43RD

FORTY-THIRD ANNUAL MEETING

OF THE

December 3–5, 2015

Manchester Grand Hyatt Hotel
San Diego, CA

Alan S. Hilibrand, MD, ***President***
Zoher Ghogawala, MD, ***Scientific Program Co-Chair***
Rick C. Sasso, MD, ***Scientific Program Co-Chair***

www.csrs.org

Future Instructional Courses

Nov 30, 2016	Westin Harbour Castle, Toronto, Ontario, Canada
Nov 29, 2017	The Diplomat, Hollywood, FL

Future Annual Meetings

Dec 1–3, 2016	Westin Harbour Castle, Toronto, Ontario, Canada
Nov 30–Dec 2, 2017	The Diplomat, Hollywood, FL

The material presented at this Annual Meeting has been made available by the CERVICAL SPINE RESEARCH SOCIETY for educational purposes only. This material is not intended to represent the only, nor necessarily best, methods or procedures appropriate for the medical situations discussed, but rather is intended to present an approach, view, statement or opinion of the Author(s), which may be helpful to others who face similar situations.

CONTINUING EDUCATION CREDIT

This activity has been planned and implemented in accordance with the accreditation requirements and policies of the Accreditation Council for Continuing Medical Education (ACCME) through the joint providership of the American Academy of Orthopaedic Surgeons and the Cervical Spine Research Society. The American Academy of Orthopaedic Surgeons is accredited by the ACCME to provide continuing medical education for physicians.

The American Academy of Orthopaedic Surgeons designates this live activity for a maximum of 17.25 *AMA PRA Category 1 Credits*™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

The American Association of Neurological Surgeons accepts these AMA PRA Category 1 Credits™ towards the Continuing Education Award in Neurosurgery to maintain membership in the AANS and towards Maintenance of Certification. You must submit a copy of the certificate to AANS for inclusion in your record:

AANS Member Services Department
5550 Meadowbrook Industrial Ct
Rolling Meadows, IL 60008
Phone: (847) 378–0500
E-mail: cme@aans.org

Cameras of any kind may not be used to record any portion of the Annual Meeting Scientific Program, E-Posters or Technical Exhibits.

Cervical Spine Research Society
9400 W Higgins Rd, Suite 500
Rosemont, IL 60018-4976
Phone: 847 698–1628 / **Fax:** 847 268–9699
E-mail: csrs@aaos.org
Staff E-mails:
wlezien@aaos.org / swift@aaos.org /
frale@aaos.org

Administrative Staff:
Peggy Flaherty-Wlezien, Executive Director
Carol Swift, Society Coordinator
Liz Frale, Society Assistant

Table of Contents

Meeting Information & Evaluations

Completion is required to obtain your Certificate of Attendance for each meeting you registered for and attended.

2015 CSRS Meetings Website:
www.csrs.org/events/2015-csrs-meetings-in-san-diego/

Annual Meeting Evaluation:
www.surveymonkey.com/r/2015CSRSAMEVAL

Ask the Expert Luncheon Symposium Evaluation:
www.surveymonkey.com/r/MYELOPATHYSESSION

Ask the Expert Dinner Symposium Evaluation:
www.surveymonkey.com/r/DEFORMITYSESSION

Directions on completing the evaluation: Once you have accessed the evaluation, you can go back to previous pages in the survey and update existing responses until the survey is finished or until you have exited. If you do not complete the survey before exiting, your responses will be captured, however, you will not see your previous answers, when you subsequently access the survey form. Your IP address is stored in the survey results to verify that you have completed the survey. Once you have answered all the questions, you will be directed to the certificate of attendance.

Feedback is important and is considered in planning future educational events.

Please complete each online survey by Friday, January 22, 2016

The Cervical Spine Research Society is an organization of individuals interested in clinical and research problems of the cervical spine. Its purpose is the exchange and development of ideas and philosophy regarding the diagnosis and treatment of cervical spine injury and disease.

The concept of a sub-specialty group devoted to the cervical spine was first considered in 1966.

As interest in this area grew, a preliminary meeting to consider the formation of such an organization was held in Las Vegas, Nevada, in February, 1973, during the annual meeting of the American Academy of Orthopaedic Surgeons.

Present at the meeting were Edward H. Simmons and Ian McNab of Toronto; Richard Rothman and Henry H. Sherk of Philadelphia; Lee H. Riley, Jr. of Baltimore; Alice L. Garrett of West Haverstraw, New York; and Bernard Jacobs and J. William Fielding of New York City.

The name “Cervical Spine Research Society” was agreed upon and annual meetings were planned. The first such meeting was held in New York City in November, 1973. Since that time, yearly meetings have taken place at various locations within the North American continent.

Since the primary purpose of the organization is to carry out research and develop and exchange information on the cervical spine, international participation has been encouraged.

To provide a wide range of interest, it was felt that the composition of the membership should reflect the varying specialties and disciplines dealing with the cervical spine; biomechanical engineering, neurology, neurosurgery, radiology, orthopaedic surgery, and others.

Qualifications for membership were to include demonstration of continued interest in the cervical spine and its related structures.

The organization has developed projects and has continued to grow. The current members are encouraged to seek out individuals, with appropriate interests, for membership to ensure the Society’s future.

J. William Fielding

Origins of the Society

President	Alan S. Hilibrand, MD
Immediate Past President	Bruce V. Darden, II, MD
Past President	K. Daniel Riew, MD
President Elect	Robert F. Heary, MD
Vice President	Darrel S. Brodke, MD
Secretary	Jeffrey C. Wang, MD
Treasurer	Christopher I. Shaffrey, MD

2015 Committees

Awards Committee

Ivan Cheng, MD, Chair	2015
D. Greg Anderson, MD	2015
Michael P. Kelly, MD	2017
Brandon D. Lawrence, MD	2017
Frank M. Phillips, MD	2015
Kristen E. Radcliff, MD	2017
Michael P. Steinmetz, MD	2017

BOS Representatives

John S. Kirkpatrick, MD	2017
R. Alden Milam, IV, MD	2016
Lee H. Riley, III, MD	2017

Communications Committee

Robert Hart, MD, Chair	2015
Christopher P. Ames, MD	2015
Ziya L. Gokaslan, MD	2015
David H. Kim, MD	2016
Eric B. Laxer, MD	2016
Jeffrey A. Rihn, MD	2015

Continuing Medical Education Committee

Ronald A. Lehman, Jr., MD, Chair	2015
Jacob M. Buchowski, MD	2015
R. Alden Milam, IV, MD	2016
John M. Rhee, MD	2015
Jean-Paul Wolinsky, MD	2015

Development Committee

John G. Heller, MD, Chair	2015
Darrel S. Brodke, MD	2018
Michael G. Fehlings, MD, PhD	2015
K. Daniel Riew, MD	2016
Christopher I. Shaffrey, MD	2017
Alexander R. Vaccaro, III, MD, PhD	2016

Editorial Committee

James S. Harrop, MD, Co-Chair	2016
Alpesh A. Patel, MD, Co-Chair	2016

Ethics/Conflict of Interest Oversight Committee

Alexander J. Ghanayem, MD, Chair	2015
Mark Bernhardt, MD	2016
Langston T. Holly, MD	2016

Exhibits Committee

Jeffrey S. Fischgrund, MD, Chair	2016
Douglas G. Orndorff, MD	2017
Jim A. Youssef, MD	2015

Finance Committee

Darrel S. Brodke, MD	2019
Bruce V. Darden, II, MD	2015
Robert F. Heary, MD	2018
Alan S. Hilibrand, MD	2017
Christopher I. Shaffrey, MD	2017

Instructional Course Planning Committee

Louis G. Jenis, MD, Chair	2017
Christopher P. Ames, MD	2015
Paul M. Arnold, MD	2015
Samuel K. Cho, MD	2017
Jonathan N. Grauer, MD	2015
Zoher Ghogawala, MD (ex officio)	2015
Rick C. Sasso, MD (ex officio)	2015

Long Range Planning Committee

Glenn R. Rechtine, II, MD, Chair	2015
Edward C. Benzel, MD	2016
Daniel B. Murray, MD	2016
Rick C. Sasso, MD	2015

Membership Committee

Clifford B. Tribus, MD, Chair	2015
Jamie L. Baisden, MD	2016
Timothy A. Moore, MD	2015
Thomas E. Mroz, MD	2016
Neil M. Wright, MD	2016
Jim A. Youssef, MD	2016

Member Survey Committee

Justin S. Smith, MD, PhD, Chair	2016
Alexander C. Ching, MD	2017
Ziya L. Gokaslan, MD	2015
Andrew C. Hecht, MD	2015
Darren R. Lebl, MD	2016
R. Alden Milam, IV, MD	2015
Themistocles S. Protopsaltis, MD	2017
Sheeraz A. Qureshi, MD, MBA	2015
Christopher I. Shaffrey, MD	2015

Neuro-Ortho Liaison Committee

Christopher I. Shaffrey, MD, Co-Chair	2015
Jeffrey C. Wang, MD, Co-Chair	2015
Peter G. Whang, MD	2017
Seth Zeidman, MD	2017

Nominating Committee

K. Daniel Riew, MD, Chair	2015
Bruce V. Darden, II, MD	2016
Michael D. Daubs, MD	2015
James S. Harrop, MD	2015
Thomas E. Mroz, MD	2015

Patient Education Committee

Dirk H. Alander, MD, Chair	2017
Timothy A. Moore, MD	2016
Ahmad Nassr, MD	2017
Glenn R. Rechtine, II, MD	2017

Program Committee

Zoher Ghogawala, MD, Co-Chair	2015
Rick C. Sasso, MD, Co-Chair	2015
D. Greg Anderson, MD	2016
Nitin N. Bhatia, MD	2017
Jacob M. Buchowski, MD	2015
Ezequiel Cassinelli, MD	2017
Jeffrey D. Coe, MD	2015
Clinton J. Devin, MD	2017
Jeffrey A. Goldstein, MD	2015
Mitchell B. Harris, MD	2017
Serena S. Hu, MD	2017
Brian K. Kwon, MD, PhD	2017
Joon Yung Lee, MD	2017
Praveen V. Mummaneni, MD	2016
Ahmad Nassr, MD	2016
Sheeraz A. Qureshi, MD, MBA	2017
Kristen E. Radcliff, MD	2016
Kern Singh, MD	2015
Leo R. Spector, MD	2017
Bobby K. Tay, MD	2015
Neill M. Wright, MD	2015
Alan S. Hilibrand, MD, (ex officio)	2015
Louis G. Jenis, MD, (ex officio)	2017

Research Committee

John M. Rhee, MD, Chair	2016
21st Century Grant Sub-Committee	
Zoher Ghogawala, MD, Chair	2015
Howard S. An, MD	2015
Branko Kopjar, MD, PhD	2015
Thomas E. Mroz, MD	2015
Beth A. Winkelstein, PhD	2016
S. Tim Yoon, MD, PhD	2017
Seed Starter Grant Sub-Committee	
Francis H. Shen, MD, Chair	2015
Christopher P. Ames, MD	2015
Scott D. Daffner, MD	2017
Clint J. Devin, MD	2016
Jung U. Yoo, MD	2015
Resident Fellow Grant Sub-Committee	
Jacob M. Buchowski, MD, Chair	2015
Andrew T. Dailey, MD	2017
Wellington K. Hsu, MD	2015
Pierce D. Nunley, MD	2015
Justin S. Smith, MD, PhD	2016

Special Projects Committee

Jens R. Chapman, MD, Chair	2015
Clinton J. Devin, MD	2017
Michael G. Fehlings, MD, PhD	2015
Zoher Ghogawala, MD	2016
Jonathan N. Grauer, MD	2017
James S. Harrop, MD	2015
Sohail K. Mirza, MD, MPH	2016
Pierce D. Nunley, MD	2015
Jeffrey A. Rihn, MD	2017
Richard L. Skolasky, Jr., ScD	2016
Justin S. Smith, MD, PhD	2016

Traveling Fellowship Committee

Alexander R. Vaccaro, III, MD, PhD, Chair	2015
Philippe Bancel, MD	2015
Kazuhiro Chiba, MD, PhD	2016
Bruce V. Darden, II, MD	2015
Michael G. Fehlings, MD, PhD	2015
Timothy A. Garvey, MD	2016
Regis W. Haid, Jr., MD	2015
Andre Jackowski, MD	2015
Tateru Shiraishi, MD, PhD	2016
Kyung-Jin Song, MD, PhD	2015
Vo Van Thanh, MD, PhD	2015
Neill M. Wright, MD	2015

Thank You 2015 Exhibit Companies*
Please visit our Exhibitors in the Seaport Ballroom

