomy with Preservation of the Uncovertebral Joint for Unilateral Radiculopathy

Izumi Koyanagi, Takahisa Kaneko, Tomohiro Murakami

Introduction: Anterior cervical foraminotomy has been developed as the minimally invasive surgery for unilateral cervical radiculopathy. The reported surgical procedures included microsurgical removal of the uncovertebral joint. However, reoperation or recurrence of disc hernia after anterior foraminotomy was also reported. Since 2000, we have performed anterior cervical foraminotomy with preservation of the uncovertebral joint. In this procedure, microsurgical drilling is mainly applied to the inferior border of the upper vertebral body. The uncinate process was only partially drilled at the base to expose the affected root sleeve. In this study, we reviewed surgical results of our patients and examined the usefulness of this method.

Methods: Twenty-five patients (disc hernia 20, spondylosis 5) underwent anterior cervical foraminotomy for unilateral radiculopathy between 2000 and 2009. There were 17 men and 8 women, aged from 39 to 76 years (mean 48.9 years). Foraminotomy at the single level was performed in 19 patients, while 6 patients underwent 2-level decompression.

Results: Twenty-three patients (92%) showed good improvement of their radiculopathy. Two patients with cervical spondylosis underwent additional anterior fusion 2 weeks and 5 months after foraminotomy due to the remained symptoms. Postoperative follow-up radiographs of the cervical spine showed significantly decreased disc height after surgery. However, no patients demonstrated instability of the cervical spine.

Conclusion: Anterior cervical foraminotomy with preservation of the uncovertebral joint can be an excellent method of surgical treatment of unilateral radiculopathy. This method is best indicated to disc hernia in the intervertebral foramen. However, surgical indication may be limited in spondylotic radiculopathy.

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Safety and Efficacy of Occipitocervical Fixation in Rheumatoid Arthritis Patients

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Introduction: A perceived high risk of complications and surgical failure exists for occipitocervical surgery in rheumatoid arthritis patients. This study evaluates the efficacy and safety of occipitocervical fixation and arthrodesis in this population.

Methods: A retrospective chart review of 15 patients with a diagnosis of seropositive or seronegative rheumatoid arthritis following occipitocervical fixation at the Cleveland Clinic Center for Spine Health between January 1, 2001 and December 31, 2009 was conducted. The primary outcomes were changes in neurological function and pain at last follow-up. Secondary outcomes were recorded for complications of surgery and postoperative surgical failures.

Results: Fifteen patients (mean age = 64.6, female = 12) were evaluated for a mean follow-up of 26.6 months. Atlantoaxial instability was the most common indication (93.3%). Patients self-reported pain reduction in 80% of cases. Neurological improvement occurred in 40%, while no patients deteriorated after surgery. Postoperative deaths were reported in two cases with one due to complications of surgery. No implant failures were observed and bony fusion was acquired in 93.3% of patients. Re-operation was only required for adjacent level degeneration (13.3%) and for pseudoarthrosis (6.7%). Other complications included surgical site infection (13.3%), dural tear (6.7%), and dysphagia (20%).

Conclusion: A consistent improvement in pain and neurological function in all patients after surgery, especially given the low incidence of complications, was observed. However, need for consistent and long-term follow-up of these patients is recommended due to increased strain on the subaxial spine that may potentiate degenerative processes and lead to re-operation.

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Minimal Access Spine Surgery for Metastatic Spinal Tumours Followed by Stereotactic Body Radiotherapy: Technique and Preliminary Outcomes

Eric M. Massicotte, Matthew Foote, Rajesh Reddy, Arjun Sahgal

Introduction: To report a novel approach in the treatment of spinal metastases with epidural disease causing mechanical instability using a combined minimal access spine surgery (MASS) technique for tumor decompression and reconstruction, followed by stereotactic body radiotherapy (SBRT).

Methods: A retrospective review of the first ten consecutive patients treated with MASS followed by SBRT was conducted. The MASS technique is based on a tubular retraction system to gain access for decompression and mechanical stabilization achieved using methylmethacrylate (MMA). SBRT consisted of one to five high dose per fraction treatments. Eight patients were symptomatic at baseline, and pain, disability and quality of life prospectively

determined using the visual analogue score, Oswestry disability index and short-form-36 version 2, respectively.
Results: The median follow-up was 13 months (range, 3-18). MASS successfully decompressed each patient, and the median blood loss was 335 ml. The median time to SBRT treatment planning was 6.5 days. Local control was observed in 7 of the 10 patients. Improvement in pain, disability and quality of life was observed post-SBRT. One patient had a complication of a dural tear during MASS. One patient required a further surgical procedure to decompression recurrent local disease. One patient who did not go on to be treated with SBRT, and considered separately in this analysis, suffered acutely from MMA extravasation rendering the patient myelopathic and subsequently died.
Conclusion: Safety and preliminary efficacy is reported with our MASS and SBRT combined approach for patients with spinal metastases and epidural disease, however, local control benefits require confirmation upon long-term follow-up.

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Our Experience with Percutaneous Bilateral Facet Motion Augmentation System: A Report of 60 Cases

Anthony P. Fabrizi, Raffaella Maina, Luigi Schiabello

Introduction: Minimally invasive surgical techniques have been rapidly diffusing in recent years. Different devices are now available for the treatment of lumbar spine degenerative disease. They allow a good symptoms relief as well as a short time of surgery and hospitalization. We present our experience with a novel system for percutaneous bilateral facet motion augmentation. This system was designed to limit painful spinal motion, enlarge the foramina and achieve intradiscal decompression. It is composed of a bilateral titanium anchor connected to a silicone stabilizer.
Methods: Since February 2009 we used the percutaneous facet motion augmentation system at our institution. Major indications were single level degenerative disc disease and spinal stenosis. We consider 60 patients for the present study. Mean age was 46.6 years old (range 38-72). Treated levels were L4-L5 (28 cases), L3-L4 (12 cases), L5-S1 (12 cases) and L2-L3 (8 cases). We performed the surgical approach under spinal anesthesia whenever was applicable (53% of patients). Follow-up data were recorded at 2-months and 6-months. Clinical results were assessed using the Visual Analogic Scale (VAS) and the EQ-5D questionnaire.
Results: Overall results were satisfactory in 56 patients. Mean pain VAS score improved from 7.7 at baseline to a value of 2.2 at 2-months follow-up. The remnant 4 patients had minimal or no changes. Two of these patients were subsequently treated with traditional transpedicular stabilization system. Mean procedure time was 26 minutes (range 18-40 minutes). Early mobilization was possible 12 hours after surgery in all patients. Hospital discharge was possible at 24-36 hours. No intra- and postoperative complications were observed.
Conclusion: Preliminary results are good and promising. Surgical technique is easy and satisfy requisites for a minimally invasive procedure. Percutaneous bilateral facet motion augmentation system represents a modern option to spinal fusion in selected cases.

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The Frankel Scale Is More Effective than Revised Acute Physiology and Chronic Health Evaluation System (APACHE II) for Prediction of Mortality in Cervical Spinal Cord Injury

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Introduction: The revised Acute Physiology and Chronic Health Evaluation system (APACHE II) is a physiologically based system including 12 physiological parameters. Cervical spinal cord injury (CSCI) can be a devastating event causing not only motor and sensory impairments but also autonomic dysfunction. Functional and morphologic changes in the sympathetic nervous system can affect respiratory, cardiovascular, renal and gastrointestinal systems. Purpose of the study is to investigate for predictive value of APACHE II according to the mortality, and to compare with Frankel scale.
Methods: This retrospective study included 47 patients with CSCI between 2005 and 2009. Patients were admitted from the emergency unit and treated at least 24 hours after their admission. APACHE II and Frankel scores were measured from the charts and collected data was analyzed for sensitivity, specificity and prediction of mortality by SPSS for Windows.
Results: The study included 36 males and 11 females. The ages of the patients varied between 21 and 82 years (meanly 45.7). Ten cases were scored with Frankel A, 2 cases B, 3 cases C, 14 cases D and 18 cases E respectively. Nine patients were dead and 38 cases were discharged after treatment. Prediction of mortality with Frankel scale is significantly helpful than APACHE II (table 1).
Conclusion: Disrupting autonomic system causes respiratory, cardiovascular, renal and gastrointestinal complications that have been considered to be the most frequent adverse events after SCI. Recently; hyponatremia and hematologic abnormalities have been recognized as the leading cause of poor outcome following SCI. Well-recognized consequence of CSCI caused to multisystemic dysfunction, however, Frankel scoring is available and superior to APACHE II still. This study is limited with fewer cases and included the first (only one) measurement of APACHE II. Further studies should include the follow-up values in hospitalization time and then compare with other scales for assessment of outcome and mortality.

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Clinical Study on Accuracy Measurement of Neuronavigated O-Arm Image-guided Surgery of the Thoracic Spine

Duccio Boscherini, Raymond Yerly, Maurizio Pintucci, Marco Barbero

Introduction: Image-guided navigation has reportedly increased the accuracy and safety of pedicle screw insertion and decreased complication rates. In former studies, the result of image-guided navigation was mainly compared qualitatively with the result of conventional fluoroscopy-guided procedures. The present clinical study aims at measuring in a clinical setting the accuracy of O-Arm (three-dimensional imaging device) coupled to a neuronavigation system. This is done by digitally overlapping the image of the virtual position of a needle tip displayed on a navigation system after percutaneous introduction into a thoracic vertebral body during a vertebroplasty procedure with the real position of the needle tip when using O-Arm intraoperative acquisition.
Methods: Forty-eight Yamshidi navigable needles were placed through a unilteral extrapedicular approach into fractured the vertebral bodies of thoracic T10-L2 levels using O-Arm guided navigation. The navigated needle tip positions were compared with the real needle tip positions from 3D O-Arm volumes acquired after immediate completion of

the needle procedure. Dynamic reference frame was attached to the iliac crest. Both digital images acquired during the procedure are overlapped and deviation is measured.
Results: The mean difference between the navigated needle position and the actual needle position was 0.8 ± 0.3 mm.
Conclusion: Accuracy of O-Arm guided navigation is high even in a clinically relevant setting and is superior to the accuracy reported in other studies

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Mini-Open Transpedicular Corpectomies with Expandable Cage Reconstruction

Daniel C. Lu, Dean Chou

Introduction: Transpedicular corpectomies are frequently used to perform anterior surgery from a posterior approach. Minimally invasive thoracolumbar corpectomies have been previously described, but these are performed through a unilateral approach. Bilateral access must be obtained for a circumferential decompression when using such techniques. We describe a technique which allows for a minimally invasive mini-open transpedicular corpectomy, 360 decompression, and expandable cage reconstruction through a single posterior approach. This is performed with percutaneous pedicle screws, the trap door rib head osteotomy, and a single midline fascial exposure.
Methods: In the one-year period between 2008 to 2009, the authors performed 8 mini-open transpedicular corpectomy procedures by minimally invasive approach in the thoracolumbar spine (T3 to L1) on patients with age ranging from 20 to 81 years for various pathologies involving trauma, infection, and metastatic disease. A comparison open cohort was obtained by matching the pathological diagnosis to the mini-open cohort.
Results: The mean blood loss was 1800 cc. Four of the patients underwent allograft fusion while the other 4 underwent autograft fusion. One patient developed a postoperative wound infection. Another patient required a reoperation for instrumentation failure. All patients with preoperative deficits demonstrated improvement of motor score after the procedure. A cohort comparison with the open and mini-open group was performed. We did not find a statistically significant difference in the parameters of age, EBL, operative time, complication rate, and follow-up length. There was however, a trend towards significance in EBL of mini-open (1213 cc) vs. open cases (2450 cc; p = 0.086).
Conclusion: The minimally invasive transpedicular corpectomy and expandable cage reconstruction can be performed with a combination of percutaneous pedicle screws, a direct midline approach, and a trap door rib head osteotomy.

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Minimal Access Surgery via the Unilateral Muscle Splitting Approach: An Innovative Breakthrough in Intraspinal Tumor Surgery

Ibet Marie Sih

Introduction: Surgical treatment options of intraspinal tumors, which commonly include nerve sheath tumors, meningiomas and astrocytomas, often include open laminectomy, multilevel laminectomies, or hemilaminectomies (with the option of intradural dissection). However, consequences of surgery include muscular, ligamentous and bony structure disruption leading to spinal instability, pain syndromes, and possible lengthy hospital stay and treatment. Minimal access spine surgery employing tubular dilators to split muscles provides good direct visualization of the operative field with minimal tissue trauma. Although its use is mainly in degenerative spine conditions, its applicability in intraspinal tumor surgery is not yet fully defined.
Methods: A prospective cohort of consecutive patients operated on by the authors (first 15 to minimal access group, next 15 to conventional group) was done. Demographic data and Nurick, ASIA motor, VAS pain scores at pre-op, day1 post-op, 1 month post-op and 3 months post-op were obtained using databases.
Results: The mean ages were 38.1 and 36.5 years respectively. At preop, day 1 post-op, 1 month post-op and 3 months post-op, the mean Nurick and ASIA scores were comparable in both groups. The mean VAS pain score of the minimal access group was less by at least 1-2 points compared to the conventional group. Although the mean tumor sizes were similar, the incision length was almost half in the minimal access group. In contrast to the conventional group, the operative time was shorter by 18%, the mean blood loss was considerably less by 59% and the discharge time was less by 28% in the minimal access group.
Conclusion: Minimal access surgery of intraspinal tumors via the unilateral muscle splitting approach using the Quadrant system is indeed an innovative alternative to laminectomies and bilateral paraspinal muscle dissection surgeries. However, it is recommended that a larger study population, randomization, longer follow-up periods will be done to further substantiate the applicability of this technique to intraspinal tumors.

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Performance Status After Lumbar Arthroplasty in the Military

Luis M. Tumialan, Ryan Ponton, Wayne Gluf

Introduction: Information regarding the level of physical performance attained and restrictions or limitations is lacking from the several FDA trials on arthroplasty. This data is essential for the military surgeon, tasked with guiding the postoperative management of an arthroplasty patient and return them to full duty.
Methods: The surgical database at a single, tertiary care military treatment facility was queried for all active duty patients who underwent placement of lumbar arthroplasty device from April 2007 until April 2010. Specific inquiries were made as to the level of performance attained, i.e. parachute jumping, diving, running and deployment. Each cohort was then compared to an age and level matched anterior lumbar interbody fusion.
Results: Fourteen patients were identified that underwent lumbar arthroplasty during the above mentioned time period. There were 12 men and 2 women with an average age of 37.3 years. The levels operated: L5-S1 (n=8), L4-5 (n=6). Twelve out of 14 (86%) patients in the lumbar arthroplasty group returned to unrestricted full duty, after an average of 22.6 weeks (range 12-29 weeks). This cohort was then age matched and level matched to 14 patients who had undergone a single level ALIF. Sixty-seven percent of these patients returned to unrestricted full duty after an average of 32.4 weeks. Although there was an apparent difference between the mean time to return to active duty, this difference was not statistically significant (p=0.156).
Conclusion: The preliminary experience with lumbar arthroplasty in the military indicates that this technology is comparable to arthrodesis and may actually expedite return to active duty. Patients are capable of returning to a high level of rigorous training and physical performance. There are no apparent restrictions or limitations required 6 months after arthroplasty. A prospective

study of lumbar arthroplasty in the military is underway.

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Lumbar Microdiscectomy Outcomes in Patients Ages Twenty-One and Under

Randall W. Porter, Mark P. Garrett, Jodie B. Woznica

Introduction: Surgical treatment of lumbar disc herniation in teenagers and young adults is uncommon, and these patients represent a unique demographic group. The long term outcomes of this population is not well documented in the literature..

Methods: We reviewed the charts of patients ages twenty-one and under from May 2004 to September 2008. We queried the charts for initial surgical treatment, initial and long term surgical results and the presence or absence of subsequent surgery or the need for further pain management.

Results: Twenty-eight patients ages 17-21 (mean and median age of 20 years old) underwent lumbar microdiscectomy at our institution during the study period after failing to respond to conservative treatment. Average follow-up was five years with a median follow-up of four years. Two patients, upon preliminary chart review, required subsequent surgical treatment. One patient underwent decompression for recurrent disc herniation at the same level 4 months postoperatively. The second patient required decompression for stenosis at two adjacent levels that had shown mild disease at the time of the initial procedure. In addition, seven patients sought pain management for recurrent disc herniation at a mean of 3.5 years (median 4.0 years) postoperatively.

Conclusion: Young adults and teenagers are an uncommon population requiring lumbar microdiscectomy. This retrospective review provides useful information in counseling patients regarding possible need for future surgery or life style modification.

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Disparities Based on Race, Ethnicity and Insurance Status in the Access to and Outcomes after Surgery for Lumbar Spinal Stenosis in the United States, 2005-2008

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Introduction: Disparities in the American healthcare system are well-known. However, the impact of race, ethnicity and insurance status on the access to and outcomes after surgery for lumbar spinal stenosis with or without spondylolisthesis has not been previously examined.

Methods: Data from the national inpatient sample (2005-2008) were retrospectively extracted. Patients were included if they had a diagnosis of spinal stenosis or spondylolisthesis and underwent lumbar decompression with or without fusion. Multivariable logistic regression analyses were conducted to calculate the odds of death, non-routine hospital discharge, and treatment at a high-volume hospital for racial or ethnic minorities. Analyses were also performed comparing patients with a lack of or underinsurance (defined as Medicaid or self-pay) to those with private insurance or Medicare. Logarithmic multivariate regression was used to evaluate the association of length of hospital stay and total hospital charges. All analyses were adjusted for differences in patient age, gender, co-morbidities, and hospital characteristics.

Results: A total of 106,751 admissions were evaluated. The adjusted odds of in-hospital mortality were not significantly associated with race, ethnicity or insurance status. Length of hospital stay was 3.9% longer for under- or uninsured patients ($p<0.001$); total hospital charges were 0.6% and 2.0% higher for minority and under- or uninsured patients, respectively ($p=0.009$). Non-Caucasian race or ethnicity (OR: 1.03, 95% CI: 1.00, 1.05, $p=0.017$) and under- or lack of insurance (OR: 1.20, 95% CI: 1.09, 1.33) were both associated with a significantly higher adjusted odds of non-routine hospital discharge. Both minority (OR: 0.78, 95% CI: 0.73, 0.82) and under- or uninsured patients (OR: 0.69, 95% CI: 0.59, 0.81) were significantly less likely to be treated at a very high-volume hospital.