Aegis Spine, Inc
Greenwood Village,CO
Booth 204

Aesculap Implant Systems
Center Valley, PA
Booth 210

AlloSource
Centennial, CO
Booth 220

Alphatec Spine Inc.
Carlsbad, CA
Booth 410

Biologica Technologies
Carlsbad, CA
Booth 309

Bioventus
Durham, NC
Booth 409

Cardinal Spine
Louisville, KY
Booth 107

Centinel Spine Inc.
New York, NY
Booth 411

Cerapedics
Westminster, CO
Booth 319

DePuy Synthes Spine
Raynham, MA
Booth 419

Globus Medical Inc.
Audubon, PA
Booth 311

K2M
Leesburg, VA
Booth 108

LDR Spine USA
Austin, TX
Booth 102

Life Instrument Corporation
Braintree, MA
Booth 111

Mazur Spine
Geneva, IL
Booth 218

Medicrea, USA
New York, NY
Booth 109

Medtronic
Memphis, TN
Booth 305

Medyssey Spine
Elk Grove Village, IL
Booth 408

NovaBone Products, LLC
Jacksonville, FL
Booth 407

NuVasive, Inc.
San Diego, CA
Booth 404

Paradigm BioDevices
Rockland, MA
Booth 117

RTI Surgical
Austin, TX
Booth 413

SeaSpine
Vista, CA
Booth 416

Shukla Medical
Piscataway, NJ
Booth 119

Solco Biomedical Co., Ltd.
Seoul, Republic of Korea
Booth 317

Spinal Kinetics, Inc.
Sunnyvale, CA
Booth 216

Spinetall
Sacramento, CA
Booth 418

Stryker Spine
Allendale, NJ
Booth 208

TeDan Surgical Innovations
Sugar Land, TX
Booth 415

Thompson Surgical Instruments, Inc.
Traverse City, MI
Booth 405

Titan Spine, LLC
Mequon, WI
Booth 105

Xenco Medical
San Diego, CA
Booth 121

Zimmer Biomet
Broomfield, CO
Booth 114

***as of Nov 5, 2015**

43RD

FORTY-THIRD ANNUAL MEETING

OF THE

CERVICAL SPINE RESEARCH SOCIETY

FOUNDED 1973

December 3 – 5, 2015

Manchester Grand Hyatt Hotel
San Diego, CA

President:	***Alan S. Hilibrand, MD***
Program Co-Chairs:	***Zoher Ghogawala, MD***
	Rick C. Sasso, MD
Local Arrangements:	***Jean-Jacques Abitbol, MD***
	Steven R. Garfin, MD

Scientific Meeting Objectives

- Present the results of current cervical spine research data.
- Promote discussion of new developments and techniques.
- Foster research concerning the diagnosis and treatment of cervical spine injury and disease.

7:00–7:10 am **Welcome and Announcements**
Zoher Ghogawala, MD and Rick C. Sasso, MD

7:11–7:59 am **Session I: MYELOPATHY**
Moderators: ***Ronald A. Lehman, Jr., MD and Thomas A. Zdeblick, MD***

7:11–7:17 am
Presentation #1
(pg. 90)
Is Preoperative Duration of Symptoms a Significant Predictor of Functional Status and Quality of Life Outcomes in Patients Undergoing Surgery for the Treatment of Degenerative Cervical Myelopathy?
Lindsay Tetreault, HBSc*; Branko Kopjar, MD, PhD; Paul M. Arnold, MD; Michael G. Fehlings, MD, PhD*

7:18–7:24 am
Presentation #2
(pg. 92)
Laminoplasty vs. Laminectomy and Fusion to Treat Cervical Spondylotic Myelopathy: Outcomes of the Prospective Multicenter AOSpine North America and International CSM Studies
Carlo Santaguida, MD*; Michael G. Fehlings, MD, PhD; Branko Kopjar, MD, PhD; Paul M. Arnold, MD; Helton Defino, MD; Shashank Kale, MD; S. Tim Yoon, MD, PhD; Giuseppe Barbagallo, MD; Ronald H.M.A. Bartels, MD, PhD; Qiang Zhou, MD; Alexander R. Vaccaro, III, MD, PhD*

7:25–7:31 am
Presentation #3
(pg. 95)
Clinical Outcome of Cervical Laminoplasty and Postoperative Radiological Change for Cervical Myelopathy with Degenerative Spondylolisthesis
Akinobu Suzuki, MD, PhD*; Koji Tamia, MD; Hidetomi Terai, MD, PhD; Masatoshi Hoshino, MD, PhD; Hiromitsu Toyoda; Sho Dohzono, MD; Shinji Takahashi, MD; Kazunori Hayashi, MD; Hiroaki Nakamura, MD*

7:32–7:38 am
Presentation #4
(pg. 97)
Cervical Anterolisthesis is a Significant Poor Predictor of Neurologic Outcomes in Patients with Cervical Spondylotic Myelopathy following Cervical Laminoplasty
Takeshi Oichi, MD*; Yasushi Oshima, MD, PhD; Yuki Taniguchi, MD, PhD; Yoshitaka Matsubayashi, MD; Hirotaka Chikuda, MD, PhD; Katsushi Takeshita, MD, PhD; Sakae Tanaka, MD, PhD*

7:39–7:45 am
Presentation #5
(pg. 100)
Physical Signs and Clinical Features of Elderly Patients with Cervical Myelopathy: Comparison of Three Different Age Groups in 100 Consecutive Operative Cases
Takahiko Hamasaki, MD

7:46–7:59 am **Discussion**

8:00–8:48 am **Session II: ECONOMICS/VALUE**
Moderators: ***Robert F. Heary, MD and John M. Rhee, MD***

8:00–8:06 am
Presentation #6
(pg. 101)
Cost Effectiveness of Operative vs. Non-Operative Treatment of Geriatric Type-II Odontoid Fracture
Daniel R. Barlow, MS; ***Brendan T. Higgins, MD, MS****; Elissa Ozanne, PhD; Anna N.A. Tosteson, ScD; Adam M. Pearson, MD, MS*

8:07–8:13 am
Presentation #7
(pg. 103)
Cost Utility Analysis of Anterior Cervical Discectomy and Fusion for Degenerative Spine Disease in Elderly Population
Silky Chotai, MD; ***Scott L. Parker, MD****; J. Alex Sielatycki, MD; Ahilan Sivaganesan, MD; Harrison F. Kay, BS; Joseph B. Wick, BA; Matthew J. McGirt, MD; Clinton J. Devin, MD*

8:14–8:20 am
Presentation #8
(pg. 105)
Determining the Drivers of Cost for Elective Anterior Cervical Discectomy and Fusion for Cervical Degenerative Disease
Silky Chotai, MD*; Ahilan Sivaganesan, MD; Scott L. Parker, MD; Oran S. Aaronson, MD; Joseph S. Cheng, MD; Matthew J. McGirt, MD; Clinton J. Devin, MD*

8:21–8:27 am
Presentation #9
(pg. 106)
Where do True Cost Savings Exist following Elective Surgery for Degenerative Spine Disease?
Silky Chotai, MD; ***Scott L. Parker, MD****; Ahilan Sivaganesan, MD; David P. Stonko, BS, MS; Matthew J. McGirt, MD; Clinton J. Devin, MD*

8:28–8:34 am
Presentation #10
(pg. 108)
Impact of Obesity on Cost per Quality Adjusted Life Years Gained following Anterior Cervical Discectomy and Fusion in Elective Degenerative Pathology
Silky Chotai, MD*; J. Alex Sielatycki, MD; Ahilan Sivaganesan, MD; Scott L. Parker, MD; Harrison F. Kay, BS; Kevin R. O'Neill, MD; Matthew J. McGirt, MD; Clinton J. Devin, MD*

8:35–8:48 am **Discussion**

8:49–9:37 am **Session III: ARTHROPLASTY**
Moderators: ***Justin S. Smith, MD, PhD and Jack E. Zigler, MD***

8:49–8:55 am
Presentation #11
(pg. 110)
Cost Utility Analysis of the Cervical Artificial Disc vs. Fusion for the Treatment of Two-Level Symptomatic Degenerative Disc Disease: Five-Year Follow-up
Jared D. Ament, MD, MPH*; Zhuo Yang, MSc; Pierce D. Nunley, MD; Marcus Stone, PhD; Kee D. Kim, MD*

8:56 – 9:02 am
Presentation #12
(pg. 113)

Seven-Year Cost-Effectiveness of Cervical Disc Replacement vs. Anterior Cervical Discectomy and Fusion – Results from Investigational Device Exemption and Post-Approval Studies of Prodisc®-C Total Disc Replacement
Kristen E. Radcliff, MD; Jason H. Lerner, PT, MBA, MSc; Thierry Bernard, MS; Chao Yang, MD; ***Jack E. Zigler, MD***

9:03 – 9:09 am
Presentation #13
(pg. 116)

Comparison of One and Two-Level Treatment with Cervical Disc Arthroplasty or Anterior Cervical Discectomy and Fusion through Five-Year Follow-up
Scott L. Blumenthal, MD; ***Michael S. Hisey, MD****; Hyun W. Bae, MD; Jack E. Zigler, MD*

9:10 – 9:16 am
Presentation #14
(pg. 118)

The Positive Effect of Continued Motion of a Cervical Artificial Disc Replacement on Radiographic Adjacent Level Degeneration at Seven-Year Follow-up
Jeffrey M. Spivak, MD*; Jack E. Zigler, MD; Michael E. Janssen, DO; Bruce V. Darden, II, MD; Kristen E. Radcliff, MD*

9:17 – 9:23 am
Presentation #15
(pg. 120)

Cervical Total Disc Replacement and Anterior Cervical Discectomy and Fusion have Similar Short-Term Complication Rates
Bryce A. Basques, MD; Nathaniel T. Ondeck, BS; Adam M. Lukasiewicz, MSc; Matthew L. Webb, AB; Andre M. Samuel, BBA; Daniel D. Bohl, MD, MPH; Junyoung Ahn, BS; Jason O. Toy, MD; Kern Singh, MD; ***Jonathan N. Grauer, MD***

9:24 – 9:37 am **Discussion**

9:38 – 10:03 am **BREAK** **Exhibit Hall in Seaport Ballrooms ABCD**

10:04 – 10:52 am

Session IV: BASIC SCIENCE

Moderators: ***Sanford E. Emery, MD, MBA and Jonathan N. Grauer, MD***

10:04 – 10:10 am
Presentation #16
(pg. 123)

Total Disc Replacement using Tissue-Engineered Intervertebral Discs: In Vivo Outcome in a Canine Model
Yu Moriguchi, MD, PhD*; Jorge Mojica-Santiago, BS; Peter Grunert, MD; Rodrigo Navarro-Ramirez, MD, MSc; Thamina Khair, BA; Connor Berlin, BS; Lawrence J. Bonassar, PhD; Roger Härtl, MD*

10:11 – 10:17 am
Presentation #17
(pg. 126)

Cervical Intervertebral Disc and Paraspinal Muscle Deconditioning following Long-Duration Spaceflight and 30-Day Recovery
Jacquelyn A. Holt*; Robert M. Healey, BS, MBA; Brandon R. Macias, PhD; Alan R. Hargens, PhD; Jeffrey C. Lotz, PhD; Douglas G. Chang, MD, PhD*

• The FDA has not cleared the drug and/or medical device for the use described (i.e., the drug and/or medical device noted with an * is being discussed for an "off label" use). See inside back cover for information.

10:18 – 10:24 am
Presentation #18
(pg. 130)

Transplantation of Human IPS Cell-Derived Oligodendrocyte Precursor Cells Enriched Neural Stem/Progenitor Cells in Chronic and Subacute Spinal Cord Injury
Soya Kawabata, MD*; Akio Iwanami, MD, PhD; Morito Takano, MD, PhD; Go Itakura, MD, PhD; Yoshiomi Kobayashi, MD, PhD; Hideyuki Okano, MD, PhD; Morio Matsumoto, MD, PhD; Masaya Nakamura, MD, PhD*

10:25 – 10:31 am
Presentation #19
(pg. 132)

Altered Forelimb Neural Circuitry Associated with Impaired Manual Dexterity in Cervical Spondylotic Myelopathy (CSM)
Kajana Satkunendrarajah, PhD*; Spyridon K. Karadimas, MD, PhD; Michael G. Fehlings, MD, PhD*

10:32 – 10:38 am
Presentation #20
(pg. 134)

• **Evaluation of Vancomycin Powder on Bone Healing in a Rat Spinal Arthrodesis Model**
Marco C. Mendoza, MD; Kevin A. Sonn, MD; Abhishek S. Kannan, BS; Sharath Bellary, MD; Sean M. Mitchell, BS; Gurmit Singh, BS; Christian Park, BS; Chawon Yun, PhD; Anjan Ghosh; Stuart R. Stock, PhD; Erin L. Hsu, PhD; ***Wellington K. Hsu, MD***
**Vancomycin*

10:39 – 10:52 am **Discussion**

10:53 – 10:58 am **Special Projects Committee Report**
Cervical Radiculopathy: Assessment of Clinical Outcomes and Cost-Effectiveness of Operative and Non-Operative Treatment
Zoher Ghogawala, MD; Jonathan N. Grauer, MD; James S. Harrop, MD; Alan S. Hilibrand, MD; ***Jeffery A. Rihn, MD***

10:59 – 11:04 am **Special Projects Committee Report**
Review of Cervical Myelopathy Evidence and Clinical Guideline Development
Michael G. Fehlings, MD, PhD*; Jeffrey C. Wang, MD*

11:05 – 11:07 am **Discussion**

11:08 am – 12:10 pm **Highlighted Poster Presentations I**
Moderators: ***Todd J. Albert, MD and Alexander R. Vaccaro, III, MD, PhD***

11:08 – 11:28 am **Outcomes**

11:08 – 11:10 am
Presentation #21 P
(pg. 137)

Return to Work Rates after Single Level Cervical Fusion Surgery for Degenerative Disc Disease Compared to Fusion for Radiculopathy in Workers' Compensation Setting
Mhamad Faour, MD*; Joshua T. Anderson, BS; Nicholas U. Ahn, MD*

Individual Disclosures can be found on pages 40 – 88.
P=Highlighted Posters

11:11 – 11:13 am
Presentation #22 P
(pg. 139)
Does Depression or Anxiety affect Patient-Reported Outcomes and Satisfaction following Operative Treatment for Cervical Myelopathy or Radiculopathy?
Harrison F. Kay, BS*; Silky Chotai, MD; Joseph B. Wick, BA; David P. Stonko, MS; Matthew J. McGirt, MD; Clinton J. Devin, MD*

11:14 – 11:16 am
Presentation #23 P
(pg. 141)
The Profile of a Smoker and its Impact on Outcomes after Cervical Spine Surgery
Raul A. Vasquez-Castellanos, MD*; Silky Chotai, MD; Joseph B. Wick, BA; David P. Stonko, BS, MS; Joseph S. Cheng, MD, MS; Clinton J. Devin, MD; Anthony L. Asher, MD; Matthew J. McGirt, MD*

11:17 – 11:19 am
Presentation #24 P
(pg. 144)
Patient-Specific Factors Predicting Dissatisfaction after Elective Surgery for Degenerative Spine Diseases
Sheyan J. Armaghani, MD*; Silky Chotai, MD; Ahilan Sivaganesan, MD; Scott L. Parker, MD; J. Alex Sielatycki, MD; David P. Stonko, BS, MS; Matthew J. McGirt, MD; Clinton J. Devin, MD*

11:20 – 11:22 am
Presentation #25 P
(pg. 146)
Clinical Obesity in Total Disc Replacement and Anterior Cervical Discectomy and Fusion Patients through Five Years Follow-up
Todd J. Albert, MD; Domagoj Coric, MD; Han-Jo Kim, MD; Elizabeth Roensch, BS; Kyle Marshall, BS; ***Kristen E. Radcliff, MD***

11:23 – 11:28 am
Discussion

11:29 – 11:49 am
Spinal Cord Injury

11:29 – 11:31 am
Presentation #26 P
(pg. 150)
Classifying Injury Severity and Predicting Neurologic Outcome after Acute Human Spinal Cord Injury with Cerebrospinal Fluid Biomarkers
Brian K. Kwon, MD, PhD*; Femke Streijger, PhD; Nader Fallah, PhD; Scott Paquette, MD, MEd; John Street, MD, PhD; Charles G. Fisher, MD, MPH; Marcel F. Dvorak, MD*

11:32 – 11:34 am
Presentation #27 P
(pg. 152)
• **Functional Assessment of Local vs. Distal Transplantation of Human Neural Stem Cells following Chronic Spinal Cord Injury**
Ivan Cheng, MD*; Michael Githens, MD; Tyler Johnston, MD; R. Lane Smith, PhD*
**Neural stem cells*

11:35 – 11:37 am
Presentation #28 P
(pg. 154)
Intrathecal Administration of Recombinant Human Hepatocyte Growth Factor for Acute Spinal Cord Injury: Road from Bench to Clinical Trial and Future Perspective
Kazuya Kitamura, MD, PhD*; Akio Iwanami, MD, PhD; Hiroki Iwai, MD, PhD; Jun-ichi Yamane, MD, PhD; Kanehiro Fujiyoshi, MD; Yoshiaki Toyama, MD; Morio Matsumoto, MD, PhD; Hideyuki Okano; Masaya Nakamura, MD*

• The FDA has not cleared the drug and/or medical device for the use described (i.e., the drug and/or medical device noted with an * is being discussed for an "off label" use). See inside back cover for information.

11:38 – 11:40 am
Presentation #29 P
(pg. 156)
Preexisting Severe Cervical Spinal Cord Compression is a Significant Risk Factor for Developing Severe Paralysis in Patients with Traumatic Cervical Spinal Cord Injury without Bone Injury: A Retrospective Cohort Study
Takeshi Oichi, MD*; Yasushi Oshima, MD, PhD; Rentaro Okazaki, MD, PhD; Seiichi Azuma, MD*

11:41 – 11:43 am
Presentation #30 P
(pg. 159)
Defining Central Cord Syndrome: Does Neurology or Injury Morphology Provide Better Discrimination of Neurological Outcomes?
Jérôme Paquet, MD; ***Jin W. Tee, MD****; Vanessa K. Noonan; Brian K. Kwon, MD, PhD; Eve C. Tsai, MD, PhD; Sean Christie, MD; Carly S. Rivers, PhD; Henry Ahn, MD; Najmedden Attabib, MD; Christopher S. Bailey, MD; Brian Drew, MD; Michael G. Fehlings, MD, PhD; Joel A. Finkelstein, MD; Daryl R. Fourney, MD; R. John Hurlbert, MD, PhD; Stefan Parent, MD; Marcel F. Dvorak, MD*

11:44 – 11:49 am
Discussion

11:50 am – 12:10 pm
OccipitoCervical Junction

11:50 – 11:52 am
Presentation #31 P
(pg. 161)
Vertebral Artery Course for Occipital Condyle Screw Fixation
Ho Jin Lee, MD*; Jae Taek Hong, MD, PhD*

11:53 – 11:55 am
Presentation #32 P
(pg. 164)
Minimum Five Year Follow-up Results for Occipitocervical Fusion Using the Screw-Rod System in Craniocervical Instability
Kei Ando, MD*; Shiro Imagama, MD, PhD; Naoki Ishiguro MD, PhD*

11:56 – 11:58 am
Presentation #33 P
(pg. 166)
Accurate and Simple Screw Insertion Procedure with Patient-Specific Screw Guide Templates for Posterior C1-C2 Fixation
Taku Sugawara, MD, PhD*; Shuichi Kaneyama, MD, PhD; Masatoshi Sumi, MD, PhD*

11:59 am – 12:01 pm
Presentation #34 P
(pg. 168)
Subaxial Cervical Sagittal Alignment following C1-C2 Fusion for Atlanto-Axial Osteoarthritis
Daniel G. Kang, MD; ***Ronald A. Lehman, Jr., MD****; Scott C. Wagner, MD; K. Daniel Riew, MD*

12:02 – 12:04 pm
Presentation #35 P
(pg. 169)
The Pathomechanisms of Dysphagia after Occipitospinal Fusion – Kinematic Analysis by Videofluoroscopic Swallowing Study
Shuichi Kaneyama, MD, PhD*; Masatoshi Sumi, MD, PhD; Koichi Kasahara, MD, PhD; Aritetsu Kanemura, MD, PhD; Masato Takabatake, MD; Akihiro Koh, MD; Hiroaki Hirata, MD, PhD*

12:05 – 12:10 pm
Discussion

Individual Disclosures can be found on pages 40 – 88.
P=Highlighted Posters

12:11 – 1:11 pm **NON-MEMBER LUNCH** **Seaport Ballrooms ABCD**

12:11 – 1:11 pm **MEMBER LUNCH** **Balboa ABC**

1:12 – 1:59 pm

Session V: RESEARCH SESSION

Moderator: *John M. Rhee, MD*

1:12 – 1:28 pm **Announcement of 2015**
21st Century Premier Donor Research Grant Winners

21ST CENTURY RESEARCH AND EDUCATION GRANTS

SEED STARTER RESEARCH AND EDUCATION GRANTS

RESIDENT FELLOW RESEARCH AND EDUCATION GRANTS

1:29 – 1:30 pm **Introduction – Research Grant Updates**

1:31 – 1:36 pm **21st Century Research and Education Grant**
The Effects of Peri-Operative Steroids on Dysphagia following Anterior Cervical Spine Surgery: A Randomized, Prospective, Double-Blind Study
***Sanford E. Emery, MD, MBA**; John C. France, MD; Scott D. Daffner, MD*

1:37 – 1:42 pm **21st Century Research and Education Grant**
Chemokine-Directed Homing of Peripheral Blood Mobilized Stem Cells to Enhance Cervical Spine Fusion
*Kevin C. Baker, PhD; **Daniel K. Park, MD**; Jeffrey S. Fischgrund, MD*

1:43 – 1:48 pm **Seed Starter Grant**
Can Human Mesenchymal Stem Cells Prevent or "Rescue" Intervertebral Disc Cells from the Inflammatory Changes Associated with Disc Degeneration?
***Christopher K. Kepler, MD, MBA**; D. Greg Anderson, MD; Dessislava Z. Markova, PhD; John D. Koerner, MD*

1:49 – 1:54 pm **Seed Starter Grant**
Disc Regeneration: Evaluation of Growth and Differentiation Factor-5 (GDF-5; BMP14) Production and Expression Pathways in Human Disc Cells Exposed to Proinflammatory Cytokines
***Helen E. Gruber, PhD**; H. James Norton, PhD; Edward N. Hanley, Jr., MD*

1:55 – 2:05 pm **Discussion**

2:06 – 2:54 pm

Session VI: COMPLICATIONS

Moderators: *Bobby K. Tay, MD and James S. Harrop, MD*

2:06 – 2:12 pm
Presentation #36
(pg. 171)
Does the Timing of Pre-Operative Epidural Steroid Injection affect Infection Risk after ACDF or Posterior Cervical Fusion?
***Jourdan M. Cancienne, MD**; Brian C. Werner, MD; Anuj Singla, MD; Hamid Hassanzadeh, MD; Frank H. Shen, MD; Adam L. Shimer, MD*

2:13 – 2:19 pm
Presentation #37
(pg. 173)
Is Obesity Correlated with Increased Complications following Cervical Surgery for Degenerative Conditions?
***J. Alex Sielatycki, MD**; Silky Chotai, MD; David P. Stonko, BS, MS; Joseph B. Wick, BA; Harrison F. Kay, BS; Kevin R. O'Neill, MD, MS; Clinton J. Devin, MD*

2:20 – 2:26 pm
Presentation #38
(pg. 175)
Complications of Iliac Crest Bone Graft in Cervical Spine Surgery
***M. Leslie Golden, BA, MD**; Steven K. Leckie, MD; John G. Heller, MD*

2:27 – 2:33 pm
Presentation #39
(pg. 176)
Does the Use of Intrawound Vancomycin Decreases the Risk of Surgical Site Infection after Elective Spine Surgery? A Multicenter Analysis
***Clinton J. Devin, MD**; Alexander R. Vaccaro, III, MD, PhD; Matthew J. McGirt, MD; Silky Chotai, MD; Jim A. Youssef, MD; Douglas G. Orndorff, MD; Paul M. Arnold, MD; Anthony K. Frempong-Boadu, MD; Isador H. Lieberman, MD, MBA; Hirad Hedayat, MD; Charles L. Branch, Jr., MD; Jeffrey C. Wang, MD; Robert E. Isaacs, MD; Kristen E. Radcliff, MD; Joshua C. Patt, MD; Kristen R. Archer, MD*

2:34 – 2:40 pm
Presentation #40
(pg. 180)
Recurrent Laryngeal Nerve Palsy after Cervical Spine Surgery – A Multicenter Study
*Ziya L. Gokaslan, MD; **Mohamad Bydon, MD**; Jay Won Rhee, MD; Rafael D. De la Garza-Ramos, MD; Zachary A. Smith, MD; Wellington K. Hsu, MD; Sheeraz A. Qureshi, MD, MBA; Samuel K. Cho, MD; Evan O. Baird, MD; Thomas E. Mroz, MD; Michael G. Fehlings, MD, PhD; Paul M. Arnold, MD; K. Daniel Riew, MD*