Conclusion: Nationwide disparities exist in the access to very high-volume spine surgery; minority and under- or uninsured patients also incur higher hospital charges after surgery for lumbar spinal stenosis.

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Computed Tomographic Morphometric Analysis of the Human Occipital Condyle for Occipital Condyle-Cervical Fusion

Tien V. Le, Shannon Hann, Ali A. Baaj, Juan S. Uribe

Introduction: Occipital condyle screws serve as an alternative fixation point in occipital-cervical fusion. Their placement requires a thorough understanding of the anatomy of the occipital condyles and associated structures. This is a computed tomography (CT)-based morphometric analysis of occipital condyles as it relates to occipital condyle-cervical fusion.

Methods: There were a total of 170 patients examined with CT's of their cranium and cervical spine at a single institution for a total of 340 occipital condyles from March 6, 2006 until July 30, 2006. All CT's were negative for traumatic, degenerative, and neoplastic pathology. The anteroposterior length, the transverse width, condyle height, screw angle, and projected screw lengths were measured in all condyles. Linear measurements were done on an EBW Portal 2.5 CT Viewer Workstation. The longest axis in the anteroposterior orientation of the occipital condyle was accepted as the length. The transverse width was a line perpendicular to the midpoint of the long axis. The height was measured in the coronal projection with the thickest cranio-caudal portion of the condyle. The screw trajectory starts 5mm lateral to the medial edge of the condyle and a line is directed anteromedially in the longest axis. The angle is measured relative to the sagittal midline. The screw length is measured from the outer cortex of the posterior wall to the outer cortex of the anterior wall.

Results: The average and standard deviations of occipital condyle measurements were as follows: anteroposterior length was 22.38 mm ± 2.19 (range 14.7 - 27.6), width was 11.18 mm ± 1.44 (range 7.4 - 19.0), height was 9.92 mm ± 1.30 (range 5.1 - 14.3), screw angle was 20.30° ± 4.89 (range 8.0° - 34.0°), and screw length was 20.30 mm ± 2.24 (range 13.0 - 27.6).

Conclusion: These measurements correlate with previous cadaveric and radiographic studies of the occipital condyle and emphasize the role of preoperative planning for feasibility of placement of an occipital condyle screw.

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Clinical Trial Design for Phase I/IIA Embryonic Stem Cell Derived Motor Neuron Progenitor Transplant (MOTORGRAFT™) for Treatment of Infantile Spinal Muscular Atrophy Type I

Samer Ghostine, Rania, Chris Airriess, Shoshanna S. Vaynman, J. Patrick Johnson, Alexa Lynne Reeves, Hans S. Keirstead

Introduction: Spinal muscular atrophy (SMA) Type I is a devastating, terminal pediatric genetic disorder characterized by progressive degeneration of spinal cord motor neurons and concomitant deterioration of muscles that control

crawling, walking, swallowing and breathing. Motor skills start to regress before age six months leading to death by age 2 years.
Methods: Stem cell transplantation therapy presents a potential therapeutic approach for motor neuron diseases such as SMA. Our own pre-clinical studies have shown safety and functional benefit of the embryonic stem-cell derived motor neuron, MotorGraft™ in multiple animal models. There are many challenges in designing a clinical trial for a novel therapy in a terminal pediatric population such as validated efficacy outcomes, survival time, selection of appropriate controls, inclusion and exclusion criteria, appropriate surgical approach, cohort design and autopsy data.
Results: Multiple focus groups were held with experts in the fields of pediatrics, neurology, transplant surgery, neurosurgery and motor neuron disease research to adress these challenges, and resulted in a fully developed clinical program and trial design. Key safety outcomes include evaluation measures for tumor formation and migration of cells. Exploratory efficacy outcomes include time to 16 hours of assisted ventilation, and frequency of respiratory infections requiring hospitalization.
Conclusion: The primary objective of this clinical trial is to evaluate the safety and tolerability of MotorGraft™ transplantation into the ventral horn of the spinal cord at multiple sites along the cranio-caudal axis in symptomatic SMA Type I infants. The secondary objective is to evaluate the ability of MotorGraft™ to improve function of damaged motor neurons.

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Sacroiliac Arthrodesis by Minimal Incision: Distraction Interposition Method, Short-term Outcomes

Chris Idemmili, John G. Stark

Introduction: The sacroiliac joint (SIJ) is a major point of force transmission between the spine and the pelvis. Though fusion has been advocated for SIJ pain and disease, no procedure has received general acceptance. The purpose of this study is to report technical outcomes, and short-term functional outcomes of patients following sacroiliac arthrodesis surgery using a distraction-interference technique.
Methods: Fifteen patients, severely symptomatic with SIJ pain, underwent SIJ arthrodesis, using a combined extra- and partial intraarticular technique featuring a posterior-midline 4cm incision, controlled distraction/measurement of the extraarticular recess, BMP-2/allografting of adjacent surfaces, and application of a interference-fit, threaded implant. Patient sample consisted of 4 males and 11 females. Mean age was 43 (range 22-65). Interim follow-up period was three months. The Oswestry Disability Index (ODI) and Million Visual Analog Scale (MVAS) were the primary functional outcome measures. Patient report of back and leg pain resolution was also recorded. Two types of global assessment, improvement and satisfaction, were collected. Preoperative ODI and MVAS scores were compared to postoperative scores using a paired t-test. A significance level of .05 was used.
Results: Blood loss averaged 55cc (range 10-300cc). Mean hospital stay was 2.2 days. Average patient function improved significantly. MVAS scores improved 35(± 25) points (40%, p<.0001). ODI scores improved 10(±21) points (17%, p<.0001). Patients reported 75% resolution of back pain (95% Confidence interval: 66%-84%) and 91% resolution of leg pain (95%Confidence interval: 83%-98%).
Conclusion: Judged by back and leg pain relief, the surgery is promising in all patients. The SIJ region can be grafted and implanted by minimal incision methods. Patient satisfaction is high. There were no nerve injuries, displacements, infections, or malpositioned implants. Most patients showed dramatic improvement by three months. Patients report a high percent of back and leg pain relief. Significant improvement in function is reflected in MVAS and Oswestry scores.

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Minimally Invasive vs. Open Transforaminal Lumbar Interbody Fusion (TLIF): An Evidenced-based Review of the Literature

Owoicho Adogwa, Scott Parker, Oran Aaronson, Joseph S. Cheng, Matthew J. McGirt

Introduction: It remains unknown whether minimally-invasive vs. open techniques for transforaminal lumbar interbody fusion (TLIF) provides a better outcome for the treatment of lumbar degenerative disc disease and spondylothesis. We performed a systematic evidence-based review of the literature to determine level of evidence that supports the performance of a minimally-invasive vs. open technique for TLIF.
Methods: Systematic Medline search was performed to identify all published studies relating to outcome after minimally-invasive or open TLIF. Levels of evidence (I - V) were assessed for each study and grades of recommendation were generated (Good, Fair, Poor, Insufficient evidence) based on the NASS Clinical Guidelines' Levels of Evidence and Grades of Recommendation.
Results: There are no level I, one level II, and three level III studies comparing MIS- to open-TLIF. There are 15 level IV series of MIS-TLIF and 21 level IV series of open-TLIF. There is fair evidence that MIS- vs. open-TLIF is associated with decreased blood loss and reduced length of hospital stay, but similar improvement in both short-term (6mo-2yr) and long-term (>2yr) pain and disability. There is insufficient evidence to determine if MIS- vs. open-TLIF reduces operative time. Lastly, there is fair evidence suggesting that MIS-TLIF is associated with similar fusion rates compared to open-TLIF.
Conclusion: There are no level I studies suggesting superior outcomes for MIS vs. open-TLIF for the treatment of spondylolithesis or lumbar degenerative disc disease. Systemic review of the literature suggests that MIS-TLIF may be associated with reduced blood loss and length of hospital stay while providing equivalent short and long-term outcomes.

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Comparing Vertebral Body Reconstruction Implants for the Treatment of Thoracic and Lumbar Metastatic Spinal Tumors

Sharad Rajpal, Roy Hwang, Thomas Mroz, Michael P. Steinmetz

Introduction: Surgery in metastatic spine disease often requires vertebral body reconstruction following tumor resection to provide anterior spinal column support. No study to date has compared spine interbody reconstruction devices in metastic tumor patients. The goal of this study is to compare the longevity of structural bone grafts, cages, and polymethylmethacrylate (PMMA) as interbody reconstruction implants in patients undergoing corpectomy for metastatic tumors in the thoracic or lumbar spine.
Methods: 37 patients underwent corpectomy with subsequent interbody reconstruction over a 15-year period at a single institution. Surgical approach, hardware and interbody device type was at the discretion of the attending surgeon. Longevity of interbody device was primarily evaluated in this study as defined by the need for any revision surgeries or postoperative complications.

Results: 27 patients underwent reconstruction with metal implants and 5 patients each had reconstruction with bone and PMMA (Table 1). 23 patients and 14 patients had tumors in the thoracic and lumbar spine, respectively. Most common tumor diagnosis was lung carcinoma. Three patients (8.1%) required additional surgery: one wound infection, one hardware revision, and one for resection of an intradural, intramedullary tumor not identified at the time of the first operation (Table 2). Overall complication rate was 43.2% in 16 patients. Postoperative complication rates were 52%, 20%, and 20% in metal, bone, and PMMA implants, respectively. Rate of revision surgery was 40%, 3.7% and 0% in the bone, metal, and PMMA interbody groups. Two patients died within 30 days of their index spine surgery, one from sepsis and one from respiratory failure.
Conclusion: Vertebral body reconstruction following corpectomy for metastatic tumors to the thoracic and lumbar spine can be done effectively with metal, bone, or PMMA. Metal implants appear to have a higher rate of overall complications, with bone interbody constructs demonstrating higher level of revision surgery.

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Extreme Lateral Interbody Fusion (XLIF) in Smokers

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Introduction: The pre- and postoperative results of XLIF were collected to assess feasibility and clinical and radiographic success in smokers.
Methods: In our single-site prospective series of 932 XLIF patients, 308 smoked at the time of surgery. Patient demographics and clinical/radiographic outcomes were assessed.
Results: Patients ranged in age from 22-84 years (average 56 years) and were treated for a variety of indications. 44% had previous spine surgery. 18% had diabetes, 38% had CAD, 7% had COPD, and 12% were chronic steroid users. 47% were obese or morbidly obese. 363 levels were treated: 263 1-levels, 35 2-levels, and 10 3-levels. Grafting materials included a composite of DBM, local bone graft, and bone marrow aspirate (69.1%), a beta-tricalcium phosphate/hydroxyapatite (FormaGraft) with bone marrow aspirate (9.7%), and allograft cellular bone matrix containing native mesenchymal stem cells (1.3%). All but two surgeries included supplemental fixation, most performed in the same surgical position. There were no transfusions or infections. Complications included 2 pneumonia, 1 reintubation, 1 ileus, 2 urinary retention, 1 atrial fibrillation, 1 endplate fracture (healed without intervention), 1 sacral fracture, 3 intraoperative hardware failures (replaced without incident), 1 osteophyte fracture (required reoperation), 2 compression fractures (required vertebroplasty), and 1 quad weakness (resolved without intervention). Hospital stay averaged 1.1 days. From pre-op to 24 months post-op, average disk height improved by 2.4mm, average slip improved by 7.4mm, average VAS pain scores decreased by 5.8 points. Signs of fusion by Lenke scores of 1 or 2 were 80% at 3 months, 94% at 6 months, and 99% at 12 months and 98% at 24 months – not significantly different from the greater non-smoking (624 pts) cohort (84%, 95%, 97% and 98%, respectively).
Conclusion: Our results show no significant difference in the clinical and radiographic outcomes between smokers and nonsmokers. MIS fusion approaches may offset some of the deleterious effects of smoking on bone healing.

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Use of Titanium Expandable Vertebral Cages in Cervical Corpectomy: A Case Series

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Introduction: The purpose of this study was to investigate the usefulness of titanium expandable cages for vertebral body reconstruction after cervical corpectomy. The authors describe a retrospective case series of patients treated with expandable titanium cages for a variety of indications.
Methods: 29 patients were treated with single or multilevel cervical corpectomy followed by placement of an expandable titanium cage for spondylosis (13), trauma (9), infection (4), previous hardware failure (1), tumor (1), and arachnoid cyst (1). All patients were evaluated clinically and radiographically at 6 weeks, 3 months, 6 months, and 12 months. Cervical collars were discontinued at 3 months.
Results: 23 patients underwent single-level corpectomy (of which 5 were in combination with 1 level ACDF and 1 in combination with 2 level ACDF), 4 patients underwent two-level corpectomy (of which 1 was in combination with 1 level ACDF), and 2 patients underwent three-level corpectomy. Anterior reconstruction alone was performed in 15 patients with single level-ACCF. Circumferential reconstruction was performed in 16 patients (9 single-level ACCF, 5 two-level ACCF, 2 three-level ACCF). All patients had an anterior cervical plate placed. 1 patient who had a C4 corpectomy and C5/6 ACDF with circumferential reconstruction developed a retropharyngeal hematoma that was evacuated on POD 2 and subsequently did well. There was evidence of fusion in all patients. There was no radiographic evidence of more than 2 mm subsidence throughout the series. There were no occurrences of instability or hardware failure.
Conclusion: Our results show that expandable cages are useful in anterior cervical corpectomies for providing adequate anterior column support and solid constructs without significant hardware complications.

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Clinical Experience, Outcomes, and Learning Curve Following XLIF for Lumbar Degenerative Conditions

Jonathan Hyde,
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Introduction: Minimally invasive spine procedures have been celebrated for reducing patient morbidity and expediting patient recovery times. Despite these strengths, many minimally invasive techniques are associated with long surgeon adjustment periods. The XLIF approach has been shown to be minimally invasive with respect to blood loss, hospital stay, and surrounding tissue disruption, but uses familiar instrumentation under direct visualization which minimizes the associated learning curve.
Methods: The records and radiographs of 78 consecutive XLIF procedures were retrospectively reviewed to assess perioperative and follow-up outcomes measures including operative time, blood loss, hospital stay, complication rates, clinical, and radiographic outcomes. A subset of single-level patients without repositioning for posterior fusion was examined for evidence of an early learning curve.
Results: Average patient age was 62.1 + 14.0 years. Two-thirds of the cases were single-level procedures, but as many as four levels were treated during a single XLIF procedure. 95% of procedures included posterior fixation. Average blood loss was 109.9 cc (range: 10-650cc) and the average operative time for all patients was 221.0 min (range 78-489). Average

hospital stay was 2.7 days (range 1-7). One third (n=26) of patients experienced transient postoperative thigh discomfort/dysesthesia. Of those patients with CT evaluations 6 months or later after surgery (n=65), 100% demonstrated evidence of solid fusion. There were 8 cases (10.3%) of implant settling/subsidence which were not clinically significant. Evidence of a learning curve was identified with respect to reduced blood loss, and procedure time over the course of the experience.
Conclusion: The reduction in operative time and blood loss over time in this cohort was suggestive of a slight learning curve; but even the earliest measures were comparable or lower than traditional open procedures. Relative to traditional open procedures, operative time for XLIF procedures is shorter, intraoperative complications are uncommon, blood loss is minimal, and fusion rates are comparable.

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Predictors of Persistent Leg Pain Following Minimally Invasive Surgery for Lumbar Radiculopathy

John W. German, Anthony G. Conte

Introduction: Minimally invasive approaches to the lumbar spine are being increasingly utilized with good efficacy. To further improve the clinical outcomes of patients undergoing surgery for lumbar radiculopathy all preoperative factors should be considered to determine which subset of patients are at risk for doing poorly. Understanding these risk factors can then be used to improve the treatment paradigm.
Methods: A retrospective review was undertaken of 140 patients undergoing surgery for lumbar radiculopathy. Medical records were reviewed and data was abstracted for demographics, past medical history, past surgical history, psychiatric co-morbidities, neurologic co-morbidities, anatomic factors, and intraoperative factors. Six month outcomes were available for patient derived outcomes included leg visual analog score (VAS). Outcomes were analyzed using the peri-operative change in which outcomes were classified as success (VAS>-2.0) or failure (VAS<-2.0) as well as a threshold method in which outcomes were classified as success (VAS<4.0) or failure (VAS>4.0). Statistical analyses included a t-test for continuous variables and a Chi square test for categorical variables with significance set at $p<0.05$.
Results: Six month outcomes were available for 56 patients. Using the peri-operative change method 18.1% of patients were classified as failures while the threshold method classifed 32% patients were classified as failures. Bivariate analysis of the leg VAS peri-operative change method suggests that the risk factors for failure were: female sex, depression, and anxiety. Bivariate analysis of the leg VAS threshold method suggests that the risk factors for failure were: depression, presence of neurologic co-morbidity, absence of CSF leak, absence of foraminotomy, absence of sequestrectomy, and absence of annulotomy.
Conclusion: Minimally invasive surgery for lumbar radiculopathy results in a successful outcome in 68 to 82% of patients at six months. The common risk factor for persistent postoperative leg pain using the two analyses methods is a preoperative self-reported history of depression.