2:41 – 2:54 pm **Discussion**

2:55 – 3:25 pm **BREAK** **Exhibit Hall in Seaport Ballrooms ABCD**

3:26 – 4:13 pm **Introduction of Henry H. Bohlman Presidential Guest Speaker**
– Alan S. Hilibrand, MD
Henry H. Bohlman Presidential Guest Lecture
The Future of Healthcare, Medicine and Bioethics
– Charles Krauthammer, MD

4:14 – 4:27 pm **Discussion**

4:28–5:16 pm

Session VII: DIAGNOSTICS

Moderators: ***Louis G. Jenis, MD and Joseph R. O'Brien, MD, MPH***

4:28–4:34 pm
Presentation #41
(pg. 181)

Predictive Risk Factors of Cervical Spine Instabilities in Rheumatoid Arthritis: A Prospective Minimum 10-Year Multicenter Cohort Study
Yoshiki Terashima, MD*; Takashi Yurube, MD, PhD; Hiroaki Hirata, MD, PhD; Daisuke Sugiyama, MD, PhD; Masatoshi Sumi, MD, PhD*

4:35–4:41 pm
Presentation #42
(pg. 184)

Morbidity Rate and Risk Factors of Cervical Lesions in Rheumatoid Arthritis Patients under Current Pharmacological Treatment Paradigm
Takashi Kaito, MD, PhD*; Hiroyasu Fujiwara, MD; Takahiro Makino, MD, DMSc; Masafumi Kashii, MD, PhD; Yusuke Sakai, MD; Kazuo Yonenobu, MD, DMSc*

4:42–4:48 pm
Presentation #43
(pg. 187)

Prevalence and Imaging Characteristics of Asymptomatic and Symptomatic Spondylotic Cervical Spinal Cord Compression in General Population
Josef Bednarik, MD, PhD*; Miloš Kerkovský, MD, PhD; Zdenek Kadanka, MD, PhD; Zdenek Kadanka, Jr., MD; Ivana Kovalová; Barbora Jurová-Jakubcova, MD*

4:49–4:55 pm
Presentation #44
(pg. 189)

What is the Most Accurate Radiographic Anterior Cervical Fusion Criteria?
Kwang-Sup Song, MD*; K. Daniel Riew, MD*

4:56–5:02 pm
Presentation #45
(pg. 191)

Circulating MicroRNAs Reflect Neural Dysfunction in Patients with Cervical Spondylotic Myelopathy: Implications for a Novel Biomarker of Disease Pathobiology
Alex Laliberte, MSc*; Spyridon K. Karadimas, MD, PhD; Sukhvinder K. Kalsi-Ryan, BScPT, MSc, PhD; Aria Nouri, MD; Eric M. Massicotte, MD; Michael G. Fehlings, MD, PhD*

5:03–5:16 pm **Discussion**

5:16 pm **Adjourn**

5:20–7:20 pm **WELCOME RECEPTION** **Exhibit Hall in Seaport Ballrooms ABCD**

• **The FDA has not cleared the drug and/or medical device for the use described (i.e., the drug and/or medical device noted with an * is being discussed for an "off label" use). See inside back cover for information.**

7:00–7:10 am **Welcome and Announcements**
Zoher Ghogawala, MD and Rick C. Sasso, MD

7:11–7:59 am

Session VIII: ANTERIOR CERVICAL SURGERY

Moderators: ***Paul M. Arnold, MD and Alexander J. Ghanayem, MD***

7:11–7:17 am
Presentation #46
(pg. 194)

What is the Fate of the Pseudarthrosis Detected at One Year after Anterior Cervical Discectomy and Fusion?
Jae Hwan Cho, MD; Jung-Ki Ha, MD; Choon Sung Lee, MD, PhD; Chang Ju Hwang, MD; Sung Hoon Choi, MD; Chul Gie Hong, MD; Youn-Suk Joo, MD; ***Dong-Ho Lee, MD, PhD***

7:18–7:24 am
Presentation #47
(pg. 197)

ACDF with Total En Bloc Resection of Uncinate in Foraminal Stenosis of the Cervical Spine: Comparison with Conventional ACDF
Kyung-Soo Suk, MD, PhD*; Hak-Sun Kim, MD, PhD; Seong-Hwan Moon, MD, PhD; Hwan-Mo Lee, MD, PhD; Jae-Ho Yang, MD; Sung-Yub Jin, MD; Pierre M. Mella, MD*

7:25–7:31 am
Presentation #48
(pg. 199)

Predictors of Extended Hospital Stay after Cervical Disc Replacement or Anterior Cervical Discectomy and Fusion: Results from 1,004 Patients in an FDA Trial
S. Tim Yoon, MD, PhD; ***Aaron J. Greenberg, MD****; Praveen V. Mummaneni, MD*

7:32–7:38 am
Presentation #49
(pg. 201)

Effect of Inclusion of Asymptomatic Spondylotic Levels on Adjacent Segment Disease following ACDF
Caleb J. Behrend, MD*; Paul W. Millhouse, MD; Vismay Thakkar, MD; Alexander R. Vaccaro, III, MD, PhD; Alan S. Hilibrand, MD; Todd J. Albert, MD*

7:39–7:45 am
Presentation #50
(pg. 203)

Adjacent Segment Range of Motion does not Increase Two Years after Single-Level Cervical Arthrodesis
William Anderst, PhD*; Tyler West; William F. Donaldson, III, MD; Joon Yung Lee, MD; James D. Kang, MD*

7:46–7:59 am **Discussion**

8:00–8:43 am

Session IX: DYSPHAGIA

Moderators: ***Howard S. An, MD and Ronald I. Apfelbaum, MD***

8:00–8:06 am
Presentation #51
(pg. 206)

• **Prospective Comparison of Dysphagia following Anterior Cervical Discectomy and Fusion (ACDF) with and without rhBMP-2**
Michael R. Murray, MD; Steven K. Leckie, MD; Bradley W. Moatz, MD; ***Adam J. Schell, MD****; Ajay Premkumar, BS; John G. Heller, MD*
** Infuse Bone Graft – Medtronic*

Individual Disclosures can be found on pages 40–88.
P=Highlighted Posters

8:07–8:13 am
Presentation #52
(pg. 208)

Influence of the Neck Postural Change on Cervical Spine Motion and Angle during Swallowing
Jun Young Kim, MD*; Il Sup Kim, MD, PhD; Sung Hoon Im, MD; Jae Taek Hong, MD, PhD*

Presentation #53

WITHDRAWN FROM PROGRAM

8:14–8:20 am
Presentation #54
(pg. 210)

Impact of Local Intraoperative Steroid Application on Patient-Reported Swallow Function following an Anterior Cervical Discectomy and Fusion: Preliminary Results
Junyoung Ahn, BS; Junho Ahn, BS; Daniel D. Bohl, MD, MPH; Ehsan Tabaraee, MD; Gabriel Duhancioglu, MS; Rahul Kamath, MS; Daniel J. Johnson, BS; Dustin H. Massel, BS; ***Kern Singh, MD***

8:21–8:27 am
Presentation #55
(pg. 213)

The Effect of Local Intraoperative Steroid Administration on the Rate of Post-Operative Dysphagia following ACDF: A National Database Study of 245,754 Patients
Jourdan M. Cancienne, MD*; Brian C. Werner, MD; Anuj Singla, MD; Hamid Hassanzadeh, MD; Frank H. Shen, MD; Adam L. Shimer, MD*

8:28–8:43 am

Discussion

8:44–8:52 am

Introduction of CSRS President–*Robert F. Heary, MD*

8:53–9:25 am

PRESIDENTIAL ADDRESS–*Alan S. Hilibrand, MD*

9:26–9:56 am

BREAK **Exhibit Hall in Seaport Ballrooms ABCD**

9:57–10:45 am

Session X: MYELOPATHY II

Moderators: *Jacob M. Buchowski, MD, MS and Christopher I. Shaffrey, MD*

9:57–10:03 am
Presentation #56
(pg. 215)

The Application of a Novel Sensitive Gait Assessment Method to Optimize the Evaluation of Patients with Degenerative Cervical Myelopathy
Sukhvinder K. Kalsi-Ryan, BScPT, MSc, PhD*; Alex Laliberte, MSc; Spyridon K. Karadimas, MD, PhD; Eric M. Massicotte, MD; Mohammed F. Shamji, MD, PhD; Michael G. Fehlings, MD, PhD*

10:04–10:10 am
Presentation #57
(pg. 218)

Surgical Decompression in an Experimental Model of Cervical Spondylotic Myelopathy induces a Neuroinflammatory Response: Implications for Perioperative Clinical Management
Pia M. Vidal, BS, PhD*; Spyridon K. Karadimas, MD, PhD; Antigona Ulndreaj, BA; Stefania Forner, PhD; Alex Laliberte, MSc; Michael G. Fehlings, MD, PhD*

• **The FDA has not cleared the drug and/or medical device for the use described (i.e., the drug and/or medical device noted with an * is being discussed for an "off label" use). See inside back cover for information.**

10:11–10:17 am
Presentation #58
(pg. 220)

The Fall and Fracture Risk of Medicare Patients with Cervical Myelopathy
Daniel J. Blizzard, MD, MS*; Michael A. Gallizzi, MD, MS; Charles Sheets, PT; Colin T. Penrose, BA, BS; Robert E. Isaacs, MD; Christopher R. Brown, MD*

10:18–10:24 am
Presentation #59
(pg. 222)

Minimum Clinically Important Difference (MCID) of the JOA Score and 10-Second Test in Cervical Myelopathy Disorders
Eiji Wada, MD

10:25–10:31 am
Presentation #60
(pg. 224)

The Minimum Clinically Important Difference of the Modified Japanese Orthopaedic Association Scale in Patients with Degenerative Cervical Myelopathy
Lindsay Tetreault, HBSc*; Branko Kopjar, MD, PhD; Pierre Cote, DC, PhD; Aria Nouri, MD; Michael G. Fehlings, MD, PhD*

10:32–10:45 am

Discussion

10:46–11:34 am

Session XI: OUTCOMES

Moderators: *Mitchel B. Harris, MD and Serena S. Hu, MD*

10:46–10:52 am
Presentation #61
(pg. 227)

The Association between Preoperative Mental Distress and Patient Reported Outcome in Patients Treated Surgically for Cervical Radiculopathy
Martin Skeppholm, MD, PhD; ***Claes Olerud, MD, PhD***

10:53–10:59 am
Presentation #62
(pg. 228)

PROMIS Physical Function: A Better Patient Reported Outcome Measure in Cervical Spine Patients
Darrel S. Brodke, MD*; Brandon D. Lawrence, MD; W. Ryan Spiker, MD; Ashley M. Neese, BS; Man Hung, PhD*

11:00–11:06 am
Presentation #63
(pg. 230)

Outcomes and Complications of Fusions from the Cervical Spine to the Pelvis: Series of 46 Cases with Average 2.7-Year Follow-up
Sravisht Iyer, MD*; Han-Jo Kim, MD; Alexander A. Theologis, MD; Venu M. Nemani, MD, PhD; Todd J. Albert, MD; Lawrence G. Lenke, MD; Shane Burch, MD; Oheneba Boachie-Adjei, MD; Vedat Deviren, MD; Themistocles S. Protopsaltis, MD; Justin S. Smith, MD, PhD; Justin K. Scheer, BS; Jun Mizutani, MD; Eric O. Klineberg, MD; Christopher P. Ames, MD*

11:07–11:13 am
Presentation #64
(pg. 232)

Impact of Adverse Events on Clinical Outcome: Results through Five-Year Follow-up
Michael S. Hisey, MD*; Donna D. Ohnmeiss, MD, DrMed; Hyun W. Bae, MD; Jack E. Zigler, MD*

Individual Disclosures can be found on pages 40–88.
P=Highlighted Posters

11:14–11:20 am Presentation #65 *(pg. 234)*	**Quality of Life and General Health following Elective Surgery for Cervical Spine Pathologies: Determining Valid and Responsive Metric of Heath State Utility** *Silky Chotai, MD; Scott L. Parker, MD; Ahilan Sivaganesan, MD;* ***J. Alex Sielatycki, MD****; Joseph B. Wick, BA; Matthew J. McGirt, MD; Clinton J. Devin, MD*
11:21–11:34 am	**Discussion**
11:35–11:43 am	**2015 CSRS North America Traveling Fellowship Report** ***Themistocles S. Protopsaltis, MD; Kern Singh, MD***
11:44–11:49 am	**Preview CSRS 2016 Annual Meeting in Toronto, Ontario, Canada** ***Michael G. Fehlings, MD, PhD***
11:50–11:55 am	**Preview CSRS Asia Pacific Section 2016 Annual Meeting in Seoul, Republic of Korea** ***Jin Sup Yeom, MD, PhD***
11:56 am–12:01 pm	**Preview CSRS European Section 2016 Annual Meeting in Prague, Czech Republic** ***Bengt I. Lind, MD, PhD***
12:01 pm	**Adjourn**

Meeting Evaluations

Completion is required to obtain your Certificate of Attendance for each meeting you registered for and attended.