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Vertex Distance Mapping as a Metric to Describe Stability of the Lumbar Spine

Dennis Allen Roberts, Boyle C. Cheng, David M. Cook, Donald M. Whiting, Jonathan B. Bellotte

Introduction: In contrast to rigid fixation for spinal fusion, dynamic fusion provides both immediate fixation and stabilization while allowing for anterior load sharing. In allowing anterior load sharing, compressive forces are applied to the anterior construct, which should stimulate bone fusion. This study investigated vertex distance mapping to evaluate facet motion on the dynamic vs. rigid construct as well as comparing it to an intact spine. Vertex Distance Mapping (VDM) measures the surface area within a specific region of interest (ROI) that fall under a set threshold, here defined as 2 mm within the ROI. Moreover, it this proximity that may describe intimate contact of facet joint surfaces and represent a proxy for stability.
Methods: Six lumbar spine cadaveric specimens were stripped of all non-ligamentous tissue. Each spine was tested intact, with the Scientx Isobar TTL Evolution device at the L3-4 level, with the dampener configured at low, medium and high levels. A rigid construct was then applied and tested on the same spine. Three cycles evaluating axial compression, flexion-extension bending, lateral bending and torsional testing were performed. Three cycles of each testing mode were performed and measurements were taken after the third cycle. The difference in surface area meeting the threshold criteria of 2 mm within the ROI at the maximum and minimum standardized time points of the 3rd cycle were calculated.
Results: The mean change and standard deviation in flexion extension bending of the Isobar TTL in the middle position compared to the rigid rod construct was 42.2mm±74.3mm and 34.0mm±44.7mm respectively. There were no statistically significant differences detected amongst the treatment groups in any mode of load sharing for the instrumented procedures.
Conclusion: Dynamic fusion has two main goals: 1) To provide immediate stabilization and fixation for a functional spinal unit. 2) To allow for anterior column load sharing to facilitate arthrodesis. The vertex distance mapping of the facet of the intact spine, Isobar construct and rigid construct shows no significant change in facet interaction. From this study, we conclude that the isobar system does in fact provide adequate lumbar spine stabilization while awaiting arthrodesis

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The Synergy Disc: 12-Month Clinical and Radiographic Outcomes for Next Generation Artificial Cervical Disc

Kemal Yucesoy, Kasim Zafer Yuksel

Introduction: The Synergy Disc is a next generation cervical artificial designed to provide controlled, physiological range of motion with predictable and reliable lordosis control. The aim of this single arm, prospective study was to assess clinical and radiographic outcomes following single and multilevel procedures.
Methods: Patients were evaluated preoperatively and postoperatively at 1, 3, 6 and 12 months. Evaluations at each visit included neurological examinations, clinical outcome measures and x-rays. Radiographic analysis, performed by Medical Metrics, Inc., evaluated the kinematics at the index level including: range of motion (ROM); translation; shell angles (SA); anterior and posterior disc heights (ADH/PDH) and center of rotation (COR).
Results: Thirty-four patients were enrolled at a single site study with five patients receiving 2 level procedures for a total of 39 implanted discs. There was no adverse event or unsuccessful insertions. The NDI score decreased significantly from 4.2 at pre-op to 1.3 at 3 months, 1.2 at 6 months and 1.0 at 12 months. The neck and arm pain VAS scores also demonstrated a significant decrease over

time (pre-op 8.0; 0.4 at 3 mos; 0.3 at 6 mos and 0.1 at 12 mos). Following surgery, there was no significant change in ROM (pre-op 12°; 12 mos 9.8°) or translation (pre-op 1.4mm; 12 mos 1.2mm) but an increase in disc height (pre-op 3.5 mm; 12mos 4.7mm). There was a minor change in both COR X and Y values. With respect to the SA, the Synergy disc maintained a 6° lordotic configuration between the device endplates.
Conclusion: Synergy disc is unique in its ability to provide predictable and reliable lordosis control while maintaining physiological spinal kinematics. The 12-month data demonstrates excellent clinical safety and performance.

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Traumatic Thoracolumbar Fractures Treated with Short-Segment Pedicle Instrumentation

David Stidd, Jack H. Dunn, Michael Lemole, Rein Anton

Introduction: Early reports of instrumentation failure and kyphotic collapse in the early 1990s led to controversy over the role of short-segment pedicle instrumentation for the treatment of unstable single-level thoracolumbar spine fractures. The classic teaching of extending transpedicular screw constructs 2 to 3 levels above and below the fractured spine segment was based on technology first introduced in the 1980s. However, posterior transpedicular fixation has since significantly evolved making long posterior constructs less necessary toward the goal of boney fusion. We report a case series of patients that presented to single level 1 trauma center with an unstable single-level thoracolumbar fracture treated with short-segment pedicle instrumentation.
Methods: A retrospective chart review was conducted of twenty-two trauma patients with one or two level unstable thoracolumbar fractures. These patients were treated with short-segment pedicle instrumentation during the study period from 2009 to 2010. Indications for surgery were at the discretion of one of the three treating senior authors. Both patients with multiorgan injuries and isolated thoracolumbar fractures were included it this review.
Results: The ages of the patients ranged from 17 to 66 and included 14 males and 8 females. The mechanisms of injury included 10 motor vehicle collisions, 8 falls, 3 motorcycle collisions, and one ATV crash resulting in 3-T12, 15-L1, 2-L2, 2 L3, and 1-L4 unstable fractures treated with short-segment pedicle instrumentation. The average follow-up was 2.5 months. There was no evidence of instrument failure or signs of boney fusion failure on imaging obtained at follow-up.
Conclusion: Thoracolumbar fractures can be successfully treated with short-segment pedicle instrumentation using contemporary technology. No instrument failure was noted in this series. Less implanted instrumentation results in less health care cost.

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Cervical Reconstruction Using Lateral Mass Cages

Michelle J. Clarke, Ian Suk, Daniel M. Sciubba, Timothy F. Witham, Reza Yassari, Ali Bydon, Ziya L. Gokaslan, Jean-Paul Wolinsky

Introduction: Recently, more aggressive surgical techniques including en bloc resections of certain tumors has resulted in a need for creative spinal column reconstruction. Iatrogenic instability of the craniocervical junction or subaxial spine following these resections requires a thoughtful approach to adequately transfer load-bearing forces from the skull and upper cervical spine to the subaxial spine. At the craniovervical junction, axial forces are transmitted from the occipital condyles to the lateral masses of C1 to the lateral masses of C2. This is the only portion of the spinal axis in which a central vertebral body does not provide the majority of support.
Methods: A retrospective review was performed of the medical records of all five patients who have undergone lateral mass cage placement at our institution. Lateral mass cages were used as a component of cervical spine reconstruction following iatrogenic destabilization. All patient notes, operative records and imaging results were reviewed with a range of follow-up. In all cases described, the lateral mass cage span was dictated by the extent of tumor resection and subsequent reconstruction needs.
Results: We describe five cases of lateral mass cage placement. A case illustration is used to describe the general technique, and we discuss how this technique and be expanded for other indications. We discuss the surgical nuances of our technique for lateral mass cage placement. Additionally, we provide our rational for the use of these constructs throughout the craniocervical junction and subaxial spine. Complications and outcomes of this challenging technique are also discussed.
Conclusion: Reconstruction of the load-bearing capacity of the upper cervical spine following large surgical resections is challenging. This series demonstrates lateral mass cages used to provide load-bearing support, including one case of bilateral cage placement in the face of major iatrogenic instability.

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Use of rhBMP-2 to Augment Posterior Allograft Fusions of C1-C2 and the Craniocervical Junction

Brian James Hood, Andrew L. Ross, Marine Dididze, Allan D. Levi

Introduction: Iliac crest autograft has been the uncontested grafting technique of choice in posterior occipital-cervical and atlanto-axial fusions due to its osteoinductive and osteoconductive properties. New evidence has emerged that suggests a modified allograft technique [1] (graft placed in a true interpositional manner and held in compression between the posterior elements of C1 and C2) in conjunction with instrumentation is able to produce almost equivalent fusion rates (88.9% allograft vs. 96.7% autograft at 24 months) while preventing the complications associated with autograft harvesting [2]. In order to augment the osteoconductive effect provided by the modified allograft technique, rhBMP2 was used to induce osteocyte proliferation and improve fusion rates.
Methods: We performed a retrospective chart review of patient data including x-rays and fine-cut CT scans of patients who underwent posterior instrumented atlantoaxial or occipital-cervical fusions using allograft and BMP2 between 2007 and 2010. A total of 22 patients underwent either C1-C2 (n=17) or O-C (n=5) fusions. Each procedure was supplemented with either extra-small (n=2), small (n=18), or medium (n=2) aliquots of rhBMP-2.
Results: The study group was 50% male with an average age of 54 years (range 6-92). Diagnoses included type II odontoid fractures (n=7), rheumatoid arthritis related C1-C2 instability (n=7), O-C1-C2 dislocations (n=2), C1-C2 facet arthrosis (n=2), and other (n=4). There were no complications directly attributable to the use of BMP2 in all 22 cases (average follow-up 9 months). There have been no cases of reported hardware failure. Osseous union was achieved in all patients (n=20) who achieved sufficient follow-up. The rate of osseous union appeared accelerated when compared to historical controls.

Conclusion: The fusion rate of achieved with allograft and rhBMP2 compares favorably with previously described autografting techniques.

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Spinal Synovial Sarcomas: A Series of Cases and Review of the Literature

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Introduction: Synovial sarcoma is a rare, aggressive neoplasm with uncertain origins affecting mainly adolescents and young adults. Reports of synovial sarcoma arising from, near, or metastatic to the spine have been extremely rare.
Methods: We retrospectively reviewed the Mayo Clinic database and identified three patients who were diagnosed and treated for spinal synovial sarcoma since 2004.
Results: The three patients with pathologically confirmed synovial sarcoma included a patient with a thoracic dumbbell tumor, a patient with a paraspinal tumor and the first report of a patient with leptomeningeal spread of synovial sarcoma. Recognition of a high-grade lesion was made intraoperatively in all cases, precluding en bloc resection. All patients underwent aggressive treatment; one patient had recurrence within 6 months, another succumbed to an unrelated brain tumor within 4 months, and the final patient has no known disease at 3 years. There are 14 additional cases of spinal synovial sarcoma reported in the literature which we review, including 8 located within the paraspinal musculature with most having foraminal extension (dumbbell shape), 3 associated with intradural spinal nerve roots, 2 metastatic lesions (one to bone and one intramedullary), and one primary bony/lytic lesion. The cases we present all involved the paraspinal muscles with two of them being associated with spinal nerve roots (dumbbell shaped), the other having significant leptomeningeal association which is the first reported in the literature.
Conclusion: Surgical excision with wide, negative margins is the currently recommended treatment with adjuvant radiotherapy and/or doxorubicin based chemotherapy. While this is a mainstay of treatment, there is no consensus on the optimal treatment strategy. These tumors are challenging to diagnosis, and late recognition may hinder appropriatly agressive initial resection. Thus clnicians must consider these lesions in their differential, especially in cases of paraspinal tumors.

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Two-level Instrumented ACDF Using Demineralized Bone Matrix and Local Bone: 184 Cases at 1 and 2-Year Follow-up

W.B. Rodgers, Edward J. Gerber, Jody A. Rodgers

Introduction: The complications and rates of fusion associated with the ACDF procedure in use with demineralized bone matrix are reported to demonstrate the feasibility, safety, and effectiveness of the approach. Clinical and radiographic outcomes were evaluated to assess complications and fusion rates at 12 and 24-month follow-up.
Methods: 184 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: 184 patients, 67 male and 117 female, with average age of 56.0 years (range 31-81 years) presented for 12-month follow-up. To date, 60 patients have presented for 24-month follow-up. Average 12-month Lenke score was 1.07, and average 24-month Lenke 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 183/184 patients at 12 and 24 months postoperatively. 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.

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Prospective Multicenter Evaluation of Percutaneous Lumbar Pedicle Screw Placement Using the Oblique or "Owl's Eye" View

Cary Idler

Introduction: Few studies have focused on the oblique technique as a potentially more accurate method of placing percutaneous lumbar pedicle screws without direct visualization. A prospective, randomized, IRB-approved study was undertaken to evaluate the accuracy and safety of the oblique technique using computer assistance to facilitate orienting the C-arm into the oblique view efficiently and accurately.
Methods: After providing informed consent, patients were randomized into one of two groups: one underwent placement of lumbar pedicle screws using the oblique technique with the assistance of Guidance; the other group underwent screw placement per the surgeon's usual technique using fluoroscopy alone (non-Guidance). Fluoro time, screw placement time, and EMG thresholds were recorded intraoperatively for both groups. A neural exam and VAS pain assessment were obtained pre- and immediately post-op. A post-op CT scan was also obtained to determine screw placement accuracy.
Results: A total of 47 patients (27 females and 20 males) have been enrolled to-date. Primary surgeries included instrumented ALIF (9), XLIF (18), and/or TLIF (22). Of the 214 screws evaluated post-op by CT, 11 (5.1%) breaches occurred: 8 (3.7%) medial, 2 (0.9%) lateral, and 1 (0.5%) inferior; 10 of the 11 pedicle breaches were less than 2mm in magnitude, and 1 breach in the non-Guidance group was 2-4mm in magnitude. None of the breached screws required revision, and there were no significant differences in clinical improvements between patients with breached screws (n=7) and those without (n=40). Use of Guidance resulted in a statistically lower fluoro usage per screw ($p<0.001$) and quicker placement of guidewires ($p<0.001$). Although there was no statistical difference in the average time it took to place each screw, average times trended lower with the use of Guidance ($p=0.059$).
Conclusion: The oblique technique for percutaneous pedicle screw placement using NeuroVision Guidance provides feedback on the appropriate targeting of the pedicle and successfully reduces the amount of fluoroscopy used without significantly adding to the time required for placing pedicle screws.

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Clinical Outcome of Cervical Arthroplasty for Adjacent Segment Degeneration After Anterior Cervical Interbody Fusion

Kyoung Suok Cho, Sang Bok Lee, Pil Woo Huh, Do Sung Yoo, Tae Gyu Lee, Chun Kun Park

Introduction: Anterior cervical discectomy and corpectomy for the treatment of cervical spondylosis and cervical disc herniation enjoy favorable rates of fusion and successful clinical outcomes. However, postoperative degenerative changes at adjacent discs may lead to the development of new radiculopathy or myelopathy. In the previous reports, the incidence of symptomatic adjacent segment disease has ranged from 7% to 25%. The present study was undertaken to investigate the incidence of symptomatic adjacent segment disease after anterior cervical interbody fusion (ACIF) and to describe our surgical method for those patients.
Methods: Between 1999 and 2007, a total of 165 patients underwent anterior cervical interbody fusion for intervertebral disc herniation and cervical spondylosis. A total of 115 of these patients could be followed up clinically and radiologically for more than 2 years (follow-up rate, 82%). Of these, 77 were men and 38 were women and the average age at operation was 51 years (range, 26 to 75 years). The average length of follow-up was 5.8 years (range, 2 to 9 years). The diagnosis of symptomatic adjacent segment disease was based on the presence of new radiculopathy or myelopathy symptoms referable to an adjacent level, and the presence of a compressive lesion at an adjacent level by magnetic resonance imaging.
Results: Symptomatic adjacent segment disease developed in 13 of 115 patients (11.3%) followed. We performed fusion extension three, fusion plus total disc replacement (TDR) one and only TDR nine patients. All patients were improved after surgery without any complication except one transient hoarseness.
Conclusion: The cervical arthroplasty is a reasonable treatment option for patients who have had previous surgery in which interbody fusion has been performed and who have developed degeneration of adjacent levels.

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The AOSpine ANEG (Access and Navigation Expert Group) Survey on the Use of Navigation in Spine Surgery

Roger Hartl, Khai Lham, Jeffrey C. Wang, Andreas Korge, Frank Kandziora, AOSpine

Introduction: Despite reports suggesting that computer-assisted navigation (CAN) can improve accuracy of screw placement and decrease radiation exposure it is not widely accepted among spine surgeons. We performed an internet-based survey among AOSpine surgeons in order to better understand the current deficits of navigation.
Methods: A 12-item questionnaire was distributed by e-mail to 3348 AOSpine surgeons worldwide. The questionnaire asked for information on number and type of surgical cases, the type of navigation equipment available and general opinions towards navigation. To investigate the existence of groups of surgeons based on their opinion profile we applied the technique of latent class modeling.
Results: Response rate was 20% (678 surgeons). Despite a widespread distribution of navigation systems in North America and Europe only 11% of surgeons use it routinely. High-volume surgeons, neurological surgeons and surgeons with a busy MIS practice are more likely to use CAN. "Routine users" consider as the main advantages of CAN its accuracy, the potential of facilitating complex surgery and the reduction in radiation exposure. The same group identifies the increase in OR time as the main reason why they do not use CAN more frequently. The lack of equipment, inadequate training and high costs are quoted by the majority of "non-users" as the main reasons for not using CAN. Overall, 79% of surgeons feel positively about CAN and 37% have strong and very strong positive beliefs about the benefits of navigation.
Conclusion: The majority of surgeons have positive beliefs about navigation. However, the high costs associated with CAN systems, lack of access to navigation systems, the increase in OR time and the lack of good scientific data supporting its clinical benefits appear to be the main reasons why surgeons do not use CAN or do not use it more frequently.

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Surgical Management of Traumatic Fractures of the Upper Thoracic Spine

Paul M. Arnold, Brett C. Ebeling, Karen K. Anderson

Introduction: Management of traumatic upper thoracic spine fractures (T1-T6) is complicated by unique biomechanical characteristics and the nature of the injuries, which are often associated with multiple comorbidities as well as complete spinal cord injury. The goal of our study was to report further evidence of the safety and efficacy of surgical treatment to achieve and maintain reduction of upper thoracic spine fractures.
Methods: This study was a retrospective analysis of traumatic unstable upper thoracic spine fractures treated at our facility between 1994 and 2009. Preoperative evaluation included neurological exam and radiographic analysis. Surgical indications were based on spinal instability, neurological status, and other patient factors. Clinical and radiographic outcomes included neurological deficit, hospital and ICU length of stay, kyphotic deformity and successful reduction of fractures.
Results: 35 patients (19 male, 16 female), with mean age of 38.1 years (range 14-83 years) were included in the study. Reduction and stabilization of the fractures was achieved using either hook and rod constructs or pedicle screws and rods. There were 165 total levels fixed, with no intraoperative complications. Hardware was removed post-fusion (1-3 years) in five patients due to pain, wound infection, or hardware failure. A sixth patient had hardware replacement after three days due to suspicion of screw migration. All patients in this study benefited from successful reduction of their fractures, and none of the patients suffered further neurological dysfunction as a result of the procedure. The average hospital length of stay was 13.8 days (range 4-53 days).
Conclusion: Surgical treatment of upper thoracic spine fractures, although complex, is safe and effective. Reduction and fixation of these fractures results in reduced risk of further neurological damage due to the injury, and allows for earlier mobilization, which correlates with shorter hospital lengths of stay and improved patient outcomes.

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Spondylolysis without Spondylolisthesis: A Missed Diagnosis by MRI

Bennett Blumenkopf, Jonathan B. Bellotte, James Burgess

Introduction: Lumbar MRI has become the imaging study of choice for the evaluation of low back pain, especially in the primary care setting. Spondylolysis is among the etiologies of low back pain, particularly in adolescents and athletes. While MRI provides superb soft tissue detail, its capability in detecting fine osseous changes, such as spondylolysis, is less clear; failure to do so may result in delays in referrals by the primary care physicians.
Methods: The formal MRI reports authored by board-certified radiologists of 13 consecutive patients with surgically-verified spondylolysis were reviewed, retrospectively, for any mention or discussion of spondylolysis. The images themselves were also reviewed by the

operating surgeon at the time of initial clinical presentation. Reports were also reviewed for mention of spondylolisthesis, and compared to formal radiology CT scan reports, as well.
Results: Six of the 13 radiologists made no mention whatsoever of spondylolysis. Some of the highlighted features included in their reports were disk degeneration, facet arthropathy, and stenosis. Five of these patients did not have spondylolisthesis noted in the report. Seven reports characterized the finding both in the discussions and impressions; 6 also noted spondylolisthesis. ($p < 0.03$, Fisher's exact test). The neurosurgeon recognized/inferred the defect in all cases during the first examination. Secondary lumbar CT confirmed that impression in the 6 false negative by MRI instances. Intraoperatively, the pars interarticularis defects were unequivocal; a Gill procedure was performed in all 13 cases.
Conclusion: Spondylolysis without spondylolistheis proved to be a diagnostic challenge for board-certified radiologists utilizing MRI. MRI may not be the imaging study-of-choice for some patients with chronic back pain, especially in the adolescent primary care and sports medicine settings. As such, an alternative/supplemental evaluation with either CT or SPECT may be appropriate.

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Clinical Indications for Arterial Imaging in Cervical Spine Trauma

Matthew J. McGirt, J.E. Evin, J.Y. Lee, Clint Devin

Introduction: Cervical spine injuries that involve displacement of the cervical spine or injuries that present with neurologic deficits warrant further evaluation with arterial imaging. Cervical spine injuries are very common in high energy trauma and are frequently seen at level one trauma centers across the country. A clinical standard of care does not exist indicating when further evaluation of the cervical vasculature is warranted after a documented cervical spine injury.
Methods: After IRB approval, a retrospective study combining the data from two level one trauma centers was undertaken. An evaluation of every arterial imaging procedure (computerized tomography and magnetic resonance arteriography) of the cervical spine was collected to further delineate indications and outcomes of these imaging modalities.
Results: From 2005 to 2009 there were a total of 159 patients who underwent cervical arterial imaging at the two participating institutions for the indication of cervical trauma with concern for arterial injury. Thirty-six (22.64%) were found to have an injury following arterial imaging. There was a statistically significant correlation with displaced cervical injuries ($p < 0.0153$) which were defined as cervical dissociations, perched, and/or jumped facets. The other statistically significant correlation was the presence of a neurological deficit ($p < 0.001$), defined as any presenting deficit of the sensory or motor physical exam. Level of injury defined as axial (O-C2) vs. subaxial (C3-C7), age, BMI, and history of cigarette smoking were not statistically related to vascular injury.
Conclusion: Our retrospective evaluation indicates that there should be a lower threshold for obtaining arterial imaging with cervical injury patterns historically known to compromise the vasculature that also have concomitant displaced cervical spine injuries and/or a neurological deficit.

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Revising the Impact of Athletic Activity on Cervical and Lumbar Spine

Laura Ganau, Nikolaos Syrmos, Mario Ganau, Igor Faquini, Dimitrios Arvanitakis

Introduction: The diffusion of athletic activity in the general population has increased markedly over the last 30 years; wellness seems to give hope for an healthy future, nevertheless the long-term effects of this widespread attitude are still debated.
Methods: To assess the impact of sport activity in an asymptomatic population of lifelong athletes we have enrolled 40 sports-men and women (ratio m/f 1:1) in the present study and performed for each of them an MRI scan of the cervical and lumbar spine. Degree of cervical and lumbar spondylosis, as well as presence of disc degeneration, herniations, type of Modic changes, and indirect signs of segmental instability were assessed. Neuroradiological data were matched with the athletic history, and compared with the incidence of spinal degenerative diseases in the general population as reported in literature.
Results: Evidence of asymptomatic spinal degenerative diseases on MRI scans was as high as 35%; and included: cervical disk protrusion (2.5%), cervical spondylosis (10%), lumbar disk protrusion (12.5%), lumbar disk herniation (2.5%), lumbar instability (2.5%), lumbar stenosis (5%). Incidence increased proportionally with aging and BMI, without gender differences. All findings proved to be asymptomatic and did not interfere with athletic activity.
Conclusion: The incidence of degenerative spinal diseases in athletes seems to be similar to that seen in the general population. Although the small sample did not allow for a statistical analyses, it seems that athletic activity should not be considered a priori protective against the patho-physiological degeneration of spinal elements, certainly neither it should be considered a risk factor.

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XLIF at L4-5 and the Protective Effect of Prophylactic Dexamethasone

W.B. Rodgers, Edward J. Gerber, Jody A. Rodgers

Introduction: It has been reported that XLIF procedures performed at the L4-5 level have a higher incidence of postoperative motor deficits compared to other lumbar segments, and must occasionally be aborted to due anatomic constraints.
Methods: In our single-site consecutive series of 941 XLIF patients, 565 (60%) included the L4-5 level. Clinical and radiographic data were prospectively collected and reviewed to assess XLIF procedure at the L4-5 level.
Results: Age averaged 62.0 years (24-88 years). 78.1% had one or more comorbidities. 31.0% had prior lumbar surgery. All procedures were successfully completed. Hospital stay averaged 1.2 days. Average VAS pain scores improved from 8.7 at pre-op to 2.4 at 12 months and 2.2 at 24 months follow-up. Lenke fusion scores of 1-2 were present in 96.8% at 6 months, and 99.0% at 12 months. Neural complications included 4 (0.6% of all cases, 0.9% of L4-5 cases) transient lower leg weaknesses (3 quads, 1 anterior tibialis; all resolved within 3 months). After the fourth postoperative motor deficit, we began to administer dexamethasone (10mgIV prior to skin incision) prophylactically in all XLIF patients in whom the L4-5 level was to be approached. Since the use of dexamethasone, no additional neural deficit developed, a statistically significant difference ($p=0.0245$).
Conclusion: The incidence of postoperative motor deficits following XLIF at L4-5 is low. The prophylactic administration of dexamethasone results in a statistically significant reduction in motor deficits.

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Minimally Invasive Surgical (MIS) Method for Simplifying Sacroiliac Joint Arthrodesis

Mark Reiley, Fred H. Geisler, David W. Polly, Jr., Leonard M. Rudolf, Arnold Graham-Smith, John Jay Halki, W. Carlton Reckling, A. Nick Shamie

Introduction: Treatment focus in spine has centered on lumbar pathology. 15-30% of individuals presenting with lower back complaints had SI joint (SIJ) problems. The incidence of SIJ degeneration is 75% in patients with previous L4-5 or L5-S1 fusions. An MIS procedure may help to address this significant unmet clinical need. An MIS implant was developed requiring minimal incision using fluoroscopic guidance. The implants are coated with porous plasma spray creating an interference fit to decrease implant motion. Because of size, geometry, and metallurgy, they provide immediate post-op fixation accomplishing the goal of open SIJ fusion through an MIS approach.

Methods: Diagnoses require appropriate interpretation of patient history, clinical exam, and imaging studies (often hip and lumbar pathology coexists with SIJ pathology). If Lidocaine is injected into SIJ and symptoms temporarily resolve, this is excellent confirmation of diagnosis. MIS procedure is performed under general in prone position with implants inserted through 3cm incision. Patients are implanted with three MIS implants across SIJ. A CT is recommended at 3, 12, and 24 months to document implant position and to observe potential bone growth.

Results: This retrospective, post-market analysis covers 52 patients. Patient satisfaction tests were utilized. Clinical significance was consistently good for patients participating in assessments at 6 and 12 months post-op vs. pre-op. 90% of patients indicated they would have the procedure again.

Conclusion: This study reinforces the need for awareness that SIJ issues, including fracture, disruption or dysfunction, are common symptom generators. Traditional treatments have shown limited efficacy. In some patients with residual symptoms after lumbar spine procedures, it may be the SIJ that is the symptom generator. With the advent of this MIS procedure, surgeons may avoid further, unnecessary surgery for failed lumbar fusion patients by looking at SIJ. Multicenter prospective studies are ongoing.

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MR Guided HIFU for Facet Joint Ablation, A Novel Approach for the Treatment of Back Pain: Results of Preclinical Studies

Sagi Harnof, Arik Hanannel, Lilach Shay, Oded Goren, Yael Inbar, Israel Caspi

Introduction: Facet joint arthropathy is a common source of back pain. Currently the best treatment is RF ablation. MR Guided High Intensity Focused Ultrasound (MRgFUS) is a novel breakthrough technology enables a non-invasive accurate ablation controlled by real-time MRI based thermometry. We have conducted the project to evaluate the feasibility of MRgFUS based treatment to achieve an accurate and safe ablation of the facet joint. Hypothesis was that under MR guidance and thermometry we will be able to develop an accurate and safe application.

Methods: The feasibility and safety of MRgFUS was evaluated in four independent experiments: A phantom test in which thermal rise was measured by MR Thermometry in the close vicinity of embedded vertebra. Thermocouple experiments to provide an absolute temperature readings in the target and potential safety hazards. An animal studies in which treatment was applied to the Facet under real time thermometry, follow-up includes imaging, histology and clinical evaluation. Simulation was done on healthy human to validate animal result. All experiments were done utilizing the ExAblate2000 system.

Results: Phantom experiments showed that targeting the facet to elevate the temperature is feasible with high safety profile, thermocouple experiments showed local temperature rise at the target with no rise at the spinal canal/foramina. Animal studies targeting the Facet at 150-400J resulted in controlled local heat with insignificant temperature rise at the spinal canal and foramina, clinical follow-up was insignificant, imaging and histology demonstrated local thermal ablation at the target without any remote damage. Human spine found to be similar to plan and treat.

Conclusion: This experiments has showed that ablation of the facet joint can be done in this non-invasive methods with accurately to create local ablation. MR guidance is extremely useful and enables real time temperature measurements to control efficacy and safety. With the promising results of those preclinical studies a human phase I study is warranted.

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Does Reconstruction of the Anterior Longitudinal Ligament (ALL) Improve the Results of Lumbar Artificial Disc Replacement (ADR)?

Kenneth Pettine, Christian Schlicht

Introduction: The ALL is the most important stabilizer of the lumbar motion segment. Several authors have reported the most common reason for ADR failure is facet pain. Biomechanical data repeatedly emphasizes the importance of the ALL in decreasing facet forces. The Embrace™ is a flexible implant designed to duplicate the biomechanics of the ALL. Biomechanical analysis of the Embrace™ is performed by Cunningham, et al. The Charité and ProDisc-L lumbar ADRs were evaluated before and after reconstruction of the ALL with Embrace™. Axial rotation and extension were significantly decreased ($p>0.05$) following reconstruction of the ALL. Facet micro-strain was also significantly decreased.

Methods: Thirty-nine patients underwent ADR followed by ALL reconstruction. Minimum follow-up was one year. Charité - 24 patients, ProDisc-L - 15 patients. Average age: 38.8 Males - 19, Females – 20. Average BMI - 27.5. One-level ADR - 27 patients, two-level ADR - 6 patients. Two-level hybrid - 4 patients, three-level hybrid - 2 patients.

Results: See charts

Conclusion: Overall clinical success (based on Purcell FDA criteria) was met in 70% of patients at 6 months and 74% at 12 months. There were no differences in the outcome data between ProDisc-L, Charité, one-level, two-level or hybrid patients. These results are superior to the one-level IDE data reported in the Charité (63% success) and ProDisc-L (63.5% success).

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Neuronavigation for Minimally Invasive Transforaminal Lumbar Interbody Fusion: Radiographic and Clinical Results

Jorge Torres, Harry H. Gebhard, Apostolos Tsiouris, Christian Geannette, Roger Hartl

Introduction: It is unclear if minimally invasive TLIF (mTLIF) outcomes are comparable to open TLIF. In addition, accurate pedicle screw placement using MIS techniques can be challenging and requires heightened reliance on radiographic guidance. The use of navigation systems combined with 3D fluoroscopy may be helpful in this setting. The aim of this study was to review operative parameters, clinical and

radiographic outcomes in a series of patients undergoing mTLIF with Iso-C3D Navigation (3D-NAV) assisted minimally invasive pedicle screw instrumentation.
Methods: 53 patients who underwent 3D-NAV assisted mTLIF were reviewed. Clinical and radiographic data were analyzed. Clinical outcomes were assessed with the Oswestry disability index, visual analog scale and Mac Nab scores. Radiographic outcomes were assessed using plain radiography and thin-slice CT.
Results: The mean age at time of surgery was 56.4 years. 178 screws were implanted with a total of 16 pedicle breaches (8.99% misplacement rate/91.01% accuracy rate). Radiographic fusion rate at a mean follow-up of 16 months in patients with bilateral pedicle screws was 91.7% (vs. unilateral screws 64.3%). No revision surgeries were necessary. At 11±6.9 months there was a mean improvement of 4.28 points in the VAS for back pain and 4.5 points for leg pain. Mean ODI improved 12.43 points. The mean post-op disc height gain was 4.84 mm and the mean post-op disc angle gain was 2.87 degrees. There was a correlation between a greater disc space height gain and lower postoperative leg pain and VAS score.
Conclusion: Minimally-Invasive techniques and neuronavigation are evolving fields within spinal surgery. Our data support the conclusion that 3D-NAV is safe and effective and combined with mTLIF can lead to results comparable to open TLIF surgery, while offering the potential advantages of lessened tissue trauma, reduced blood loss, less radiation exposure and shorter length of stay.

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Clinical Usefulness of Intraoperative O-Arm in Minimally Invasive Cervical Microforaminotomy

Jin-Sung Kim, Sang-Ho Lee, Ho-Yeon Lee, Sang Soo Eun, Sun Kwon, David Del Curto
Introduction: This study was done to describe the surgical technique and clinical results of minimally invasive anterior transcorporeal or posterior laminoforaminotomy assisted by an O-arm-based navigation system for the treatment of unilateral radiculopathy due to foraminal disc herniation or foraminal stenosis. Anterior transcorporeal or posterior laminoforaminotomy are promising minimally invasive techniques for treating radiculopathy caused by foraminal disc herniations with or without foraminal stenosis. Their major benefits are avoidance of fusion, thus preserving mobility and stability, and reduced postoperative neck pain.
Methods: Twenty-four patients underwent anterior assisted by transcorporeal foraminotomy (ten) and posterior aminoforaminotomy (fourteen) using O-arm navigation using the Metrix tubular retractor. Main symptoms were unilateral radicular arm pain without axial complaints. Most of them had slight to moderate arm weakness. Study images showed foraminal herniated discs and/or foraminal stenosis in one or two segments. All patients with central disc herniations or spinal canal stenosis, and symptoms of myelopathy or radiculomyelopathy were excluded from the study.
Results: Successful relief of radicular pain was achieved in all twenty-four patients. There were no cases of instability or recurrence except one patient who underwent anterior transcorporeal foraminotomy. This patient showed disc height loss and angular instability due to violation of disc space and uncovertebral joint. Owing to intraoperative feedback to surgeon, 8 out of 24 patients (33.3%) underwent additional foraminotomy after checking the patients using O-arm. The peri-operative complications observed were a dural tear in one patient, which was adequately treated with fibrin glue and bed rest and postoperative wound hematoma in one patient. The duration of the symptoms was 7.6 months on average. The operation time was 128 minutes on average. Additional time for the image guidance surgery based on O-arm based navigation was about 25 minutes on average.
Conclusion: Anterior transcorporeal and posterior microforaminotomy assisted by O-arm-based navigation is a safe, effective and minimally invasive procedure in the treatment of foraminal compressive diseases of the cervical spine, and offers the advantages of preserving segment mobility and stability with decreased postoperative pain and early return to normal activity.

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Fluroscopically-Guided Percutaneous Iliac Screw Placement: Initial Clinical Experience with 17 Cases

Michael Y. Wang, Seth Williams, Praveen V. Mummaneni, Jonathan D. Sherman
Introduction: Percutaneous pedicle screws have become an accepted method for segmental fixation in a variety of settings. However, fixation to the pelvis, which offers unique biomechanical advantages, has remained elusive from a minimally invasive approach. This report describes our initial clinical experience with minimally invasive iliac screw placement using a fluoroscopic technique.
Methods: A retrospective review was undertaken for patients undergoing percutaneous iliac screw placement over a period of 24 months. A total of 17 patients (mean age =53 + 13 years) were treated in this manner at three institutions, using primarily X-Ray guided screw insertion (obturator outlet view technique). Indications for surgery included trauma (N=10), deformity (N=3), infection (N=2), and neoplasia (N=2). All patients underwent early postoperative CT scanning to determine the accuracy of screw positioning within appropriate anatomic confines.
Results: A total of 33 cannulated screws were placed for fixation in the lumbosacral spine using a fluroscopically guided technique. Fixation was to L1 (N=1), L2 (N=5), L3 (N=2), L4 (N=6), and L5 (N=3). Additional iliosacral screw placement was utilized in two cases. Intraoperative blood loss averaged 510 + 784 cc, and total operative time on average was 235 + 170 minutes. Screw dimensions varied between 7.0-9.0 mm in diameter and 65-100 mm in length. All of the percutaneous screws were placed appropriately as verified by postoperative fine cut CT scanning, and there was no evidence of any bony violations or sciatic notch encroachment. Complications included a 75-year-old patient suffering a sacral fracture who died of unknown causes on postoperative day 10.
Conclusion: An image-guided technique for iliac screw placement can be performed safely with a low likelihood of bony violation. This technique offers unique advantages for stabilization of the lumbosacral junction and represents a significant advance in the field of minimally invasive spinal surgery.

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Degree of Correction of Cervical Kyphosis Using Sub-axial Facet Osteotomies

Nathaniel P. Brooks, Sharad Rajpal, Edward C. Benzel
Introduction: Symptomatic cervical kyphosis can be difficult to treat surgically requiring multiple surgical approaches to achieve a satisfactory result. Improved lordosis has been shown to be associated with less propensity for further degeneration and improvements in myelopathy.(1) There are multiple techniques to correct a cervical deformity

including ventral and dorsal approaches. The degree of correction obtained with a bilateral facet osteotomy in the sub-axial cervical spine is not well described. The goal of this study is to evaluate the degree of correction obtained using facet osteotomies in the sub-axial cervical spine.

Methods: This a retrospective review of the senior author's cases. Eight patients were candidates for the study. They had a dorsal only approach for cervical deformity correction with facet osteotomies in the sub-axial cervical spine for myelopathy and/or neck pain. Two of the patients died peri-operatively, one from a ruptured colon and the other from myocardial infarction, and were not included in the study. Therefore, a total of six patients were enrolled in the study to evaluate initial correction. Only five patients completed at least 12 months of follow-up. Pre and postoperative upright lateral radiographs were used to measure the angle of intersection of the perpendicular to the inferior endplate of C2 and C7 (Cobb angle), as described by Gwinn et al.(2) The measurements were obtained by two fellowship trained spine surgeons.