2015 CSRS Meetings Website:
www.csrs.org/events/2015-csrs-meetings-in-san-diego/

Annual Meeting Evaluation:
www.surveymonkey.com/r/2015CSRSAMEVAL

Ask the Expert Luncheon Symposium Evaluation:
www.surveymonkey.com/r/MYELOPATHYSESSION

Ask the Expert Dinner Symposium Evaluation:
www.surveymonkey.com/r/DEFORMITYSESSION

Friday, Dec 4, 2015 Seaport Ballrooms FGH

OPTIONAL LUNCHEON PROGRAMMING

Additional Registration Fee Required

12:30–2:30 pm	**MYELOPATHY SESSION** **Open Case Presentation: "Ask the Experts"** **Moderators:** ***K. Daniel Riew, MD and Jin Sup Yeom, MD, PhD***	
12:30–12:35 pm	**Introduction**	***K. Daniel Riew, MD***
12:30–1:15 pm	**Lunch Service**	
12:36–2:20 pm	**Case Presentations and Discussion** **Panelists:** ***Rick C. Sasso, MD*** ***Zoher Ghogawala, MD*** ***Jeffrey C. Wang, MD*** ***Michael G. Fehlings, MD, PhD*** ***K. Daniel Riew, MD***	
2:21–2:30 pm	**Final Comments, Questions**	***K. Daniel Riew, MD***

OPTIONAL DINNER PROGRAMMING

Additional Registration Fee Required

6:00–8:15 pm	**DEFORMITY SESSION** **Open Case Presentations: "Ask the Experts"** **Moderator:** ***Alexander R. Vaccaro, III, MD, PhD and Bengt I. Lind, MD, PhD***	
6:00–6:05 pm	**Introduction**	***Alexander R. Vaccaro, III, MD, PhD***
6:00–6:45 pm	**Dinner Service**	
6:06–8:05 pm	**Case Presentations and Discussion** **Panelists:** ***Robert F. Heary, MD*** ***Jens R. Chapman, MD*** ***Kazuhiro Chiba, MD, PhD*** ***Paul A. Anderson, MD*** ***K. Daniel Riew, MD***	
8:06–8:14 pm	**Final Comments, Questions**	***Alexander R. Vaccaro, III, MD, PhD***
8:15 pm	**Adjourn**	

7:00–7:05 am **Welcome and Announcements**
Zoher Ghogawala, MD and Rick C. Sasso, MD

7:06–7:54 am **Session XII: TRAUMA**
Moderators: *Brian K. Kwon, MD, PhD and Kristen E. Radcliff, MD*

7:06–7:12 am
Presentation #66
(pg. 235)
Cervical Facet Dislocations in the Pediatric Population: A Report of 21 Cases at a Level-1 Trauma Center from 2004–2014
Alireza K. Anissipour, DO; Carlo Bellabarba, MD; ***Richard J. Bransford, MD***

7:13–7:19 am
Presentation #67
(pg. 236)
Comparison of the Vacuum Mattress vs. the Spine Board Alone for Immobilization of the Cervical Spine Injured Patient: A Biomechanical Cadaveric Study
Mark L. Prasarn, MD*; Per Kristian Hyldmo, MD; MaryBeth Horodyski, PhD; Glenn R. Rechtine, II, MD*

7:20–7:26 am
Presentation #68
(pg. 238)
The Incidence and Associated Risk Factors of Cervical Spine Epidural Hematoma following Adult Trauma
Pedro A. Ricart, MD, MS*; Ravi Verma, MD, MBA; Steven J. Fineberg, MD; Kyle Fink; David E. Asprinio, MD; Louis F. Amorosa, MD*

7:27–7:33 am
Presentation #69
(pg. 240)
Dens Fractures Displacement is Dependent on the Sagittal Alignment of the Subaxial Cervical Spine Rather than the Force of Injury
Jung U. Yoo, MD*; Sabina R. Blizzard, BA; Natalie L. Zusman, BS; Matthew S. Shinseki, BS; Marcel W. Betsch, MD; Bala Krishnamoorthy, PhD*

7:34–7:40 am
Presentation #70
(pg. 242)
Risk Factors for Dysphagia in Acute Cervical Spinal Cord Injury
Tetsuo Hayashi, MD, PhD*; Takeshi Maeda, MD, PhD; Hiroaki Sakai, MD; Yuichiro Morishita, MD, PhD; Keiichiro Shiba, MD, PhD*

7:41–7:54 am **Discussion**

7:55–8:55 am **Symposium I: Complications**
Moderator: *Mitchel B. Harris, MD*

7:55–8:04 am **Pseudarthrosis** ***Darren R. Lebl, MD***

8:05–8:14 am **Pseudarthrosis** ***Darrel S. Brodke, MD***

8:15–8:24 am **Discussion**

8:25–8:34 am **Post-op Dysphagia** ***John C. France, MD***

8:35–8:44 am **Post-op Dysphagia** ***Paul M. Arnold, MD***

8:45–8:55 am **Discussion**

• The FDA has not cleared the drug and/or medical device for the use described (i.e., the drug and/or medical device noted with an * is being discussed for an "off label" use). See inside back cover for information.

8:56–9:43 am **Session XIII: MYELOPATHY III**
Moderators: *Darrel S. Brodke, MD and Bradford L. Currier, MD*

8:56–9:02 am
Presentation #71
(pg. 245)
Does Age affect Surgical Outcomes in Patients with Degenerative Cervical Myelopathy? Results from the Prospective, Multicenter AOSpine International Study in 479 Patients
Hiroaki Nakashima, MD*; Lindsay Tetreault, HBSc; Narihito Nagoshi, MD, PhD; Aria Nouri, MD; Michael G. Fehlings, MD, PhD*

9:03–9:09 am
Presentation #72
(pg. 249)
A Clinical Prediction Rule for Functional Outcomes in Patients Undergoing Surgery for Severe Degenerative Cervical Myelopathy: Analysis of an International AOSpine Prospective Multicentre Dataset of 254 Subjects
Lindsay Tetreault, HBSc; Branko Kopjar, MD, PhD; Pierre Cote, DC, PhD; Paul M. Arnold, MD; ***Michael G. Fehlings, MD, PhD***

9:10–9:16 am
Presentation #73
(pg. 253)
Signal Intensity Ratio on Magnetic Resonance Imaging and Neurological Status as Prognostic Factors in Patients with Cervical Compressive Myelopathy
Jun-Jae Shin, MD, PhD

9:17–9:23 am
Presentation #74
(pg. 256)
Clinical Outcomes following Surgical Management of Coexistent Parkinson's Disease and Cervical Stenosis with Myelopathy
Roy Xiao, BA; ***Jacob A. Miller, BS****; Daniel Lubelski, MD; Thomas E. Mroz, MD; Edward C. Benzel, MD; Ajit A. Krishnaney, MD; Andre Machado, MD, PhD*

9:24–9:30 am
Presentation #75
(pg. 259)
Symptomatic Lumbar Spinal Stenosis Increases the Risk of Spondylotic Cervical Spinal Cord Compression and Cervical Spondylotic Myelopathy
Josef Bednarik, MD, PhD*; Blanka Adamova, MD, PhD; Miloš Kerkovský, MD, PhD; Ivana Kovalová; Zdenek Kadanka, Jr., MD; Zdenek Kadanka, MD, PhD*

9:31–9:44 am **Discussion**

9:45–9:49 am **Announcement of Poster Award Winners**

9:50–9:55 am **Presentation of CSRS Medallion to *Robert F. Heary, MD***

9:56–10:11 am **BREAK** **Seaport Ballroom Foyer**

Individual Disclosures can be found on pages 40–88.
P=Highlighted Posters

10:12 – 11:00 am **Session XIV: DEFORMITY**
Moderators: ***Ivan Cheng, MD and Jeffrey D. Coe, MD***

10:12 – 10:18 am
Presentation #76
(pg. 261)

Variations in Sagittal Alignment Parameters Based on Age: A Prospective Study of Normal Patients using EOS Imaging
Sravisht Iyer, MD*; Lawrence G. Lenke, MD; Venu M. Nemani, MD, PhD; Michael C. Fu, MD; Grant D. Shifflett, MD; Todd J. Albert, MD; Brenda A. Sides, MA; Lionel N. Metz, MD; Matthew E. Cunningham, MD, PhD; Han-Jo Kim, MD*

10:19 – 10:25 am
Presentation #77
(pg. 264)

Cervical Deformity Surgery does not Result in Acute Post-Operative Dysphagia: Preliminary Results from a Prospective Cervical Deformity Study
Han-Jo Kim, MD*; Sravisht Iyer, MD; Justin S. Smith, MD, PhD; Michael P. Kelly, MD; Michael F. O'Brien, MD; Munish C. Gupta, MD; Todd J. Albert, MD; Themistocles S. Protopsaltis, MD; Gregory M. Mundis, MD; Peter G. Passias, MD; Eric O. Klineberg, MD; Christopher P. Ames, MD; International Spine Study Group*

10:26 – 10:32 am
Presentation #78
(pg. 266)

Cervical Kyphosis does not Imply Cervical Deformity: Predicting Cervical Curvature Required for Horizontal Gaze Based on Spinal Global Alignment and Thoracic Kyphosis
Bassel G. Diebo, MD*; Jonathan H. Oren, MD; Matthew A. Spiegel, BA; Shaleen Vira, MD; Elizabeth M. Tanzi, NP; Barthelemy Liabaud; Renaud Lafage, MS; Jensen K. Henry, BA; Themistocles S. Protopsaltis, MD, Thomas J. Errico, MD; Frank J. Schwab, MD; Virginie C. Lafage, PhD*

10:33 – 10:39 am
Presentation #79
(pg. 268)

Does Spinopelvic Alignment Change after Cervical Laminoplasty in Patients with Cervical Spondylotic Myelopathy?
Jun Ouchida*; Yasutsugu Yukawa, MD, PhD; Masaaki Machino, MD*

10:40 – 10:46 am
Presentation #80
(pg. 269)

Changes in Sagittal Cervical Alignment after Posterior Spinal Fusion for Adolescent Idiopathic Scoliosis: An Evaluation of 141 Patients
Joshua M. Pahys, MD*; Jahangir K. Asghar, MD; Alexander A. Theologis, MD; Suken A. Shah, MD; Patrick J. Cahill, MD; Amer F. Samdani, MD; Christopher P. Ames, MD*

10:47 – 11:00 am **Discussion**

• **The FDA has not cleared the drug and/or medical device for the use described (i.e., the drug and/or medical device noted with an * is being discussed for an "off label" use). See inside back cover for information.**

11:01 am–12:13 pm **Highlighted Poster Presentations II**
Moderators: ***Pasquale X. Montesano, MD and Thomas M. Reilly, MD***

11:01 – 11:24 am **Surgical Techniques**

11:01 – 11:03 am
Presentation #81 P
(pg. 272)

• 540° Cervical Realignment Procedure for Extensive Cervical OPll with Kyphotic Deformity
Sang-Hun Lee, MD, PhD*; Ki-Tack Kim, MD; Jung-Hee Lee, MD; Kyung-Chung Kang; Sang-Phil Hwang, MD; Soo-Jin Jang, MD*
** Cervical lateral mass screw, cervical pedicle screw*

11:04 – 11:06 am
Presentation #82 P
(pg. 275)

Regional Thoracic and Lumbar Sagittal Cobb Angle Changes and UIV Determine Evolution of Cervical Alignment after ASD Surgery: Series of 171 Patients with Two-Year Follow-up
Brian J. Neuman, MD*; Amit Jain, MD; Daniel M. Sciubba, MD; Eric O. Klineberg, MD; Han-Jo Kim, MD; Luke P. Zebala, MD; Gregory M. Mundis, MD; Virginie C. Lafage, PhD; Peter G. Passias, MD; Renaud Lafage, MS; Themistocles S. Protopsaltis, MD; D. Kojo Hamilton; Justin K. Scheer, BS; Christopher P. Ames, MD; International Spine Study Group*

11:07 – 11:09 am
Presentation #83 P
(pg. 277)

• Are Collapsed Cervical Discs Amenable to Total Disc Arthroplasty? Analysis of Prospective Clinical Study Results with Two-Year Follow-up
Avinash G. Patwardhan, PhD*; Gerard Carandang, MS; Leonard I. Voronov, PhD; Robert M. Havey, BS; Gary Paul; Carl Lauryssen, MD; Domagoj Coric, MD; Thomas A. Dimmig, MD; David B. Musante, MD*
** Cervical Disc Arthroplasty (M6 cervical disc prosthesis)*

11:10 – 11:12 am
Presentation #84 P
(pg. 280)