Results: The initial average degree of correction per level was 11 degrees (SD = 10.8 deg). The degree of correction per level with a minimum of 12-months follow-up was 10 degrees (SD = 8.7 degrees).

Conclusion: Dorsal facet osteotomy in the sub-axial cervical spine can be used to obtain lordotic correction of the cervical spine. Care must be taken as these patients have significant morbidity and mortality associated with cervical deformity correction by any technique.

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Outcomes of MIS Spinal Fusion: 12 and 24 Months

W.B. Rodgers, Edward J. Gerber, Jody A. Rodgers

Introduction: XLIF outcomes at 1 year are presented and are compared with initial 2 year data.

Methods: Consecutive series of 941 XLIF patients, 451 follow-up at 12 months and 191 at 24 months. Clinical and radiographic measures were prospectively evaluated to assess pain scores, changes in disk height and alignment, listhesis, and fusion and correlated to a patient questionnaire of satisfaction at 12 months.

Results: Age ranged from 25-87 years (avg 62.7 yrs). VAS improved from 8.8 pre-op to 2.9 at 12 months. Disk height improved from 6.7mm to 10.8mm at post-op, settling about 1mm to 9.4mm by 12 months. Listhesis was reduced from 4.5mm to 0.75mm, maintained at 12 months. Definitive signs of fusion (Lenke 1-2) were present in 87% at 3 months, 96% at 6 months, and 98% at 12 months. In the 2 year group, VAS was reduced from 8.6 to 2.7, disc height gained was maintained at 12 and 24 months (9.1mm). Slip reduction was also similar and maintained at 24 months (0.8mm). Signs of fusion were present in 98.8% at 24 months. At 12 months, 88% were very satisfied or satisfied with their surgery. 89% would definitely or likely do the surgery again. 77% were considered excellent or good outcomes by the surgeon.

Conclusion: Our data shows satisfactory intermediate term clinical outcomes in our series of XLIF. VAS scores improved, disk height was restored and maintained, and slip was reduced. Patient and surgeon satisfaction scores at 12 months are encouraging.

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Clinical Significance of Hypermobility in Cervical Artificial Disc Replacements

Kenneth Pettine, Christian Schlicht

Introduction: Normal range of motion in terms of total flexion/extension at C4-5 averages 18.8º, C5-6 averages 18.4º and C6-7 averages 15.4º. Cervical artificial discs have been designed to emulate normal spine kinematics. The Prestige ST and the ProDisc-C are designed to allow 10º of flexion from a neutral position and 10º of extension for a total 20º of range of motion. The Bryan allows 22º total range of motion.

Methods: Published FDA IDE data was evaluated from the Prestige ST, ProDisc-C and Bryan disc in terms of range of motion at the operated level. Internal analysis of these hypermobile patients by each company revealed no difference in their FDA success. Preoperative flexion/extension views do not correlate with patients who post op develop hypermobility. Overall range of motion of the entire cervical spine remains within normal limits in these patients. Thus, more motion is occurring at the cervical artificial disc replacement than adjacent levels which may decrease the incidence of adjacent level degeneration. This is opposite compared to fusion.

Results: Histograms of the Prestige ST, ProDisc-C and Bryan disc indicate 15% of Prestige ST patients, 24% of ProDisc-C patients and 6% of the Bryan disc patients had greater than 14º of total motion in flexion/extension. These results are based on a single flexion/extension x-ray at two-year follow-up. In terms of the total group, these patients are considered to have hypermobile cervical artificial discs.

Conclusion: The average range of motion reported after CADR is 8º of total flexion/extension, substantially less than the 15-18º considered normal range of motion. If the goal of artificial discs is to emulate normal spine kinematics, hypermobility may be a desirable result. At two-year follow-up no conclusions can be made whether these hypermobile patients demonstrate long-term clinical advantages.

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Evaluation of Interlaminar Lumbar Instrumented Fusion (ILIF) in a Sheep Model

Hyun Bae

Introduction: Every year nearly 100,000 spinal fusions are performed to treat degenerative conditions of the lumbar spine. Various surgical techniques are utilized to eliminate motion and instability at a diseased lumbar segment, each with its intrinsic surgical advantages and disadvantages. The most frequently utilized surgical techniques include interbody arthrodesis and posterolateral fusion, and less commonly, but growing in popularity, interlaminar/interspinous fusion procedures.

Methods: 8 sheep received an interspinous process translaminar procedure at L2-3 and L4-5 and were grouped into two different treatment categories: Group I with a biologic in all levels and Group II with allograft spacer only in all levels. Specifically, Group I: (n=4) allograft spacer with biologic with a spinous process plate, or allograft spacer with graft material alone; Group II: (n=4) allograft spacer together with a spinous process plate, or an allograft spacer alone. Upon euthanization, the spines were explanted and a full histological and radiographic (radiographs and CT) evaluation was conducted to assess fusion.

Results: 16 spinal levels were treated. Histological and radiographic reports demonstrated that the specimens implanted with a spinous process plate, allograft spacer, and biologic showed the presence of bridging bone and graft remodeling, while the specimens without a biologic were incompletely fused. Bony fusion was unequivocal in 4/4 of the operative levels in the interspinous plate +bone allograft+biologic group. Bony fusion was seen radiographically in 2/4 of

the operative levels in the interspinous plate+bone allograft group. In the allograft+graft substrate group (no plate), fusion was apparent in 4/4 of levels and 2/4 fused in the allograft only group.
Conclusion: ILIF is a less disruptive approach to traditional instrumented posterior lumbar decompression and fusion. Based on the sheep model, this procedure results in a fused segment in the lumbar spine when treated in conjunction with an allograft spacer, a spinous process plate, and a biologic.

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Redesigning A K-Wire Limits Inadvertent Advancement: A Biomechanical Study

Carolyn Hardin, Joshua E. Preiss, Sergio Gutiérrez, Robert E. Isaacs

Introduction: The migration of K-Wires is a well-known complication that can occur with potentially catastrophic consequences. This study investigates a guidewire technology designed to increase the force it takes to advance a K-Wire after it is deployed.
Methods: A biomechanical study was designed to test the force required to displace the guidewire through both cancellous and cortical bone. Guidewires were placed at every vertebral level between L1 to L5 in human cadaveric specimens. The design was internally randomized between a standard guidewire and a Y-Wire™, allowing each vertebra to serve as its own control. Displacement and axial load were measured. The regions of interest were the mid-vertebral cancellous bone and the anterior cortical wall.
Results: The force for a standard wire stayed roughly the same throughout the cancellous bone tested (p=0.83). In contrast, the force to advance a Y-Wire™ increased in a linear fashion. The median cancellous force values exceeded 400% of the values obtained from a standard guidewire (435%, range 272%-2136%). The force to displace a Y-Wire™ exceeded the cortical values obtained in the same vertebra after it was deployed 5.0 mm (range 1.0-8.4 mm). Additionally, the force required to breach the anterior cortex with a Y-Wire™ was 219% greater than a standard guidewire (p<0.001, range 184%-7129%).
Conclusion: Y-wire™ offers the ability to increase the push-in force to advance a guidewire placed into cancellous bone to values that exceed the force which cause standard guidewires to break through the anterior cortex. By altering the distal tip design of a guidewire, Y-Wire™ substantially decreases the chances of inadvertently advancing a guidewire away from its desired location.

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A Systematic Review of Accuracy and Comparison of Intraoperative Biplanar and Volumetric Image Guidance Systems

Alan T. Villavicencio, Alexander Mason, Ewell Lee Nelson, Sharad Rajpal, Frances A. Carr, Brittany Weeks, Sigita Burneikiene

Introduction: Intraoperative spinal navigation has evolved to allow surgeons the ability to utilize real time visualizations of the surgical site. The literature reports comparably low rates of pedicle screw misplacement using volumetric three-dimensional navigation, but greater accuracy is inherently associated with increased radiation exposure. The study was undertaken to examine the accuracy of pedicle screw placement and compare two-dimensional and volumetric intraoperative image guidance systems using a systematic literature review method. This method will allow us to make more generalized conclusions and potentially justify increased radiation exposure for the tradeoff of screw placement accuracy.
Methods: A PubMed literature search was conducted to explore published literature that focused on the accuracy of pedicle screw placement using intraoperative image guidance in clinical settings. The search identified articles that analyzed accuracy of volumetric and biplanar image guidance systems.
Results: We analyzed 32 studies with collected data from 1991 to 2008. The studies totaled 8,072 pedicle screws and, of these, 7,278 were placed accurately, yielding a total of 90.2% accuracy rate. When comparing accuracy of the two systems, there was a significantly higher rate of misplaced screws when two-dimensional navigation was employed ($?2=206.85$, df =1, $p < 0.0001$). Out of the total of 794 misplaced pedicle screws, 73.3% (582) were misplaced using two-dimensional imaging system compared to 26.7% (212) using volumetric intraoperative image guidance systems. Further, 14.7% of the total screws placed utilizing biplanar fluoroscopy were misplaced vs. a misplacement rate of 5.2% of the total volumetrically placed screws. The accuracy of pedicle screw placement between the levels of the vertebral spine resulted in the identification that there were more misplaced screws in the thoracic compared to lumbar and lumbar spine ($?2= 81.23$, df = 2, $p < 0.0001$).
Conclusion: The results of this study suggest a significantly greater rate of pedicle screw placement accuracy when volumetric intraoperative navigation is used. This increased accuracy is noted in all levels of the vertebral spine.

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Stabilizing the Spine Following Disc Herniation: A Feasibility Study of a New Technique

Werner Schmolz, Daniel B. Murrey, Finn Christensen, Bruce Robie

Introduction: 60% of patients with disc herniations have significant back pain preoperatively[1], and back pain has been associated with excessive axial rotation[2,3]. A device that resists axial rotation might positively impact low back pain. A dynamic stabilization device resists axial rotation and consists of a specially designed suture anchor, a high strength suture and a button, placed parallel to the disc space (Fig. 1). The purpose of this experiment was to determine whether the ARO would restabilize the spine in axial rotation without impacting other motions following a herniation.
Methods: Lower lumbar spine cadaver specimens were tested in a six DOF spine tester. Four specimens were tested intact, with a unilateral incision through the posterolateral annulus (herniation), then with the stabilization device. Loads were applied in flexion, extension (F/E), bilateral lateral bending (LB), and bilateral axial rotation (AR-A - away from the herniation, and AR-T - towards the herniation). Displacements were measured. Results were reported as median percent of intact motion.
Results: The simulated herniation increased motion in AR-A to 115% of intact. Lesser impacts were in lateral bending (LB) (108%), AR towards (AR-T) the herniation (107%), and F/E (102%). The device restored stability in AR-A (96% of intact) and had minimal impact in F/E, AR-T and LB (99%, 104% and 105% of intact, respectively).
Conclusion: The results show that the ARO successfully resisted excessive axial rotation resulting from a model herniation, while having minimal impact in other directions. The results are consistent with previous testing of cadavers with and without herniations[4,5]. As low back pain has been associated with excessive axial rotation[2], the device might clinically impact low back pain. Further development and testing of the ARO device appears warranted.

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Management of Thoracolumbar Flexion Distraction Injuries

David Kung, Patrick W. Hitchon

Introduction: Thoracolumbar flexion-distraction injuries result from disruption of the posterior tension band and involve all three vertebral columns. Surgical treatment is often required for these unstable injuries, partly because the associated ligaments heal poorly, despite reduction and prolonged immobilization. Conservative management often results in kyphotic deformity. We present our 7-year experience with management of thoracolumbar flexion-distraction injuries.

Methods: We reviewed our prospectively collected spine trauma database and identified 23 cases of thoracolumbar flexion-distraction injuries from May 2003 to August 2010. Demographic, clinical, radiographic and surgical data were reviewed.

Results: Twenty-three patients were identified. The mean age was 26 years. Male to Female ratio was 2:1. Seventeen cases resulted from motor vehicle accidents, five cases involved falls from a height, and one from a skiing accident. All patients were recommended surgery, but one declined. Radiographically, all patients had injury to the posterior ligamentous complex which includes the supraspinous ligament, interspinous ligament, ligamentum flavum, and facet joint capsules. Levels of injury spanned T4 to L2. The most commonly injured level was L1, followed by T12. With the exception of 2, all surgical patients underwent open reduction and posterior instrumentation. Three patients underwent short segment instrumentation, defined as less than two levels above and two levels below the injured level. Mean follow-up was 14 months. Kyphotic angulation improved by 5.5 degrees on average. Two patients required revision for misplaced pedicle screws. One patient developed wound infection that was treated conservatively. The patient who declined surgery has persistent back pain and progression of kyphosis from 8 degrees on initial admission to 32 degrees at 5 month follow up.

Conclusion: Our experience shows that for thoracolumbar flexion-distraction injuries, a posterior approach with instrumentation is sufficient to restore stability, correct deformity, and decompress the neural elements. Percutaneous screw fixation my further simplify the surgical management of this injury.

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Complications and Oncologic Outcomes After Multilevel En Bloc Spondylectomy in 11 Patients

Marcella Madera, Ilya Laufer, Ziya L. Gokaslan, Ali Bydon, Daniel M. Sciubba, Timothy F. Witham, Jean-Paul Wolinsky

Introduction: En bloc spondylectomy has emerged as a surgical treatment of spinal primary and metastatic tumors when oncologic resection is desired. These procedures are technically demanding, and multilevel en bloc spondylectomy has been reported in limited cases in the literature. The purposes of this study are to explore the complications that multilevel spondylectomies incur, to determine if level of resection affects rate of complications, and to explore the rate of local control that can be achieved with this approach.

Methods: We retrospectively reviewed all the en bloc spondylectomies done at our institution from 2004-present and evaluated the complications of all multilevel cases.

Results: Of 38 total en bloc spondylectomies, 11 patients underwent multilevel surgery (8 for primary and 3 for metastatic tumors). Distribution of cases was as follows: 1 cervical (C2-4 resected), 1 cervicothoracic (C7-T3), 4 thoracic (T1-3, T7-8, T6-7, T1-5), 1 thoracolumbar (T12-L2), and 4 lumbar (3 at L4-5 and 1 at L3-5). There was a 100% major complication rate in the cervical, cervicothoracic, and lumbar cases. There were no complications in the thoracolumbar case, and the major complication rate for thoracic cases was 25%. No patients had recurrence at last follow-up (median 8 months, range 1-32 months). There were no perioperative deaths. 2 of the 3 patients with metastatic disease died after last follow-up.

Conclusion: Multilevel en bloc spondylectomy has a high major complication rate in the cervical and lumbar spine, but our results suggest that thoracic resections may be less morbid. None of the multilevel spondylectomy patients in our series had recurrence at last follow-up. Although our series is small, it represents the largest series in the literature for multilevel en bloc spondylectomy focused on critically evaluating complications. This data will help surgeons make educated decisions with patients; the risk of major complications must be weighed with the oncologic result.

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Complications of Open vs. Minimally Invasive Lumbar Spine Decompression

Richard G. Fessler, Patrick Shih, Timothy R. Smith

Introduction: Lumbar stenosis is a debilitating disease with significant morbidity. Minimally invasive modalities have demonstrated efficacy in the treatment of neurogenic claudication. Direct comparison, however, between complication rates of these newer techniques with open surgical techniques for lumbar decompression are lacking.

Methods: This single-institution study examined neurogenic claudicants between August 2007 and June 2009. 26 patients received open surgical decompression, and 23 patients microendoscopic decompression. Baseline demographic characteristics, peri-operative morbidity and mortality, length of hospital stay, and final disposition following hospitalization were recorded. Morbidity was divided into major and minor categories as defined by degree of requisite intervention and adverse impact on hospital stay.

Results: Average age, number of surgical levels, and preoperative ASA scores were similar in each group ($p>0.05$). There was a trend towards longer operative time associated with the minimally invasive surgical group (meanopen=112.0 min, SDopen=50.0 min, meanMIS=141.7 min, SDMIS=56.0 min, $p=0.056$). When compared to the minimally invasive surgery group, the open surgical group had higher average EBL (meanopen=139.81 ml, SDopen=133.9 ml; meanMIS=61.9 ml, SDMIS=67.4 ml; $p=0.027$), and longer length of hospital stay (meanopen=2.9 days, SDopen=2.0 days; meanMIS=2.0 days, SDMIS=2.4 days; $p=0.004$). There was a trend toward increased utilization of ancillary support after discharge in the open surgery group (23% in the open group vs. 4% in the MIS group, $p=0.063$).

Conclusion: This study demonstrates that minimally invasive decompression is at least as safe as open decompression for lumbar stenosis. While MIS may be associated with slightly longer operative times, there is decreased blood loss, shorter hospital stays, and likely decreased requirements for ancillary support services upon discharge.

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The Use of the Mayfield Frame Facilitates Trajectory in Anterior Odontoid Screw Fixation

Jonathan A. Grossberg, Heather Spader, Thomas W. Belknap, Adetokunbo A. Oyelese

Introduction: Type II odontoid fractures may be managed with halo immobilization, posterior fusion, and anterior odontoid screw fixation. While anterior odontoid screw fixation has shown excellent fusion results, screw placement is difficult and contraindicated in posteriorly displaced fractures and in barrel-chested patients because of difficult screw trajectory. We report our experience using three-point cranial fixation, with a Mayfield headframe to aid in alignment and screw placement of complex fractures.

Methods: Demographic and outcome data were retrospectively collected in 19 patients with type II odontoid fractures treated with Mayfield assisted anterior odontoid screw fixation. The Mayfield frame allowed neck extension to reduce posteriorly displaced fractures and to achieve a favorable screw trajectory in barrel-chested patients.

Results: Mean patient age was 71.4 (Range: 37-92); Six of the patients were female and eleven were male. Seven of the nineteen patients had fractures with radiographically measured posterior displacement of the fracture fragment of greater than 2 mm. The mean displacement in these patients was 5.8 mm (Range 3-8 mm). At least three of the patients had barrel chests that would have precluded anterior odontoid screw placement without the Mayfield. There were no instances of hardware complications on follow-up. No procedure was aborted because of poor trajectory or inability to reduce the fracture. There were no mortalities in the population. Complications included pneumonia (five patients), gastrostomy tube placement due to patient failing swallow evaluation (six patients), and vocal cord paralysis (one patient).

Conclusion: Utilization of a three-point Mayfield fixation frame allows the achievement of favorable screw trajectory for anterior odontoid screw placement in posteriorly displaced fractures and in barrel-chested patients. It represents a novel modification of a well established procedure that allows screw placement in heretofore difficult patients while avoiding the morbidity and loss of range of motion from a posterior fusion in this population.

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Effect of Post-Operatory Deep Wound Infection in Lumbar Arthrodesis on the Long-Term Outcome in Patients with Degenerative Disease: A Case-Cohort Study

Asdrubal Falavigna, Orlando Righesso, Alisson Teles, Pedro Guaresi Silva

Introduction: Deep wound infection is one of the most common and serious complications in spine surgery. The influence of this kind of complication on long-term outcome for the patients is not well established. The purpose of this study is to evaluate the satisfaction and functional outcome in patients with deep wound infection after lumbar arthrodesis for degenerative disease.

Methods: A case cohort study with 13 patients with clinical and radiological diagnosis of lumbar spondylosis who that presented deep wound infection after decompression and instrumented surgical procedure between January of 1997 and January of 2010. A 3:1 cohort (n=39) was selected for the comparisons, based in the following variables: gender, age and period of surgery. The patients were treated with wound opening, collection of material for microbiological examination, thorough washing, debridement of devitalized tissues, placement of continuous washing system, primary suture of the wound and intravenous antibiotic therapy followed by oral administration. In all cases the instrumentation was maintained. Validated instruments were used to evaluate pain, numerical rating scale of pain (NRS), disability, Oswestry Disability Index (ODI), quality of life, short-form 36 (SF36), anxiety and depression, Beck depression scale (BDI) and Hospital Anxiety and depression scale (HADS) and patient satisfaction.

Results: The median patient follow-up was 22 months (P25: 12 - P75: 32; min: 6 - max: 108). The mean age was of 61.74 (±9.78) and 59.6% of the patients were female. There was no significant difference in the evaluation of pain, functional disability, quality of life, depression and anxiety. However, 53.8% of the patients with infection were considered dissatisfied with the procedure on the final evaluation, compared with 15.4% of the patients without deep wound infection (p=0.001).

Conclusion: Patients submitted to lumbar arthrodesis who that presented postoperative deep wound infection are more likely to be dissatisfied with the procedure than patients who did not present wound infection in the long-term outcome.

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The Finite Helical Screw Axis and the Kinematic Response of the Lumbar Spine

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Introduction: Spinal fixation for a myriad of vertebral and spinal injuries continues to evolve and so too has the implants for spinal fixation. The appropriate implant(s) to assist arthrodesis at diseased levels and enhance lumbar spinal fixation in a timely and durable manner is unclear. Finite helical screw axis has been one of many parameters used to explain the kinematic response of a spinal construct to loading. The aim of this study is to explain this concept in relation to spinal fixation with both rigid and semi-rigid rods.

Methods: Six lumbar cadaveric specimens were used. The specimens were stripped of all soft tissue with osteoligamentous structures retained. In addition, the specimens were thoroughly assessed for levels of degeneration and underwent bone density scanning and CT imaging. Biomechanical testing including flexion and extension bending, axial compression lateral bending and torsional testing. Treatments were carried out from least invasive to most invasive. The intact spine was examined following discectomy and implantation of interbody grafts; and spines with rigid or semi-rigid rods along with interbody grafts. The semi-rigid rod was tested in three locations: midway between and against each superior and inferior pedicle screws. One-way repeated-measures ANOVA was used for statistical analysis with $p<0.05$ considered significant.

Results: The shift in the finite helical axis with respect to the intact spine was assessed. It is well known that rigid posterior fixation shifts the axis posteriorly, and this is not refuted by our data. However, no difference was detected in the way the axis was shifted by the rigid and semi-rigid rods. Also, it did not seem to matter how the rod was positioned. There were no statistically significant differences detected between treatment groups in any mode of loading.

Conclusion: There were no differences between treatment groups. Therefore, with respect to fused vertebrae, semi rigid rods and rigid rods showed no significant difference when movement was considered.

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Initial Discectomy May Affect Adjacent Disc Level Associated with Progress of Degeneration and Aging

Ali Dalgic, Ali Yildirim, Onder Okay, Ergun Daglioglu, Ozhan Uckun, Osman Nacar, Cagatay Ozdol, Ersin Polat, Deniz Belen

Introduction: Failure of surgical treatment for lumbar disc herniation (LDH) can be commonly caused by recurrence of LDH and new LDH at the different level. There are many debates regarding the risk factors of rLDH and it is very difficult to define them because many clinical and complicated biomechanical parameters are involved. The purpose of study was to evaluate the long term result of re-discectomy for LDH at the same level and adjacent segments.

Methods: Between 1999 and 2009, overall 1898 cases were operated on 142 (6.4%) patients underwent re-discectomy following initially operation. The study included 65 patients who were operated on single level discectomy, and their charts analyzed retrospectively.

Results: There were 32 (50%) women and mean age was 45.5 years (range, 24 - 73 years). rLDH was diagnosed at initial level in 39 (60.9%), but adjacent and/or opposite level herniation (with or without the first level) were founded in remaining 25 cases (39.1%). Recurrence at same level (SLG) and adjacent level groups (ALG) were similar according to the clinical outcomes in follow-up meanly (34.1 months). Admission period after initial operation was also parallel SLG and ALG (54.7 and 53.1 months, respectively) however mean age of ALG (49.4) was significantly higher (p=0.05) than SLG (42.8).

Conclusion: As the pathologic changes have been correlated with excessive resection of bony structures and soft tissue, responses to axial compression on intervertebral disc pressure caused to deformations of adjacent neural arches despite of its appear to be limited. Eventually, the symptoms due to accelerated degeneration can already be found after 2 years and collapsed discs are biomechanically more stable than those with preserved disc height. However, stable segment eliminated motion of the functional spinal segment and may overload the adjacent segments. Finally, altered biomechanical loading next to a fusion resulted in ongoing degeneration with aging at the affecting entire lumbar spine.

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Comparison of Navigated vs. Non-Navigated Pedicle Screw Placement: Screw Accuracy and Complexity of Surgery

Neal Luther, Harry H. Gebhard, Tatianna Olivia Saleh, Juliano Fratezi, Apostolos Tsiouris, Roger Hartl

Introduction: Pedicle screw fixation is an effective method for achieving fusion in the thoracic and lumbar spine. However, incorrectly positioned screws which significantly breach the pedicle can cause spinal cord, nerve root, or vascular injury, as well as dural tears and CSF leaks. These potential risks are heightened in cases where other factors increase complexity, such as previous surgery which may distort anatomy, or the presence of deformity. Computer 3D navigation (3D NAV) techniques in spinal instrumentation can theoretically improve screw placement accuracy and reduce potential injury to critical neurovascular structures.

Methods: We retrospectively analyzed the accuracy of 3D NAV in pedicle screw placement for 109 patients (526 screws) in comparison to screws placed with conventional lateral fluoroscopy in 84 patients (600 screws) on postoperative CT scans using a four-point scale (0-3). Complex cases were deemed as those with significant deformity, previous surgery, or a minimally-invasive approach. We evaluated whether specific preoperative surgical criteria with regards to complexity influenced the use of 3D NAV.

Results: Screw accuracy overall was compared statistically between the 3D NAV and the lateral fluoroscopy group by Fisher's exact test. The number of grade 0 vs. grade 1 and higher (i.e. breached screws) in both groups were compared. No significant difference was seen between groups (p=0.08). The use of 3D NAV strongly correlated with case complexity, as 92% were designated as complex, whereas 79% of the fluoroscopy cases were complex (p<0.05).

Conclusion: The use of 3D NAV results in highly accurate screw placement when compared to standard fluoroscopic guidance, and may be of particular utility in cases of higher degrees of complexity.

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Effect of a Novel Annular Repair Device (Barricaid) on Same Level Recurrent Disc Herniation and Disc Height Loss After Primary Lumbar Discectomy: Results of a Multicenter Non-randomized Prospective Cohort Study

Scott Parker, Kaisorn L. Chaichana, Darko Ledic, Milorad Vilendecic, Matthew J. McGirt

Introduction: A subset of patients will experience same-level recurrent disc herniation and disc height loss and degeneration after lumbar discectomy. Techniques to reduce these consequences may improve outcomes after lumbar discectomy. In a prospective, non-randomized, comparison cohort study, we set out to evaluate if an annular repair device could be implanted safely, reduce same-level recurrent disc herniation, or attenuate disc height after lumbar discectomy.

Methods: Fifty-four patients undergoing lumbar discectomy for a single-level herniated disc at two institutions were prospectively followed with clinical and radiographic evaluations every three months for one year after surgery (control cohort). Subsequently, a second consecutive cohort of 30 patients undergoing 31 lumbar discectomies with implantation of an annular repair device (Barricaid) was followed for 12 months. Incidence of recurrent disc herniation, percent disc height loss, and leg and back pain visual analogue scale (VAS), Oswestry Disability Index (ODI), and quality of life (SF-36) were compared between cohorts.

Results: Cohorts were similar in regards to age, weight, preoperative disc height, and level of disc herniation, Table1. Recurrent same-level disc herniation occurred in 5 (9.2%) patients in the control cohort vs. 0 (0%) patients in the annular repair cohort (p=0.08). Mean one-year percent disc height loss was 26.4% in the control cohort vs. 13.8% in the annular repair cohort (p<0.01), Figure 1. Patients in both cohorts experienced significant (p<0.01) improvement in back and leg pain VAS, ODI, and SF-36, Figure 3. Twelve months after discectomy, patients in the annular repair cohort experienced less leg pain compared to the control cohort (VAS: 0.6 vs. 1.6, p<0.05), Figure 2.

Conclusion: Implantation of a novel annular repair device was performed without any device related morbidity and was associated with a reduction in postoperative disc height loss, a trend of

reduced recurrent disc herniation, and improved one-year leg pain.

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Digital Protractor as a Supplement to Thoracic and Lumbar Pedicle Screw Placement: A Cadaveric Study

Maureen A. Darwal, Bradley T. Bagan, Mirza N. Baig, Robert A. Hirschl, Chris S. Karas

Introduction: The objective of this study is to test the ability of a novel device to assist in the insertion of pedicle screws with respect to the medial-lateral angle.
Methods: A digital protractor was added to the handle of a surgical multi-axial screwdriver. The device was zeroed at a plane parallel to the spinous process at the anatomic entry point, and then moved laterally to an angle already defined in a previous anatomical study by Zindrick et al. (2000), which corresponds to the medial angulation of the pedicle. Screws were inserted by the device at the specified angle. The procedure was performed at levels T1-L5 with the addition of lateral fluoroscopy in the lumbar spine to define the superior-inferior angle. Medial-lateral angles of each screw were confirmed on postoperative CT scan. Successful screw placement was defined as standard pedicle purchase or purchase parallel to the pedicle in the medial-lateral plane.
Results: At all levels the screws purchased the pedicle entirely or were implanted with partial purchase and with an angle parallel to the pedicle. All screws were successfully angulated in the medial-lateral plane using the novel device, including those placed by individuals with no previous spinal instrumentation experience.
Conclusion: The addition of a digital protractor to current spine instrumentation is a useful adjunct to the accurate placement of thoracic and lumbar pedicle screws. Further studies must be done to more precisely define the proper entry point when considering the supplementation of pedicle screw placement with digital protraction.

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Avoid Failed Back Surgery Syndrome Due to Lumbo-sacral Epidura1 Fibrosis

Iñaki Arrotegui

Introduction: The objective of this Prospective, Randomized Controlled Trial was to investigate the potential benefits of using the Collagen Dural Matrix as an adhesion barrier following spine surgery in order to avoid periradicular lumbar fibrosis.
Methods: 2006-2008 (DuraGen Plus 200 cases 2-years follow-up) was conducted by the investigator at a single site OUTCOME MEASURES: Clinical follow-up: 2 years, 1 month, 6 months, 1- 2 years Gadolium IRM (if complain of pain). Postoperative Pain Assessment at each time point: 2 = No Pain, 3 = Mild Pain, 4 = Moderate Pain, 5 = Severe Pain. VAS questionaire Extent of Fibrosis graded by Gad-MRI: Control Group 100 standr procedure (Discectomy) 2006 Matrix Group 200 standr+ matrix (2006). Clinical follow-up+stadistical tests+vas questionaire
Results: Results from the DuraGen Group Postsurgical fibrosis was found in 1.8% vs. 6% S group. Pain Outcomes: Results from the Control Group (Standard Practice). Patients with more fibrosis, shown by the arrows, exhibited more significant symptoms. Mean post operative pain scores for the DuraGen Group were lower at all time points and statistically lower at 3 to 6 months. The difference in re-operation rate between the collagen matrix group and the standard procedure group is statistically significant ($p<0.001$).
Conclusion: The use of DuraGen plus resulted in statistically significant surgical outcomes 1.8 % vs 6 % None of the 100 patients from the collagen Group required re-operation due to clinical symptoms.

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Collagen Dural Matrix Used To Avoid Complications In Carpal Tunnel Release

Iñaki Arrotegui

Introduction: A thorough knowledge of the anatomy of the carpal tunnel is essential in order to avoid complication and to ensure optimal patient outcome. There are many strong arguments for open (Short Incision 2.5 cm) vs. conservative treatment.
Methods: The study cohort (collagen matrix group) consisted of consecutive patients (250 patients) who were treated with collagen Dural matrix. Patients in the standard procedure group (250 patients in all) were operated on prior to the adoption of matrix use by the surgeon. OUTCOME MEASURES: Patients underwent carpal tunnel surgery same technique in both groups and completed follow-up evaluations at no less than 12-months post-operation. Clinical symptons EMG studies, VAS questionaire **Methods:** All patients complained of numbness and/or sensory or weakness disturbance in the median nerve distribution of the hand. Tinel and phalen sign tests were positive in approximately two-thirds of the patients. EMG studies were performed in all patients and were positive between mild to severe.
Results: Numbness and paresthesias were relieved in 89% DG group and 86% in Control Group; pain was relieved in 89% DG and 86% CG. Motoric Weknes was relieved in 95% DG and 92 % CG. Normal grip strength was found in 93% DG and 91% had normal pinch strength. Control group: Adhesion of the flexor tendons in 3 patients. 5 patients had scarring of the median nerve. DuraGen group: Recurrent pain: 1 patients for incomplete division of transverse carpal ligament The difference in re-opration rate between the collagen matrix group and the standard procedure group is statiscally significant ($P<0.01$).
Conclusion: Findings in this study (reduced pain and lower incidence of adhesions) are consistent with the Collagen Dural Matrix acting as an effective adhesion barrier.

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Minimally Invasive Lumbar Fusion (XLIF) Using a ² TCP-HA Bone Graft Substitute (FormaGraft): Fusion Rates Out to 2 Years

W.B. Rodgers, Edward J. Gerber, Jody A. Rodgers

Introduction: Good short-term outcomes post-XLIF have been shown. Fusion outcomes have been assumed to meet or exceed those of other interbody fusion procedures due to access for greater disk preparation, large structural implant, and retention of stabilizing ligaments. No reports to date focused on fusion rates associated with XLIF, or on the graft materials used in XLIF. Given the limitations of autograft, many surgeons use bone morphogenic protein in lumbar fusions. However, early resorption and hospital cost have fueled consideration of other bone graft substitutes.
Methods: The use of a beta-tricalcium phosphate/hydroxyapatite (FormaGraft) with bone marrow aspirate (BMA) was prospectively studied in 57 consecutive 1- and 2-level XLIF procedures. Radiographic outcomes were evaluated to demonstrate fusion and were compared with clinical results.
Results: Patient age ranged 25-79 years (ave55.9yrs). Primary diagnoses included stenosis (31), DDD (12), spondylolisthesis (8), and HNP (6). Comorbid conditions included previous spine surgery (47.4%); smokers (40.35%); diabetes (22.81%); chronic steroid use (8.77%); obesity/morbid obesity (52.6%). 64 levels were treated: 50=1-level, 7=2-level; 1 at

T8-9, 4 at L1-2, 6 at L2-3, 16 at L3-4, 37 at L4-5. Graft included equal amounts by volume FormaGraft and BMA, aspirated from adjacent vertebral body (lateral exposure). All included supplemental fixation. Hgb change and hospital stay averaged 1.20g and 1.04 days. Complications included one iatrogenic HNP requiring secondary decompression. One patient died at 10 months post-op, unrelated to his surgery. Average disk height improved from 6.35mm to 10.86mm, maintained at 10.0mm at 24 months. Fusion by Lenke score=1 and 2 was 90.0% at 24 months. Average VAS pain scores decreased from 9.0 pre-op to 3.2 and 3.6 at 12 and 24 months. 89% expressed satisfaction at 12 months, and 89% said they would do it again.

Conclusion: XLIF has proven to be a safe, effective procedure, and now 24-month results using ßTCP-HA bone graft substitute confirm fusion, maintenance of improvements, and overall patient satisfaction.

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PLIF: Implications for the Post-op Radiological Examination and QoL

Nikolaos Syrmos, Mario Ganau, Cristian Gragnianiello, Dimitrios Arvanitakis

Introduction: The aim of this study is to evaluate the clinical and radiological results after PLIF surgery for lumbar Degenerative Disc Disease (DDD) and instability in a consecutive series of 24 patients.

Methods: By using appropriate clinical scales (VAS, JOA and SF-36) and repeated radiological exams (plain X-rays and CT scans) the following parameters have been reviewed: clinical satisfaction, quality of life (QoL), cage size, segmental lordosis and pre/post-op ratio of the intersomatic distance.

Results: VAS score decreased significantly after surgery, as well a remarkable increase in the JOA score was noticed in all patients, even in cases of low pre-op values. The SF-36 test confirmed good results in terms of QoL. Radiological analyses of cage size, segmental lordosis and pre/post-op ratio of the intersomatic distance allowed for a quantitative evaluation of surgical **Results:** good correction of spinal instability and increase in disc height was always achieved despite a slight reduction in lumbar lordosis. No cases of cage dislocation were noticed during the follow up (up to 36 months).

Conclusion: It seems that expandable cages give more advantages in terms of prevention of rotation and retropulsion after interbody placement, nevertheless no data actually support this hypothesis. Clinical results are also positive regarding the QoL, even despite the poorest pre-op conditions.

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Dynamic Spinal Fusion Constructs and the Range of Motion of the Functional Spinal Unit

Abraham E. Sabersky, Daniel Cook, Jonathan B. Bellotte, Donald M. Whiting, Boyle C. Cheng

Introduction: There has been an increase in interest in the use of dynamic spinal fusion systems. Dynamic fusion devices provide stabilization through immediate fixation while allowing load sharing which, theoretically, should facilitate the bone healing process. A biomechanical study was designed to characterize the range of motion (ROM) of the functional spinal unit (FSU) in its native form, with a rigid rod construct, and a dynamic fusion construct with the dampener in three different positions.