Can C3 Laminectomy Reduce Interlaminar Bony Fusion and Preserve Cervical Range of Motion after Cervical Laminoplasty?
Dong-Ho Lee, MD, PhD; ***Jung-Ki Ha, MD****; Jae Hwan Cho, MD; Choon Sung Lee, MD, PhD; Chang Ju Hwang, MD; Sung Hoon Choi, MD; Chul Gie Hong, MD; Youn-Suk Joo, MD*

11:13 – 11:15 am
Presentation #85 P
(pg. 283)

Is it "In" or "Out"? The Optimal Fluoroscopic Views for Intraoperative Determination of Proper Lateral Mass Screw Placement
Sangbum Kim, MD, PhD; ***John M. Rhee, MD****; Kun Young Park, MD; Chulmin Kim, PhD*

11:16 – 11:18 am
Presentation #86 P
(pg. 285)

An Approach to Primary Tumors of the Upper Cervical Spine with Total Spondylectomy using a Combined Approach: Our Experience with 19 Cases
Feng Wei, MD; Zhongjun Liu, MD, PhD; Xiaoguang Liu, MD, PhD; Liang Jiang; Genting Dang; ***Peter G. Passias, MD****; Miao Yu; Fengliang Wu; Lei Dang*

11:19 – 11:24 am **Discussion**

Individual Disclosures can be found on pages 40 – 88.
P=Highlighted Posters

11:25–11:48 am **Quality**

11:25–11:27 am
Presentation #87 P
(pg. 288)
Collar Fixation is not Mandatory after Cervical Laminoplasty – A Randomized Controlled Study
***Tetsuro Hida, MD**; Yoshito Sakai, PhD; Kenyu Ito; Shiro Imagama, MD*

11:28–11:30 am
Presentation #88 P
(pg. 290)
Missing Data May Invalidate Spine Surgery Database Studies
*Bryce A. Basques, MD; **Nathaniel T. Ondeck, BS**; Andre M. Samuel, BBA; Matthew L. Webb, AB; Adam M. Lukasiewicz, MSc; Daniel D. Bohl, MD, MPH; Junyoung Ahn, BS; Kern Singh, MD; Jonathan N. Grauer, MD*

11:31–11:33 am
Presentation #89 P
(pg. 294)
Iatrogenic Instability at the Supra-Adjacent Level of Posterior Cervical Instrumentation Constructs for Cervical Laminectomies: A Biomechanical Analysis
***Sina Pourtaheri, MD**; Andrew T. Healy, MD; Daniel Lubelski, MD*

11:34–11:36 am
Presentation #90 P
(pg. 296)
Characteristics of Residual Symptoms following Laminoplasty in Diabetic Patients with Cervical Spondylotic Myelopathy: A Prospective Cohort Study in 505 Patients with Cervical Spondylotic Myelopathy
***Masaaki Machino, MD**; Yasutsugu Yukawa, MD, PhD; Shiro Imagama, MD, PhD*

11:37–11:39 am
Presentation #91 P
(pg. 298)
Number of Operative Levels Minimally Impacts Risk for Adverse Events following an Anterior Cervical Decompression and Fusion
*Daniel D. Bohl, MD, MPH; Junyoung Ahn, BS; Dustin H. Massel, BS; Benjamin C. Mayo, BA; Bryce A. Basques, MD; **Nathaniel T. Ondeck, BS**; Jonathan N. Grauer, MD; Kern Singh, MD*

11:40–11:42 am
Presentation #92 P
(pg. 300)
Most 30-Day Readmissions after Anterior Cervical Discectomy and Fusion are not due to Surgical Site-Related Issues: An Analysis of 10,006 Patients
*Andre M. Samuel, BBA; Jason O. Toy, MD; **Michael C. Fu, MD**; Adam M. Lukasiewicz, MSc; Matthew L. Webb, AB; Daniel D. Bohl, MD, MPH; Bryce A. Basques, BS; Todd J. Albert, MD; Jonathan N. Grauer, MD*

11:43–11:48 am **Discussion**

11:49 am–12:12 pm **Cervical Myelopathy**

11:49–11:51 am
Presentation #93 P
(pg. 304)
The Efficacy and Safety of Additional Posterior Foraminotomy Performed with Laminoplasty for Cervical Spondylotic Myeloradiculopathy
*Jung-Ki Ha, MD; Jae Hwan Cho, MD; Choon Sung Lee, MD, PhD; Chang Ju Hwang, MD; **Sung Hoon Choi, MD**; Chul Gie Hong, MD; Youn-Suk Joo, MD; Dong-Ho Lee, MD, PhD*

11:52–11:54 am
Presentation #94 P
(pg. 307)
Quality of Life and Functional Outcomes after Surgical Decompression in Patients with Cervical Ossification of the Posterior Longitudinal Ligament: Results from the Prospective, Multicenter AOSpine International Study on 479 Patients
***Hiroaki Nakashima, MD**; Lindsay Tetreault, HBSc; Narihito Nagoshi, MD, PhD; Aria Nouri, MD; Michael G. Fehlings, MD, PhD*

11:55–11:57 am
Presentation #95 P
(pg. 310)
The Modified Japanese Orthopaedic Association Scale: Establishing Criteria for Mild, Moderate and Severe Disease in Patients with Degenerative Cervical Myelopathy
*Lindsay Tetreault, HBSc; **Aria Nouri, MD**; Anoushka Singh, PhD; Ronald HMA Bartels, MD, PhD; Branko Kopjar, MD, PhD; Paul M. Arnold, MD; Michael G. Fehlings, MD, PhD*

11:58 am–12:00 pm
Presentation #96 P
(pg. 313)
What Happens to the Disc Bulge after Posterior Laminectomy and Fusion in Patients with Cervical Myelopathy?
***Saankritya Ayan, MD**; Jonathan Morris, MD; Manal Abouelrigal, MD; Woojin Cho, MD, PhD; Alok D. Sharan, MD*

12:01–12:03 pm
Presentation #97 P
(pg. 316)
Anterior Decompression with Fusion vs. Posterior Decompression with Fusion for Massive Cervical Ossification of Posterior Longitudinal Ligament with 50% Canal Occupying Ratio or More: Retrospective Multicenter Study
***Toshitaka Yoshii, MD, PhD**; Takashi Hirai, MD, PhD; Satoshi Sumiya, MD; Tsuyoshi Kato, MD, PhD; Shigenori Kawabata, MD, PhD; Atsushi Okawa, MD, PhD; Kenichi Shinomiya, MD, PhD*

12:04–12:06 pm
Presentation #98 P
(pg. 318)
Is it Necessary to Extend a Multilevel Posterior Cervical Decompression and Fusion to the Upper Thoracic Spine?
***Gregory D. Schroeder, MD**; Christopher K. Kepler, MD, MBA; Mark F. Kurd, MD; Loren B. Mead, BS; Kristen Nicholson, PhD; Christie E. Stawicki, BS; Priyanka Kumar, BS; Paul W. Millhouse, MD; Kristen E. Radcliff, MD; Jeffery A. Rihn, MD; D. Greg Anderson, MD; Alan S. Hilibrand, MD; Alexander R. Vaccaro, III, MD, PhD*

12:07–12:12 pm **Discussion**

12:13–12:17 pm **Closing Remarks** ***Robert F. Heary, MD***

12:17 pm **Adjourn**

CERVICAL SPINE RESEARCH SOCIETY

FOUNDED 1973

E-Poster Catalog

- The FDA has not cleared the drug and/or medical device for the use described (i.e., the drug and/or medical device noted with an * is being discussed for an "off label" use). See inside back cover for information.

Individual Disclosures can be found on pages 40–88.

BASIC SCIENCE (CONT.)

E-Poster #8 *(pg. 332)*

Cervical Spinal Cord Injury Modifies Distal Lumbar Locomotor Central Pattern Generator (CPG)

***Spyridon K. Karadimas, MD, PhD**; Kajana Satkunendrarajah, PhD; Mohamad Khazaei, PhD; Simon Gosgnach, PhD; Michael G. Fehlings, MD, PhD*

BIOMECHANICS

E-Poster #9 *(pg. 334)*

- **An *In Vitro* Evaluation of Sagittal Alignment in the Cervical Spine after Insertion of Supraphysiologic Lordotic Implants**

***Donald J. Blaskiewicz, MD**; Patrick Han, MD; Jeffrey E. Harris, MS; Alexander W. Turner, PhD; Gregory M. Mundis, MD*

** NuVasive CoRoent Small Interbody system device only cleared for use at one level with anterior cervical plating.*

E-Poster #10 *(pg. 336)*

The Location of Instant Center of Rotation in the Cervical Spine during In Vivo Dynamic Flexion-Extension

***Kwang Sup Song, MD**; Seong Hwan Kim, MD; Jae Jun Yang, MD; Seung Bum Koo, PhD*

CERVICAL ARTHROPLASTY

E-Poster #11 *(pg. 338)*

Arthroplasty and ACDF Compared to ACDF Alone for Two- and Three-Level Cervical Disc Disease

***Jin Young Kim, MD**; K. Daniel Riew, MD*

CERVICAL FUSION

E-Poster #12 *(pg. 341)*

Intraoperative Correction of the O-C2 Angle can Prevent Dysphagia and/or Dyspnea after Occipitocervical Fusion Surgery

***Keita Nakayama, MD**; Tetsuya Abe, MD, PhD; Kengo Fujii, MD; Kosei Miura, MD; Masaki Tatsumura, MD, PhD; Masashi Yamazaki, MD*

E-Poster #13 *(pg. 343)*

Does Cervical Sagittal Alignment Correlate with Outcomes following Anterior Cervical Surgery?

***J. Alex Sielatycki, MD**; Sheyan Armaghani, MD; Arnold Silverberg, BS; Matthew J. McGirt, MD; Clinton J. Devin, MD; Kevin R. O'Neill, MD, MS*

E-Poster #14 *(pg. 345)*

Outcome of Correction Surgery using Pedicle Screw for Cervical Kyphosis Exclusive of Ankylosing Spondylitis

Hiroshi Miyamoto, MD; Terumasa Ikeda, MD; Kazuki Hashimoto, MD; Masao Akagi, MD

E-Poster #15 *(pg. 347)*

Cervical Spine Fusion: 16-Year Trends in Epidemiology, Indications, and Bone Morphogenetic Protein Utilization by Surgical Approach

***Lukas P. Lampe, MD**; Alexander P. Hughes, MD; Peter Derman, MD, MBA; Janina Kueper; Ting Jung Pan, MPH; Federico P. Girardi, MD; Todd J. Albert, MD; Stephen Lyman, PhD*

- **The FDA has not cleared the drug and/or medical device for the use described (i.e., the drug and/or medical device noted with an * is being discussed for an "off label" use). See inside back cover for information.**

E-Poster #16 *(pg. 350)*

Preoperative Nomograms Predicting Patient-Specific Cervical Spine Surgery Clinical and Quality of Life Outcomes

Daniel Lubelski, MD; Vincent Alentado, BS; Michael Shriver, BS; Amy Nowacki, PhD; Kalil G. Abdullah, MD; Michael P. Steinmetz, MD; Edward C. Benzel, MD; ***Thomas E. Mroz, MD***

E-Poster #17 *(pg. 353)*

- **Comparison of Long Term (Five-Year) Reoperation Rates and Outcomes of Long Fusions to the Cervico-Thoracic Junction: Multilevel ACDF with BMP-2 vs. Posterior Fusions**

***Nicole Record, DO**; Michael Faloon, MD, MS; Ki Soo Hwang, MD; Kumar G. Sinha, MD; Kimona Issa, MD; Conor Dunn, MS; Arash Emami, MD*

** Bone Morphogenic Protein – 2 has a black box warning for use in the cervical spine.*

COMPLICATIONS

E-Poster #18 *(pg. 355)*

Risk Factors and Functional Outcomes of Re-Intubation after Anterior Cervical Spine Surgery: Results from AOSpine North America Multicenter Study on 8,887 Patients

***Narihito Nagoshi, MD**; Michael G. Fehlings, MD, PhD; Hiroaki Nakashima, MD; Lindsay Tetreault, HBSc; K. Daniel Riew, MD; Zachary A. Smith, MD; Wellington K. Hsu, MD; Chadi Tannoury, MD; Tony Y. Tannoury, MD; Vincent C. Traynelis, MD; Paul M. Arnold, MD; Thomas E. Mroz, MD; Anthony DeGiacomo, MD; Bruce C. Jobse, MS; Eric M. Massicotte, MD*

E-Poster #19 *(pg. 358)*

The Incidence of an Epidural Hematoma following Cervical Spine Surgery

***Gregory D. Schroeder, MD**; Alan S. Hilibrand, MD; Paul M. Arnold, MD; David E. Fish, MD, MPH; Jeffrey C. Wang, MD; Zachary A. Smith, MD; Wellington K. Hsu, MD; Ziya L. Gokaslan, MD; Robert E. Isaacs, MD; Adam Kanter, MD; Thomas E. Mroz, MD; Ahmad Nassr, MD; Rick C. Sasso, MD; Michael G. Fehlings, MD, PhD; Zorica Buser, PhD; Mohamad Bydon, MD; Elizabeth Lord, MD; Emily C. Nguyen, MD; K. Daniel Riew, MD*

E-Poster #20 *(pg. 362)*

A Multicenter Study of the Presentation, Treatment, and Outcomes of Cervical Dural Tears

Kevin R. O'Neill, MD; Michael G. Fehlings, MD, PhD; Thomas E. Mroz, MD; Zachary A. Smith, MD; Wellington K. Hsu, MD; Adam Kanter, MD; Michael P. Steinmetz; MD; Paul M. Arnold, MD; Praveen V. Mummaneni, MD; Dean Chou, MD; Ahmad Nassr, MD; Sheeraz A. Qureshi, MD, MBA; Samuel K. Cho, MD; Evan O. Baird, MD; Justin S. Smith, MD, PhD; Chadi Tannoury, MD; Tony Y. Tannoury, MD; Ziya L. Gokaslan, MD; Robert A. Hart, MD; Robert E. Isaacs, MD; Rick C. Sasso, MD; David B. Bumpass, MD; Mohamad Bydon, MD; Mark Corriveau, MD; Anthony DeGiacomo, MD; Adeeb Derakhshan, BS; Bruce C. Jobse, MS; Daniel Lubelski, MD; Sungho Lee, MD; Eric M. Massicotte, MD; Jonathan Pace, MD; Gabriel Smith, MD; Khoi Duc Than, MD; ***K. Daniel Riew, MD***

Individual Disclosures can be found on pages 40–88.

COMPLICATIONS (CONT.)

E-Poster #21 *(pg. 364)*

Hospital-Acquired Pneumonia Occurs in 20.5% of Cervical Spinal Cord Injury Patients and is Associated with Poor Inpatient Outcomes: An Analysis of 5,198 Patients in the National Trauma Data Bank

***Andre M. Samuel, BBA**; Pablo J. Diaz-Collado, MD; Michael C. Fu, MD; Adam M. Lukasiewicz, MSc; Matthew L. Webb, AB; Daniel D. Bohl, MPH; Bryce A. Basques, BS; Jonathan N. Grauer, MD*

DEFORMITY

E-Poster #22 *(pg. 367)*

Predictive Model for Cervical Alignment Outcomes following Surgical Correction of Adult Spinal Deformity

***Peter G. Passias, MD**; Cheongeun Oh, PhD; Cyrus M. Jalai, BS; Nancy J. Worley, BS; Renaud Lafage, MS; Justin K. Scheer, BS, Eric O. Klineberg, MD; Robert A. Hart, MD; Han-Jo Kim, MD; Justin S. Smith, MD, PhD; Virginie C. Lafage; PhD; Christopher P. Ames, MD; International Spine Study Group*

E-Poster #23 *(pg. 370)*

Extent of Proximal Fusion Correlates with Worse Clinical Outcomes in Cervical to Pelvis Fusions

***Han-Jo Kim, MD**; Sravisht Iyer, MD; Alexander A. Theologis, MD; Todd J. Albert, MD; Lawrence G. Lenke, MD; Vedat Deviren, MD; Venu M. Nemani, MD, PhD; Oheneba Boachie-Adjei, MD; Shane Burch, MD; Jun Mizutani, MD; Eric O. Klineberg, MD; Themistocles S. Protopsaltis, MD; Justin S. Smith, MD, PhD; Justin K. Scheer, BS; Christopher P. Ames, MD*

DIAGNOSTICS

E-Poster #24 *(pg. 373)*

A Novel Radiographic Indicator of Developmental Cervical Stenosis

***Phillip H. Horne, MD, PhD**; Lukas P. Lampe, MD; Joseph T. Nguyen, MPH; Richard J. Herzog, MD; Todd J. Albert, MD*

E-Poster #25 *(pg. 376)*

A Novel Comprehensive MRI Classification System for Cervical Foraminal Stenosis

***Sang-Hun Lee, MD, PhD**; So-Young Park, MD; Ki-Tack Kim, MD; Sang-Phil Hwang, MD; Soo-Jin Jang, MD; Jeffrey C. Wang, MD*

ECONOMICS/VALUE

E-Poster #26 *(pg. 379)*

The Total Cost to the Healthcare System for the Treatment of Cervical Myelopathy

***Gregory D. Schroeder, MD**; Mark F. Kurd, MD; Kristen E. Radcliff, MD; Jason W. Savage, MD; Jeffery A. Rihn, MD; D. Greg Anderson, MD; Alan S. Hilibrand, MD; Alexander R. Vaccaro III, MD, PhD; Christopher K. Kepler, MD, MBA*

LAMINOPLASTY

E-Poster #27 *(pg. 381)*

Sagittal Imbalance Might Be a Risk Factor of Increasing Post Laminoplasty Kyphosis

***Yoshitaka Suzuki, MD**; Tetsuya Ohara, MD; Taichi Tsuji, MD; Tosiki Saito; Ayato Nohara, MD; Ryoji Tauchi, MD; Noriaki Kawakami, MD*

- **The FDA has not cleared the drug and/or medical device for the use described (i.e., the drug and/or medical device noted with an * is being discussed for an "off label" use). See inside back cover for information.**

MYELOPATHY

E-Poster #28 *(pg. 383)*

A 30-Meter Walking Test as a Measure of Cervical Spondylotic Myelopathy Severity: Test Characteristics and Results from Two Multicenter Cohort Studies

*Parker E. Bohm, BA, BS; Michael G. Fehlings, MD, PhD; Branko Kopjar, MD, PhD; **Paul M. Arnold, MD***

E-Poster #29 *(pg. 385)*

Disability and Impairment of the Upper Limb and How they Define the Patient with Degenerative Cervical Myelopathy (DCM)

***Sukhvinder K. Kalsi-Ryan, BScPT, MSc, PhD**; Jerri M. Clout, BS; Pouya Rostami, BS; Eric M. Massicotte, MD, Mohammed F. Shamji, MD; Michael G. Fehlings, MD, PhD*

NEW TECHNOLOGIES

E-Poster #30 *(pg. 387)*

Noninvasive Evaluation by Magnetospinography of Electrophysiological Activity in the Cervical Spine after Peripheral Nerve Stimulation in Humans

***Satoshi Sumiya, MD**; Shigenori Kawabata, PhD; Toshitaka Yoshii; Tsuyoshi Kato, MD, PhD; Atsushi Okawa*

OTHER

E-Poster #31 *(pg. 388)*

Risk and Cost of Reoperation after Single-Level Posterior Cervical Foraminotomy: A Large Database Study

*Arash J. Sayari, BS; Alexander Tuchman, MD; Jeremiah R. Cohen, BS; John C. Liu, MD; Frank L. Acosta, MD; Mark J. Spoonamore, MD; Thomas C. Chen, MD, PhD; Patrick C. Hsieh, MD, MSc; Zorica Buse, PhD; **Jeffrey C. Wang, MD***

E-Poster #32 *(pg. 390)*

Over 10-Year Aggravation of Cervical Spine Instabilities in Rheumatoid Arthritis: A Prospective Cohort Study of Outpatients

***Hiroaki Hirata, MD, PhD**; Takashi Yurube, MD, PhD; Masatoshi Sumi, MD, PhD; Yoshiki Terashima, MD*

E-Poster #33 *(pg. 393)*

Operative Treatment in Patients with Suboccipital Spinal Metastasis: Is a Posterior Approach Alone Enough?

***Panya Luksanapruksa, MD**; Jacob M. Buchowski, MD, MS; David B. Bumpass, MD; Neill M. Wright, MD*

OUTCOMES

E-Poster #34 *(pg. 394)*

The Effects of Anticoagulation or Antiplatelet Agents in Cervical Spine Surgery Patients

***Jong-Hyun Ko, MD**; Ju-Rang Lee, MD; Kyung-Jin Song, MD*

E-Poster #35 *(pg. 395)*

Morbidity and Mortality Associated with Transoral Approaches to the Cervical Spine

***Jeremy Steinberger, MD**; Dante M. Leven, DO, PT; Branko Skovrlj, MD; Nathan J. Lee, BS; Parth Kothari, BS; Javier Z. Guzman Tejero, BS; John I. Shin, MD; John M. Caridi, MD; Samuel K. Cho, MD*

Individual Disclosures can be found on pages 40–88.

OUTCOMES (CONT.)

E-Poster #36 *(pg. 398)*
Preoperative Functional Status as a Predictor of Morbidity and Mortality following Elective Cervical Spine Surgery
Shobhit V. Minhas, MD; Aditya S. Mazmudar, BA; ***Alpesh A. Patel, MD***

E-Poster #37 *(pg. 400)*
Stability of Clinical Outcome Measures following Anterior Cervical Spine Surgery
Donna D. Ohnmeiss, DrMed; Richard D. Guyer, MD; ***Jack E. Zigler, MD****;*
Scott L. Blumenthal, MD

E-Poster #38 *(pg. 402)*
Does Patient Satisfaction Reflect Quantitative Pain and Function Measurements in Cervical Spine Surgery?
Kristen E. Radcliff, MD*; Domagoj Coric, MD; Han-Jo Kim, MD; Elizabeth Roensch, BS; Kyle Marshall, BS; Todd J. Albert, MD*

E-Poster #39 *(pg. 404)*
Identifying Predictors of Upper Body Post-Operative Pain and Disability Improvement in Surgical Cervical Spine Radiculopathic Patients
Peter G. Passias, MD*; Kristen E. Radcliffe, MD; Robert E. Isaacs, MD; Kristina Bianco, BA; Cyrus M. Jalai, BA; Nancy J. Worley, BA; Paul M. Arnold, MD; Patrick C. Hsieh, MD, MSc; Alexander R. Vaccaro, III, MD, PhD; Michael C. Gerling, MD*

E-Poster #40 *(pg. 407)*
Validation of Patient-Reported Outcomes Measurement Information System (PROMIS) Computer Adaptive Tests (CATS) in Cervical Spine Surgery
Alpesh A. Patel, MD*; Surabhi Bhatt, BS; Wellington K. Hsu, MD; Jason W. Savage, MD*

SPINAL CORD INJURY

E-Poster #41 *(pg. 409)*
MRI Prognostic Factors for Ambulatory Ability after Spinal Cord Injury without Bony Injury (SCIWOBI)
Miki Komatsu, MD, PhD*; Kota Suda, MD; Satoko Matsumoto, MD; Chikara Ushiku, MD; Katsuhisa Yamada, MD*

E-Poster #42 *(pg. 411)*
Mechanism of Injury vs. AOSpine Classification: Is the Setting/Environment in which the Injury Occurs or the Morphology of the Spinal Column Injury the Better Predictor of Severity of Spinal Cord Injury?
Jin W. Tee, MD*; Marcel F. Dvorak, MD; Nader Fallah, PhD; Vanessa K. Noonan; Charles G. Fisher, MD, MPH; Brian K. Kwon, MD, PhD; John Street , MD, PhD; F. Cumhur Öner; Alexander R. Vaccaro, III, MD, PhD*

SURGICAL ISSUES

E-Poster #43 *(pg. 414)*
Incidence of and Risk Factors for Incorrect Level Needle Localization during Anterior Cervical Discectomy and Fusion Surgery (ACDF)
Deepak Reddy, MD*; David T. Endriga, MD; Eric M. Kiskaddon, MD; Steven D. Glassman, MD; Kelly R. Bratcher, RN, CCRP; Katlyn E. McGraw, BA; Leah Y. Carreon, MD, MSc*

TRAUMA

E-Poster #44 *(pg. 415)*
ASIA Impairment Scale Predicts the Need for Tracheostomy after Cervical Spinal Cord Injury
Benjamin R. Childs, BS; ***Timothy A. Moore, MD****; John J. Como, MD, MPH; Heather A. Vallier, MD*

E-Poster #45 *(pg. 416)*
Clearing the C-Spine in Obtunded Trauma Patients Based on Admission CT: A Prospective Randomized Trial
Christopher P. O'Boynick, MD*; Timothy M. Lonergan, MD; Howard M. Place, MD*

Individual Disclosures can be found on pages 40–88.