Methods: Six fresh-frozen spines where cleaned of muscle and soft tissue and tested for range of motion. The biomechanical testing employed a standard flexibility protocol with independent motors driven in load control for bending modes of loading. Each specimen was subjected to four modes of testing for each treatment including 1) axial compression, 2) flexion/extension, and 3) lateral bending. The three dimensional kinematic response between each of the vertebral bodies was measured through a calibrated optical tracking unit. The ROM was measured as a displacement response in a given plane for each mode of loading with a repeated measure one way ANOVA to test for differences between the means of each treatment group.

Results: ROM of the index level was taken from the 3rd cycle of each test protocol. The scalar value of the angular or translational change during the 3rd cycle was reported for each specimen. The mean from all specimens for each treatment was calculated and reported along with the standard deviation. A statistically significant difference was detected between the native specimens and all treatment groups but no significant difference was detected between the treatment groups in any mode of loading.

Conclusion: The dynamic spinal fusion construct allows stabilization comparable to that of a rigid rod. In the postoperative period, the device serves to provide a large portion of the immediate stabilization and fixation at the index level. This design attribute requires further validation in the clinical setting in order to gauge the appropriate response so that significance can be predicted.

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Characterization of Articulation of the Lumbar Facets in the Human Cadaveric Spine Using a Facet-Based Coordinate System

Mithulan Jegapragasan, Daniel Cook, Dave Gladowski, Adam S. Kanter, Boyle C. Cheng

Introduction: The three-joint-complex, which includes the two facet joints and the intervertebral disc, significantly directs the movement of the lumbar spine. When studying the biomechanics of this complex, kinematics have traditionally been measured relative to a vertebrae-based reference frame. Recently, a facet-based reference system has been used to describe the same motions, but relative to the facets.

Methods: Seven fresh-frozen, noninstrutmented human cadaveric lumbar spines from L1 sacrum were tested in flexion extension, axial rotation and lateral bending. Three coordinate systems were assigned to each vertebrae from L1-L5: one corresponding to the vertebrae reference frame (X, Y, Z) and two corresponding to the left and right facet reference frames (A, B, C). The facet-based reference frame was aligned to each facet surface to provide descriptions of in plane (articulation) and out of plane (separation) motion. For each of the three modes of loading, the magnitude of the translational range of motion vector was calculated for the three reference frames.

Results: During flexion extension, there was a significant difference in the magnitude of the translational range of motion vector of the right facet as compared to the vertebrae at L1-L2. During axial rotation, there was a significant difference between the magnitude of the translational range of motion vector at L2-L3, L3-L4, and L4-L5. L1-L2 trended towards significance. During lateral bending, there was a significant difference in the magnitude of the translational range of motion vector at L1-L2, L2-L3, L3-L4, and L4-L5.

Conclusion: A facet-based reference frame accounts for variations in facet orientation and provides a valuable characterization of facet articulation and

separation that is not possible to derive from translations in a vertebrae-based reference frame.

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Use of Three-Dimensional Computed Tomography and Image Guidance During Occipital Condyle Screw Placement and Occipitocervical Instrumentation: A Technical Note

Clinton Judson Burkett, Tien V. Le, Edwin Ramos, Fernando L. Vale, Juan S. Uribe

Introduction: The use of occipital condyle screws for occipitocervical fixation has been described as a safe reproducible technique in both cadaveric and clinical reports. Avoidance of critical structures of the complex craniocerivical junction during placement of these screws is of vital importance. Visualizing the placement of condyle screws using fluoroscopic XRay can be difficult. Intraoperative 3D CT imaging and image guidance allows for acquisition and immediate interpretation of multi-planar three dimensional images. Intraoperative image guidance can be applied to the placement of occipital condyle screws for increasing the accuracy, reproducibility, and safety of the procedure.
Methods: The authors describe a technique for placing occipital condyle screws in conjunction with C1 and C2 screws using 3D image guidance. This technique has been used in four patients to date. Intraoperative 3D CT imaging (O-Arm) and image guidance (Stealth Station S7 & Treon) were used in this study. Image guidance was used for localizing, drilling, tapping, and placement of occipital condyle, C1 lateral mass, and C2 pars screws in all four patients. The 3D CT scan was performed in the operating room in two patients for image guidance and checking screw trajectories before closure.
Results: No complications resulted from the use of image guidance or with the placement of occipital condyle, C1 lateral mass, and C2 pars screws. In two patients, 3D CT scan after placement of all screws ensured proper placement of all screws before leaving the operating room.
Conclusion: Placement of occipital condyle screws with 3D CT imaging and image guidance is safe and effective. A second 3D CT scan done after placement of screws is useful to guarantee adequate screw trajectories, which may prevent an unplanned return to the operating room.

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A Clinical Evaluation of Two-Level Lumbar Fusion Using a Combination of the AxiaLIF and XLIF

W.B. Rodgers, Edward J. Gerber, Jody A. Rodgers

Introduction: The peri- and postoperative complications associated with the XLIF and AxiaLIF procedures are reported to demonstrate the feasibility, safety, and effectiveness of the approaches when used in combination. In our single-site consecutive series of 190 AxiaLIF patients, 32 had two level fusions with a combination of the AxiaLIF (L5-S1) and XLIF (L4-L5) techniques.
Methods: Peri- and postoperative complications and their relation to clinical and radiographic outcomes were evaluated, in addition to surgical details, hospital stay, VAS scores, disc heights, and reoperation rate. Thirty-two patients with a mean age of 55.4 years and a mean BMI of 30.9 received two-level fusions with an AxiaLIF at L5-S1 and XLIF at L4-L5 . The VAS scores, disc heights, and radiographic evaluations are presented at 3, 6, 12 and 24 months postoperatively separated by level.
Results: The mean VAS score in these patients preoperatively was 8.9 and demonstrating a 5.1 point drop (57% reduction) in the VAS score. OR time averaged 137 minutes. There were no transfusions or infections. One patient required a laminectomy at 4 weeks and another an XLIF at 24 months. There were consistent differences in radiographic parameters between the XLIF and AxiaLIF levels at 12 months: Lenke scores at L45 averaged 1.16 and 2.22 at L5S; while the L45 levels lost 0.8 mm in disk height over 12 months, the L5S1 levels lost 2.15 mm.
Conclusion: Multilevel fusion at the lumbosacral junction can be achieved using a combination of XLIF and AxiaLIF procedures. While the associated complications markedly less than traditional open techniques, fusion was infrequently demonstrated at the L5-S1 level even at 24 months.

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Are MIS Spinal Fusion Outcomes Predictable? Factors of Statistically Significant Outcomes Predictability in Minimally Invasive Spinal Fusions

W.B. Rodgers, Edward J. Gerber, Jody A. Rodgers

Introduction: Herein, we assess if MIS fusion success or reoperation can be predicted based on demographic and outcome factors.
Methods: Clinical and radiographic outcomes from our series of 941 XLIFs were prospectively recorded. Factors were analyzed to determine the statistical significance of effect on success, defined as improvement of at least two points on the VAS-pain-scale. Outcome measures included the results of statistical analysis testing the effect of demographic characteristics and outcome factors on success (VAS decrease of at least 2pts) or the occurrence of reoperation. Statistical significance defined as $p<0.05$.
Results: Preop VAS was a factor in 12mos VAS success. ($p=0.0283$). At 24 months, preop VAS approached significance ($p=0.0548$). Age was a significant factor in success at 12 months ($p=0.0283$); patients achieving success were on average, older. Patients with COPD were less likely to have success at 24 months ($p=0.0114$). Smoking trended towards significance at 12 months ($p=0.0502$) but was not a factor at 24 months. Other aspects found not to be significant factors in 12 or 24 months outcomes: occurrence of complications or reoperations, prior fusions, and comorbidities (CAD, diabetes, steroid use, and cancer). Loss of disc height at 6 months postop was a statistically significant predictor of reoperation for residual symptoms. Specifically, greater than 5mm lost from postop to 6 months, or a loss of >50% of surgically gained disc height, is predictive of reoperation ($p=<0.0001$). Patients who lose <1mm (or <10% disc height) from postop to 6 months require significantly less reoperations ($p=0.0034$).
Conclusion: The ability to predict long-term MIS fusion outcomes may have considerable impact. Results of the age analysis are significant for relief of pain in the elderly, a challenging group to treat. Also of importance is potential to prevent reoperation. Technique, implant size, and posterior fixation method may also be factors.

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Minimally Invasive Treatment of Thoracolumbar Spine Fractures

Jacinto Manon, Cara Sedney, Brenton R. Coger, James Mills, Terrence D. Julien

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 30 months were reviewed. Cases of minimally invasive fusions done for thoracolumbar trauma were identified. Laminectomies and kyphoplasty/vertebroplasty were included. 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 95 minimally invasive cases performed over a 30 month period by the senior author, 30 of these were minimally invasive fusions for thoracolumbar spinal trauma. The average number of levels fused was 5. Average estimated blood loss was 254 ml. Average operative time was 3 hours and 40 minutes. Average hospital stay was 8.9 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, postoperative 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.

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The Treatment of Thoracolumbar Burst Fractures by Using Short Segment Transpedicular Screw Instrumentation

Ulas Yener, Deniz Konya, Gulden Demirci

Introduction: One of the major problems in the surgical treatment of thoracolumbar burst fractures is to maintain enough support to the anterior column. In this research we present the assestment of thoracolumbar burst fracture patients clinically and radiologically who had been treated with short segment transpedicular screw instrumentation.
Methods: 21 cases (12 male, 9 female) were retrospectively reviewed who had thoracolumbar burst fractures and treated with short segment transpedicular screw instrumentation. Mean age was 53 (range 26 - 78). Mean follow-up period was 13.7 (range 3 - 28) months. The most common fracture level was at L1 vertebra (10 cases) and T12 vertebra (4 cases), L3 vertebra (3 cases), L2 vertebra (1 case). Vertebroplasty had been also administered to 15 cases to support the anterior column. In 10 cases at the level of collapsed vertebra we used shorter transpedicular screws.
Results: All cases were totally recovered at their last controls. Their mean VAS score in the preoperative period was 8.3 and 3.7 at the 3rd month control ($p<0.05$). Mean SDI score was 72.5 in the preoperative period and 36 in the post operative period. After the surgery no patient had any additional neurological deficit.
Conclusion: The use of short segment transpedicular screw instrumentation in the treatment of thoracolumbar burst fractures less mobile segments are fused together, posterior stabilization is enhanced at the level of fracture and in suitable cases by adding vertebroplasty to the treatment proper anterior column support is achieved. For these reasons fixation with short segment traspedicular screw instrumentation is a safe treaatment choise for thracolumbar burst fractures.

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Fractures of the Thoracolumbar Spine: A 33-year Review from the General Hospital Heraklion in Crete

Nikolaos Syrmos, Mario Ganau, Antonella De Carlo, Dimitrios Arvanitakis

Introduction: Thoracolumbar fractures can be a disabling condition that requires rapid and focused evaluation on admission to the Emergency Department and a thorough treatment to avoid catastrophic and neurologically threatening injuries. The spectrum of injuries is broad and includes: fractures, bony and/or ligamentous instability and neurologic compromise.
Methods: Clinical data from a 1978-2009 timeframe were retrieved from the General Hospital Heraklion's archives: a total of 120 patients (mean age 39y; 86.6% men and 13.4% women) were admitted for thoracolumbar spine fractures.
Results: Most common mechanism of injury were: accidental falls 58.4% and car accidents 24.1%. In 79.1% of records patients presented multiple traumas. Instability fractures accounted for 52.5%; neurological impairment for 25.8%. A conservative treatment was choosen in more than half of the cases. Only 43.4% of patients were operated: a good outcome was demonstrated in 76.9% with partial or complete regression of neurological deficits. Rate of instrumentation was 68% and rate of revision surgery was 7%.
Conclusion: Spinal trauma is classified according to the mechanism of injury and the presence or absence of spine stability. A variety of imaging modalities including radiography, conventional tomography, computed tomography, and magnetic resonance imaging have improved along the years the assessment of spinal injuries. Revising our data we can state that: nonoperative treatment was successful in most of those injuries, whereas surgery was choosen in selected cases of structural instability or neurologic compromise. Timing of surgery did not change along the years, and neurological compromise always prompted an immediate surgical decompression.

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Observations on Bone Morphogenetic Protein in Transforaminal Lumbar Interbody Fusions

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Introduction: Ectopic bone formation, radiculopathy, seroma development and osteolysis have been identified in TLIF's with rhBMP-2. ALIF's with rhBMP-2 in lumbar tapered cages, however, have not exhibited the same pattern of complications.
Methods: A retrospective review of clinical and radiographic data was performed on all patients over a three-year period who had undergone lumbar interbody fusion through either a transforaminal or anterior approach with rh-BMP-2.
Results: Delayed radiculopathy, ectopic bone formation and osteolysis were all identified within the TLIF group. A delayed radiculopathy after a transforaminal lumbar interbody fusion appears to be the result of an inflammatory response of rh-BMP-2 interacting with the exposed cancellous bone from the facetectomy. The area of hyperintensity on T2 weighted MR imaging obtained 9-12 weeks postoperatively is highly predictive of where bone deposition will occur. Bone formation has a tendency to form outside the collagen sponge and in the presence of the rh-BMP-2 solution that is in contact with the cancellous bone from the violations of the endplate or the facectectomy. Violation of the cortical endplate and exposure of the cancellous bone appears to be the cause of osteolysis. None of these complications were identified in those patients who underwent an ALIF with the same or greater amount of rh-BMP-2.
Conclusion: A lower dose of rh-BMP-2, eliminating the exposure of rh-BMP-2 solution to the neural elements and

limiting the rh-BMP-2 enhanced sponge to an interbody device to avoid its compression, collectively minimizes the risk of delayed complications from use of this protein.

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The Hybrid Interspinous Implant and Fusion System in the Multilevel Lumbar Spinal Stenosis

Insoo Kim

Introduction: Patients with multilevel lumbar spinal stenosis resistant to conservative therapy are typically treated with either fusion or non-fusion surgical techniques. Unfortunately, spinal fusion alters the normal biomechanics of the spine, and the loss of motion at the fused level is compensated by increased motion and load at the other unfused segments. Possibly as a result of altered biomechanics at the adjacent mobile segments, adjacent-segment disease (ASD), a serious complication of PLIF, can occur. To reduce the incidence of ASD, the two techniques can be applied at adjacent levels using interspinous implants in a segment-by-segment treatment of multiple level spinal stenosis. The objective of this study was to evaluate the clinical and radiological outcome of patients treated with hybrid application of device for intervertebral assisted motion in one adjacent level as a non-fusion device and in other segments in combination with a posterior lumbar interbody fusion (PLIF) as a fusion device.
Methods: A retrospective review was performed in all patients who underwent posterior lumbar instrumentation of the hybrid interspinous implant with unilateral laminotomy bilateral decompression and PLIF fusion system. The follow-up period ranged from 22 to 39 months. Clinical outcome was evaluated by Oswestry disability index (ODI), back- and leg-pain scores (VAS). Fusion success and system failure were assessed by CT, AP and lateral X-rays.
Results: A total of 15 consecutive patients underwent lumbar fusion surgery in which the hybrid system was used. Back pain (VAS) was improved from 6.9 to 3.2 ($p<0.05$), leg pain (VAS) was from 8.1 to 2.3($p<0.05$), and ODI was from 53.6 % to 27.3 % ($p<0.05$). There was no major complication and system failure.
Conclusion: A combination of interbody fusion and non-fusion interspinous implant treatments is technically feasible, safe, and effective for the surgical treatment of multilevel lumbar spinal stenosis.

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Radiographic Evaluation of Interbody Height Following Minimally Invasive L5-S1 Trans-sacral Axial Fusion

Zachary Adam Smith, Budong Chen, Samantha Hemingway, Larry T. Khoo

Introduction: Pre-sacral minimally invasive spinal (MIS) L5-S1 fusion continues to emerge as an important treatment for disease of the lumbosacral spine. Disk height (DH) loss and distraction are important radiographic outcomes, and the authors present initial radiographic findings and discuss their implications in 26 patients.
Methods: Between June 2005 and January 2009, 26 patients were treated with MIS L5-S1 pre-sacral interbody fusion. There were 12 females and 14 males, with an average age of 48.7 years. The authors considered these radiographic parameters: anterior and posterior disc height (ADH, PDH) relative to endplate (%, Farfan method), percentage increase or decrease of ADH or PDH following operation; DH relative to implant (%, modified Farfan) at follow-up. Predictors of DH loss are reported and analyzed.
Results: Using a fixed end-plate length (Farfan method), average ADH distraction was 46.7% (range 26.9-144.0) and PDH distraction 4.1% (-30.0-69.4) in eleven patients. The increase in ADH was significant ($p = 0.05$, student's t test). Inter-rater reliability was .95. DH loss of 15.9% (2.4-31.9) was observed in 22 patients at 7.44 months (range 2-11 months). In 16 patients with pedicle fixation, DH was 9.9% (range 2.6-17.9). In 8 with transfacet fixation, DH loss was 20.9% (12.6-31.9%), ($p <0.001$). Smoking history, age, time, and degree of distraction did not predict disk height loss. Weight > 250 lbs was predictive with multiplicative analysis ($p = 0.04$). Inter-rater reliability was .87.
Conclusion: MIS pre-sacral fusion provides significant distraction of the anterior disk space. DH loss with time is similar to established approaches for interbody fusion. Preservation of postoperative DH may best preserved with pedicle screw fixation.

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L5 Vertebrectomy for the Surgical Treatment of Tumoral and Traumatic Lesions of L5 Vertebrae

Tuncay Kaner, Tunc Oktenoglu, Mehdi Sasani, Ali Fahir Ozer

Introduction: L5 vertebrectomy performed for rarely observed L5 vertebral lesions in the lumbosacral junction of the spine entails certain surgical difficulties. We retrospectively reviewed the clinical characteristics and surgical results of our seven patients who were treated with L5 vertebrectomy.
Methods: Pathologies, clinical characteristics, preoperative and postoperative radiological findings, surgical techniques, and instrumentation that were used on seven L5 vertebrectomy patients between 1998 and 2008 were reviewed in their entirety. Operations were planned after performing biopsies in tumoral cases in the preoperative period. Patients were checked at three-month intervals in the first year, six-month intervals in the second year and thereafter on a regular basis.
Results: The mean follow-up period was 46.3 months (ranging from 12 to 128 months). One patient had a traumatic L5 burst fracture, and the other six patients had tumoral pathologies in L5 vertebrae. All patients were treated with anterior L5 vertebrectomy, and anterior reconstruction and posterior rigid stabilization were performed. None of the patients developed any perioperative complications. Revision surgery was not performed on any patients. Recurrence was observed in the patient with the chordoma in the second postoperative year. This patient received radiotherapy after the recurrence, a reoperation was not performed and patient exitus was observed in the third postoperative year.
Conclusion: Although L5 vertebrectomy is a difficult surgery to perform, providing appropriate patient selection it can be preferred in tumoral and traumatic lesions of L5 vertebrae as a surgical option. The lumbo-sacral region presents significant stabilization problems for the surgeon. In order to provide stabilization, L5 vertebrectomy initiation should be accompanied by anterior and posterior rigid stabilization.

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En Bloc Hemisacrectomy and Internal Hemipelvectomy Done from the Posterior Approach: A Report of Two Cases

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Introduction: En bloc resection of primary tumors has a demonstrated long-term disease-free survival benefit over palliative intralesional resections. In patients with pelvic tumors, traditional surgical treatment was the radical

hemipelvectomy or "hindquarter amputation". More recently, limb-sparing internal hemipelvectomy through a lateral approach has been used. While a portion of the sacrum may be resected, in patients with disruption of S1, this trajectory will not allow appropriate lumbopelvic fixation. Previously, a posterior only approach to total sacrectomy has been described, which allows en bloc resection of the sacrum below the L5-S1 disc space and lumbopelvic fixation in a single stage through a midline incision. By extending the dissection laterally, we have been able to perform an internal hemipelvectomy and hemisacrectomy in a single procedure, operating the patient in the supine position.

Methods: We present two cases of sacroiliac tumors successfully treated by a posterior-only hemisecreactomy and internal hemipelvectomy with subsequent reconstruction.

Results: The surcial procedure for an en bloc hemisacrectomy and internal hemipelvectomy is described. The first surgical priority is en bloc tumor resection with negative margins. The second priority is skeletal stabilization: maintaining pelvic ring and lumbosacral continuity to stabilize the pelvic girdle and transfer weight-bearing forces from the axial to appendicular skeleton, which allows locomotion and posture.

Conclusion: A posterior approach to hemisacrectomy and internal hemipelvectomy is possible in the appropriate patient. This approach allows excellent bilateral stabilization of the lumbosacral juntion and decreases surgical morbidity while allowing the surgeon to achieve an en bloc resection. However, surgeons must be comfortable with the posterior approach as retroperitoneal access is eliminated. Additonally, the limits of lateral access may preclude complete pelvic-femoral reconstruction if required.

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The Evaluation of Intraoperative Computed Tomography with Navigation System in Lumbar Spine Trans-pedicle Screw (TPS) Application

Jen-Tsung Yang, Ming-Hsueh Lee, Chu-Hsiang Chu, Martin Lin, Wei-Hsun Yang, Chun-Hsien Lin, Chun-Yu Cheng

Introduction: Trans-pedicle screw fixation and posterolateral fusion for lumbar spondylolithesis is a well-established procedure. The accuracy of screw insertion is important for adequate fixation and subsequent successful fusion. Traditionally, screw insertion is done under fluoroscopic guidance. However fluoroscopic views only provide spatial information in 2 dimensions. A novel approach to trans-pedicle screw (TPS) insertion is the combine use of intraoperative computed tomography (iCT) and navigation technology for enhanced precision and safety of screw insertion. The accuracy of screw placement, time for computed tomography acquisition (for navigation registration, screw placement confirmation or adjustment) and patient safety were evaluated in this study.

Methods: From August 1, 2010 to September 13, 2010, 15 patients with lumbar spondylolisthesis who underwent lumbar spinal fixation and posterolateral fusions with a total of 60 trans-pedicle screws were evaluated. The fixation accuracy was evaluated by measuring the distance of the screw tip to the anterior vertebral body wall, the number of pedicle fracture and screw revision were documented. The time spent for each screw insertion and for computed tomography acquisition were recorded.

Results: The distance from screw tip to anterior vertebral body wall was 7.9±2.8 mm. The time was 8.54±1.2 minutes for each screw inserted and 4 minutes for iCT acquisition. Pedicle fracture occurred in 2 out of 60 screws (3.2%) and revision was done for 2 out of 60 screws (3.2%) without neurologic impairment.

Conclusion: The results showed that instrumentation by trans-pedicle screw using iCT with navigation system technology can improve the precision of fixation by enhancing the trajectory and penetrance of screw into the vertebral body, pedicle fracture does not occur often, and it can be revised immediately within the same operation.

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Computerized Image Guided Spine Surgery: The State-of-the-Art

J. Patrick Johnson, Terrence T. Kim, Shoshanna S. Vaynman, Samer Ghostine, Michael Scott Turner, Kamal Ronald Woods, Marshall L. Grode, Srinath Samudrala, Robert S. Pashman

Introduction: Computerized image-guided spinal surgery has remained limited due to difficulties in applying intraoperative navigational technologies, with its slow development over the past decades largely due to difficulties with registration and inability to update imaging intraoperatively. Specifically, complex spine surgery for uncommon procedures has remained challenging due to limitations of fluoroscopy, artifacts related to previous operations, and difficult spatial orientation. We have been involved in the development of several generations of image-guidance surgery (IGS), whose application has recently been facilitated with the latest advances in intraoperative computer tomography (CT) imaging.

Methods: We have applied IGS to nearly every application in the spine and now report our experience with CT-based IGS in 100 spinal procedures (50 thoracic, 35 lumbar, 10 cervicothoracic junction, and 5 sacral), considered complex anatomic and reconstruction problems. Patients were positioned on a fluoroscopic operating table to allow intraoperative CT imaging with the Medtronic O-arm. Standard fluoroscopic localization of surgical level(s) was confirmed and the CT scanner was positioned for image data acquisition, with an automatic registration process working in tandem with the image-guidance system for surgical navigation. Tracking arrays optimized trajectory and placement of surgical instruments, primarily the high-speed drill and screw placement. Accuracy was determined by recording known intraoperative landmarks with the IGS monitor and measuring the difference.

Results: All patients had successful image-guided procedures to achieve the desired surgical goal, with a 0% revision rate for infection, screw malpositioning, or hardware failure. Registration was accomplished with a remarkably high accuracy. Procedure adequacy can also be determined using IGS and post-procedure CT imaging.

Conclusion: IGS has made significant advances in ease-of-use, primarily due to automatic registration developed to be intrinsic to the technology. This technology has great potential application for routine spinal procedures, less invasive techniques, to ultimately reduce morbidity and improve outcomes.

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Pressure Dynamics in the Cervical Prevertebral Space Related to the Presence and Absence of an Anterior Cervical Plate in an Ex Vivo Model

J. Frederick Harrington, Elizabeth Kenney

Introduction: Prolonged dysphagia after ACDF is common. Anterior plate profile is considered to be a factor related to local pressure on, or deformation of the esophagus. We tested whether a typical anterior cervical plate will create different

local pressure changes compared with an uninstrumented spine in the prevertebral space in an ex vivo system.
Methods: Sawbone cervical spines were potted in acrylic To C2 rostrally and C7 caudally. A 1mm diameter pressure transducer was placed in contact at the C45 disc space level with and without an anterior cervical plate at C45 without a simulated esophagus. The spine was encased in 15% gelatin to simulate soft tissue. Pressure readings were obtained in neutral and 10 Degrees of flexion and extension.
Results: Extension results in increased pressure and flexion a decrease. With the sensor facing in and contacting the spine in the presence of a plate, pressure increased an average of 76mmHg in flexion and decreased an average of 107mmHg in flexion, while without a plate pressure changes were 4mmHg increased in extension and decreased 2mmHg in flexion. Neutral position pressures were lowest in uninstrumented spines.
Conclusion: Anterior cervical plates increase local pressures in the prevertebral space. Pressure increases in occur in extension and neutral position and are greater in instrumented spines.

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Dynamic Stabilization for Degenerative Spondylolisthesis: Evaluation of Radiographic and Clinical Outcomes

Li-Yu Fay, Jau-Ching Wu, Wen-Cheng Huang, Henrich Cheng

Introduction: Dynamic stabilization is as an option in the treatment of lumbar spondylosis but its effect on degenerative spondylolisthesis remains unclear.
Methods: This retrospective study included a cohort of 38 patients (mean age 63.7 years) with one- or two-level lumbar spinal stenosis who underwent laminectomy and Dynesys dynamic stabilization system. Preoperatively, 24 had degenerative spondylolisthesis while the other 14 had no instability but only stenosis. Mean follow-up was 17.5 months (range, 12-29 years). Pre- and postoperative radiographic evaluations and clinical outcomes were analyzed.
Results: The mean range of motion (ROM) at the index level was reduced significantly from 10.0°±3.3° preoperatively to 2.8°±1.9° postoperatively ($p<0.001$). Screw loosening occurred in 13.3% of levels, 21.1% of patients, and 4.6% of screws. There were no significant differences between patients with and without spondylolisthesis in pre- and postoperative ROM, and screw loosening rates per level, per patient, and per screw ($p=0.693$, 0.358, 0.105, 0.385, and 0.671, respectively). Overall, the mean Visual Analogue Score (VAS) improved significantly from 6.0±3.2 to 2.9±3.4 ($p<0.001$) and the Oswestry Disability Index (ODI) scores improved significantly from 50.6±19.5 to 28.8±24.6 ($p<0.001$) compared to preoperative scores. There were no significant differences in pre- and postoperative VAS and ODI scores between the non-spondylolisthesis and spondylolisthesis groups ($p=0.361$, 0.120, 0.964, 0.113, respectively).
Conclusion: There are significant restrictions in segmental range of motion (<3°) and clinical improvement after laminectomy and dynamic stabilization with Dynesys for symptomatic lumbar spinal stenosis. Radiographic findings, screw loosening rates, and clinical outcomes are all similar. The dynamic stabilization system provides equal radiographic stability and clinical effects for patients regardless of preoperative degenerative spondylolisthesis.

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CO2 Laser-Assisted Lumbar Fusions: Safety, Clinical Outcomes and Technical Considerations

Alan T. Villavicencio, Ewell Lee Nelson, Alexander Mason, Jason Babuska, Frances A. Carr, Sharad Rajpal, Sigita Burneikiene

Introduction: The purpose of this study was to evaluate potential technical advantages of the CO2 laser technology in open transforaminal lumbar interbody fusion (TLIF) surgeries and report our preliminary clinical data on the safety and clinical outcomes.
Methods: Safety and clinical outcomes were compared between two groups: 24 patients that underwent CO2 laser-assisted one-level TLIF surgeries and 30 patients that underwent standard one-level TLIF surgeries without the laser performed from November of 2008 to November of 2009. The safety of spine surgeries was assessed by monitoring all intraoperative and perioperative surgical technique related complications. In addition, MRI scans were reviewed for possible laser-related thermal injury complications. The efficacy was evaluated by documenting and comparing postoperative lower back and leg pain (10-point Visual Analog Scale, VAS).
Results: There were no neural thermal injuries or other intraoperative laser-related complications encountered in this cohort of patients. At a mean follow up of 6.5 months, significantly reduced lower back pain scores (P=0.002) were reported in the laser-assisted patient group compared to standard fusion patient group. The lower extremity(ies) radicular pain intensity scores were similar in both groups. Laser-assisted TLIF surgeries showed a tendency (P = 0.07) of shorter operative times that was not statistically significant.
Conclusion: Based on this preliminary clinical report, the safety of the CO2 laser device for lumbar fusion surgeries was demonstrated. There were no neural thermal injuries or other intraoperative laser-related complications encountered in this cohort of patients. Further investigation of CO2 laser-assisted lumbar fusion procedures in a prospective randomized fashion is warranted.

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Use of a Novel Ultrasonic Bone Scalpel for Osteoplastic Laminoplasty in the Resection of Intradural Spinal Cord Pathology

Scott L. Parker, Ryan M. Kretzer, Pablo F. Recinos, George I. Jallo, Violette Renard Recinos

Introduction: Osteoplastic laminoplasty is a well described alternative to laminectomy in the treatment of spinal pathology. Recent studies have shown that laminoplasty may decrease the incidence of progressive kyphotic deformity when used in the setting of intradural spinal cord tumor resection, especially in the pediatric population [1,2]. A novel device, the BoneScalpel™ by Aesculap (Figure 1), is an ultrasonic osteotome that precisely cuts bone while preserving the underlying soft tissues. In the case of laminoplasty, this potentially reduces the risk of dural laceration. In addition, the device allows for fine osteotomies as narrow as 0.5 mm, which may facilitate better postoperative bone healing.
Methods: We present our experience with 11 patients who underwent osteoplastic laminoplasty using the BoneScalpel™ in the setting of intradural pathology between January 2009 and September 2010. Following lesion resection, titanium plates were used to reconstruct the lamina. The technical advantages and procedure-related complications of using an ultrasonic bone osteotome in the resection of intradural spinal cord lesions were analyzed.
Results: Successful laminoplasty was carried out in all 11 cases (Table 1). One case of incidental durotomy was noted following use of the device, which was repaired primarily without neurological or clinical sequelae. There were no cases of perioperative complications such as wound infection or CSF leak. There was also no incidence of immediate postoperative spinal instability (Figure 2).
Conclusion: The BoneScalpel™ by Aesculap is a safe and technically feasible device for performing osteoplastic laminoplasty. It allows for a narrower laminar trough to be performed than conventional drilling, which may lead to improved laminar healing and prevent delayed post-laminectomy kyphosis. Further studies and longer clinical follow-up are needed to delineate the true role of this device in the treatment of spinal cord pathology.

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Modification of the Prestige ST Cervical Artificial Disc to Allow Multi-level Implantation

Kenneth Pettine, Christian Schlicht

Introduction: The purpose of this abstract is to describe a modification of the Prestige ST implant to allow multi-level implantation in any patient. The second purpose is to report the safety and efficacy of this modification. The Prestige ST implant has anterior phalanges with screw fixation into the superior and inferior vertebral body that requires a minimum 15mm of vertebral body height to allow multi-level implantation. Modification dovetails the phalanges requiring only 8mm of vertebral body for multi-level implantation. Utilizing the Prestige ST implant in a multi-level fashion is an FDA off-label use of the device. There are currently two cervical FDA approved artificial discs. Each has unique characteristics. The ProDisc-C implant allows multi-level implantation without modification.
Methods: Every patient from 2007 to April 2010 who underwent a multi-level Prestige ST implant was evaluated and subdivided into groups with (two levels = 10 patients, three levels = 2 patients) and without (two-level = 28 patients, three-level = 2 patients) modification. There was no significant difference in the demographics between the groups. The following illustration demonstrates the modification. Modification of the Prestige ST implant is achieved with a high-speed Dremel saw in approximately one minute followed by smoothing of the edges. The implant is modified such that the locking screw can still be utilized. Our experience is that approximately 40% of male patient and 0% of female patients can undergo a multi-level non-modified Prestige implant.
Results: In both groups, range of motion averaged 8º at each implant level. There were no implant problems in either group.
Conclusion: Our experience indicates modifying the Prestige ST implant allows for use in a multi-level fashion in all patients who have a vertebral body height of at least 8mm. The clinical results of patients with a modified Prestige ST implant are equal to the patients with non-modified implants.

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Management of Giant Pseudomeningoceles After Spinal Surgery

Enayatkhater Omar Elkelany

Introduction: Pseudomeningoceles are a rare complication after spinal surgery, and studies on these complex formations are few.
Methods: Between October 2000 and March 2008, 11 patients who developed symptomatic pseudomeningoceles after spinal surgery were recruited. In this retrospective study, we reported our experiences in the management of these complex, symptomatic pseudomeningoceles after spinal surgery. A giant pseudomeningocele was defined as a pseudomeningocele >8 cm in length.

We also evaluated the risk factors for the formation of giant pseudomeningoceles.
Results: All patients were treated successfully with a combined treatment protocol of open revision surgery for extirpation of the pseudomeningoceles, repair of dural tears, and implantation of a subarachnoid catheter for drainage. Surgery-related complications were not observed. Recurrence of pseudomeningocele was not observed for any patient at a mean follow-up of 16.5 months. This result was confirmed by magnetic resonance imaging.
Conclusion: We conclude that a combined treatment protocol involving open revision surgery for extirpation of pseudomeningoceles, repair of dural tears, and implantation of a subarachnoid catheter for drainage is safe and effective to treat giant pseudomeningoceles.

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Early Experience with Expandable PEEK Spacers for Interbody Fusion for Degenerative Lumbar Disease

Benjamin Shin, Christoph Hofstetter, Eric H. Elowitz, Roger Hartl

Introduction: To determine the clinical and radiological efficacy of expandable PEEK Spacers in lumbar interbody fusion for degenerative lumbar disc disease.
Methods: This is a retrospective analysis of 22 consecutive patients (median age 66; 9 men and 13 women operated on in 2009 and 2010) who underwent lumbar single-level interbody fusion with expandable PEEK spacers in combination with posterolateral pedicle screw-rod instrumentation. Silicated calcium phosphate substitute was used as the bone graft. Clinical outcomes were evaluated using the Visual Analogue Scale (VAS) and the Oswestry Disability Index (ODI). In addition, disc height, Cobb angles, and total graft subsidence were evaluated on pre-op, post-op, and at the latest follow-up.
Results: Significant improvement was observed only in VAS Back (8.06 vs. 5.03, p = .005) and VAS Leg pain (5.95 vs. 3.16, p =.028) from pre-op to follow-up. Cages were expanded from 7 mm to a mean of 11.09 ± 1.23 mm (S.D.). Review of pre- and postoperative CT scans revealed a significant increase in the anterior disc height (7.37 mm vs. 11.8 mm, p = .001) and posterior disc height (4.40 mm vs. 7.44 mm, p = .002). There was a non-significant tendency towards an increase of the foraminal height (14.63 mm to 15.97 mm, p = .125). The average total graft subsidence was 3.71 mm. The local disc angle and lumbar lordosis did not change significantly. At a mean follow-up time of four months, radiographic parameters were unchanged except for foraminal height which decreased by 2.62 mm (p = .02).
Conclusion: Our preliminary results indicate that stackable PEEK wafers for single level lumbar interbody fusions restore disk height and are associated with improvement in clinical outcome. More patients with longer follow-up are needed to assess long-term clinical and radiological outcome.

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