Alphabetical Participant Disclosure List

Disclosure information submitted to the AAOS Orthopaedic Disclosure Program.

a = Awards Committee • c = CSRS Staff • df = Dinner Symposium • lf = Lunch Symposium • m = Moderator • p = Program Committee • rc = Research Committee • rs = Research Session • s = Symposium Presenter • sp = Special Presenter

Name	Received	Presentation	E-Poster
Aaronson, Oran S	No Conflicts to Disclose; Submitted 05/06/2015	8	
Abdullah, Kalil G	No Conflicts to Disclose; Submitted 05/01/2015		16
Abe, Tetsuya	No Conflicts to Disclose; Submitted 05/01/2015		12
Abouelrigal, Manal	No Conflicts to Disclose; Submitted 05/03/2015	96 P	
Acosta, Frank L	Submitted 05/30/2015 NuVasive: Paid consultant		31
Adamova, Blanka	No Conflicts to Disclose; Submitted 04/22/2015	75	
Ahn, Henry	No Conflicts to Disclose; Submitted 05/05/2015	30 P	
Ahn, Junho	No Conflicts to Disclose; Submitted 04/12/2015	54	
Ahn, Junyoung	No Conflicts to Disclose; Submitted 04/11/2015	15, 54, 88 P, 91 P	
Ahn, Nicholas U	Submitted 05/04/2015 NASS: Board or committee member Spine: Editorial or governing board The Spine Journal: Editorial or governing board Ulrich: Other financial or material support; Research support	21 P	
Akagi, Masao	Submitted 05/05/2015 Japanese Ortho Society: Board or committee member KYOCERA Medical: Paid presenter or speaker; Research support Zimmer: Paid consultant		14
Albert, Todd J [m]	Submitted 04/23/2015 AAOS: Board or committee member AOA: Board or committee member ASIP: Stock or stock options Biomet: IP royalties Biometrix: Stock or stock options Breakaway Imaging: Stock or stock options Crosstree: Stock or stock options DePuy, A Johnson & Johnson Company: IP royalties; Paid consultant FacetLink: Paid consultant; Stock or stock options Gentis: Stock or stock options In ViVo Therapeutics: Stock or stock options Invuity: Stock or stock options Jay Pee: Publishing royalties, financial or material support JBJS: Editorial or governing board Paradigm Spine: Stock or stock options Pioneer: Stock or stock options PMIG: Stock or stock options Saunders/Mosby-Elsevier: Publishing royalties, financial or material support SRS: Board or committee member Spine: Editorial or governing board Spine Deformity Journal: Editorial or governing board	25 P, 49, 63, 76, 77, 92 P	15, 23, 24, 38

Name	Received	Presentation	E-Poster
Albert, Todd J [m] (cont.)	Spinicity: Stock or stock options Thieme: Publishing royalties, financial or material support United Healthcare: Other financial or material support Vertech: Stock or stock options	25 P, 49, 63, 76, 77, 92 P	15, 23, 24, 38
Alentado, Vincent	No Conflicts to Disclose; Submitted 05/05/2015		16
Ament, Jared D	Submitted 04/28/2015 LDR Spine: Paid consultant	11	
Ames, Christopher P [rc]	Submitted 05/01/2015 Biomet Spine: IP royalties DePuy: Paid consultant Doctors Research Group: Stock or stock options Fish & Richardson: Other financial or material support Medtronic: Paid consultant Stryker: IP royalties; Paid consultant Visualase: Stock or stock options	63, 77, 80, 82 P	22, 23
Amorosa, Louis F	No Conflicts to Disclose; Submitted 05/04/2015	68	
An, Howard S [m,rc]	Submitted 10/08/2015 Amer Journal of Orthopedics: Editorial or governing board Articular Engineering LLC: Stock or stock options Bioventis: Paid consultant Medyssey: Research support Medyssey: Stock or stock options RTI: Stock or stock options Spinal Kinetics: Stock or stock options Spinalcyte: Research support Spine: Editorial or governing board U & I: IP royalties; Stock or stock options Yuhan: Research support Zimmer: IP royalties		
Anderson, D Greg [a,p,rs]	Submitted 04/15/2015 CSRS, Society for Minimally Invasive Spinal Surgery: Board or committee member DePuy, A Johnson & Johnson Company: IP royalties; Paid consultant; Paid presenter or speaker; Research support ISD: Stock or stock options Journal of Spine Disorders and Techniques, Spine Universe, Spinal Deformity: Editorial or governing board Medtronic: IP royalties; Paid consultant; Paid presenter or speaker PST: Stock or stock options Spinicity: Stock or stock options Synthes, Globus Medical: Paid consultant Thieme: Publishing royalties, financial or material support	98 P	26
Anderson, Joshua T	No Conflicts to Disclose; Submitted 04/04/2015	21 P	

a = Awards Committee • c = CSRS Staff • df = Dinner Symposium • lf = Lunch Symposium • m = Moderator • p = Program Committee • rc = Research Committee • rs = Research Session • s = Symposium Presenter • sp = Special Presenter

Name	Received	Presentation	E-Poster
Anderson, Paul A [ds]	Submitted 10/01/2015 AAOS, ASTM, CORR, LSRS, NASS: Board or committee member Aesculap/B.Braun: Paid consultant Expanding Orthopedics: Stock or stock options; Unpaid consultant Pioneer: IP royalties Pioneer surgucal: Stock or stock Options SI Bone: Stock or stock Options; Unpaid consultant Spartec: Stock or stock Options Spatatec: Unpaid consultant Spine Arthroplasty Society: Board or committee member Spine section of AANS/CNS: Board or committee member Stryker: IP royalties; Paid consultant Titan Surgical: Stock or stock Options; Unpaid consultant CORR, JBJS, Journal of Orthopaedics and Traumatology, Journal of Spinal Disorders, neruosurgery, Spine, Spine Arthropalsty Journal: Editorial or governing board		
Anderst, William	Submitted 05/01/2015 Journal of Ortho Research: Editorial or governing board	50	
Ando, Kei	No Conflicts to Disclose; Submitted 05/25/2015	32 P	
Anissipour, Alireza K	No Conflicts to Disclose; Submitted 04/02/2015	66	
Apfelbaum, Ronald I [m]	Submitted 09/30/2015 Aesculap/B.Braun: IP royalties; Paid consultant Medtronic: Stock or stock options		
Archer, Kristen R	No Conflicts to Disclose; Submitted 04/30/2015	39	
Armaghani, Sheyan J	No Conflicts to Disclose; Submitted 08/31/2015	24 P	13
Arnold, Paul M [m,s]	Submitted 10/01/2015 AANS/CNS: Board or committee member AOSpine: Board or committee member; Research support; Other financial or material support Cerapedics: Research support Covidien: Research support DePuy Spine: Research support FzioMed: Paid consultant IAMI, Asubio Pharmaceuticals, Spineology, Acorda Therapeutics, AOSpine: Research support LANX: Research support LSRS, NASS: Board or committee member Medtronic Sofamor Danek: Paid consultant Spine Trauma Study Group: Research support Stryker: Paid consultant Z-plasty: Stock or stock options Journal of Spinal Disorders and Techniques,The Spine Journal, Spine, Yonsei Medical Journal, Journal of Neurosurgery: Spine, Indian Journal of Cancer, Neurosurgery, Indian Journal of Orthopedics,	1, 2, 39, 40, 72, 95 P	18, 19, 20, 28, 39

Name	Received	Presentation	E-Poster
Arnold, Paul M [m,s] (cont.)	Journal of Spinal Cord Medicine, Global Spine Journal, Journal of Pediatric Neuroradiology, World Journal of Surgical Oncology, Nigerian Journal of Surgery, Surgical Neurology Int'l, Journal Radiology Case Reports, Journal of Spine, Public Library of Science One: Editorial or governing board	1, 2, 39, 40, 72, 95 P	18, 19, 20, 28, 39
Asghar, Jahangir K	Submitted 08/15/2015 SRS: Board or committee member	80	
Asher, Anthony L	Submitted 05/05/2015 Hyperbranch Corporation: Stock or stock options Medtronic: Paid consultant	23 P	
Asprinio, David E	Submitted 05/05/2015 Synthes: Research support	68	
Attabib, Najmedden	No Conflicts to Disclose; Submitted 05/04/2015	30 P	
Ayan, Saankritya	No Conflicts to Disclose; Submitted 05/01/2015	96 P	
Azuma, Seiichi	No Conflicts to Disclose; Submitted 05/03/2015	29 P	
Bae, Hyun W	Submitted 05/05/2015 Biomet: IP royalties Bioness: Research support DePuy, A Johnson & Johnson Company: IP royalties; Paid presenter or speaker IsoTis Orthobiologics: Research support KASS: Board or committee member LDR Spine: IP royalties; Paid presenter or speaker; Research support Medtronic: Paid consultant; Paid presenter or speaker; Research support; Stock or stock options Mesoblat: Research support NuVasive: IP royalties; Paid presenter or speaker Prosidyan: IP royalties Relievant: Research support Stryker: IP royalties; Paid presenter or speaker Stryker, Orthovita, Spinal Restoration, Difusion: Stock or stock options Synthes: Paid consultant Zimmer: IP royalties; Paid consultant; Paid presenter or speaker	13, 64	
Bailey, Christopher S	No Conflicts to Disclose; Submitted 05/05/2015	30 P	
Baird, Evan O	No Conflicts to Disclose; Submitted 05/01/2015	40	20
Baker, Kevin C [rs]	Submitted 05/29/2015 Arthrex: Research support K2M: Research support LSRS: Board or committee member		

Name	Received	Presentation	E-Poster
Baker, Kevin C [rs] (cont.)	Stryker: Research support Synthes: Research support Zimmer: Research support		
Barbagallo, Giuseppe	Submitted 05/04/2015 AO Foundation: Board or committee member DePuy, A Johnson & Johnson Company: Paid presenter or speaker; Research support SinteaPlustec: Paid consultant	2	
Barlow, Daniel R	No Conflicts to Disclose; Submitted 04/29/2015	6	
Bartels, Ronald HMA	Submitted 04/30/2015 CSRS: Board or committee member European Spine Journal: Editorial or governing board	2, 95 P	
Basques, Bryce A	No Conflicts to Disclose; Submitted 05/07/2015	15, 88 P, 91 P, 92 P	21
Beck, David	No Conflicts to Disclose; Submitted 09/02/2015		3
Bednarik, Josef	No Conflicts to Disclose; Submitted 04/30/2015	43, 75	
Behrend, Caleb J	No Conflicts to Disclose; Submitted 04/13/2015	49	
Bellabarba, Carlo	Submitted 03/29/2015 CSRS, NASS: Board or committee member Orthopedics Today: Editorial or governing board	66	
Bellary, Sharath	No Conflicts to Disclose; Submitted 05/04/2015	20	
Benzel, Edward C	Submitted 04/02/2015 AxioMed: IP royalties; Paid consultant; Publishing royalties, financial or material support; Stock or stock options CSRS: Board or committee member DePuy, A Johnson & Johnson Company: IP royalties Spine, The Spine Journal, Journal of Spinal disorders, Neurosurgery and World Spine Journal, World Neurosurgery: Editorial or governing board	74	16
Berlin, Connor	No Conflicts to Disclose; Submitted 10/21/2015	16	
Bernard, Thierry	Submitted 04/06/2015 DePuy, A Johnson & Johnson Company: Employee	12	
Betsch, Marcel W	No Conflicts to Disclose; Submitted 05/03/2015	69	
Bhatia, Nitin N [p]	Submitted 04/03/2015 Alphatec Spine: IP royalties; Paid consultant; Paid presenter or speaker; Research support Biomet: IP royalties; Paid consultant; Paid presenter or speaker DiFusion: Paid consultant; Stock or stock options NASS: Board or committee member OKO: Editorial or governing board SeaSpine: IP royalties; Paid consultant; Paid presenter or speaker; Research support Spineart: Paid presenter or speaker Zimmer: Paid consultant		

Name	Received	Presentation	E-Poster
Bhatia, Nitin N [p] (cont.)	SpineLine: Editorial or governing board Stryker: IP royalties; Paid consultant; Paid presenter or speaker Western Orthopaedic Assoc: Board or committee member		
Bhatt, Surabhi A	No Conflicts to Disclose; Submitted 04/17/2015		40
Bianco, Kristina	No Conflicts to Disclose; Submitted 05/06/2015		39
Blaskiewicz, Donald J	Submitted 05/06/2015 NuVasive: Paid consultant; Paid presenter or speaker		9
Blizzard, Daniel J	No Conflicts to Disclose; Submitted 05/27/2015	58	
Blizzard, Sabina R	No Conflicts to Disclose; Submitted 05/01/2015	69	
Blumenthal, Scott L	Submitted 04/13/2015 Aesculap/B.Braun: Other financial or material support; Paid consultant; Paid presenter or speaker; Research support DePuy, A Johnson & Johnson Company: Other financial or material support; Research support Exactech: Other financial or material support Orthofix,: Other financial or material support Paradigm, Centinel, LDR: Paid presenter or speaker Vertiflex , Ranier, Centinel: Stock or stock options Vertiflex, Paradigm, Centinel,Vertiflex, Ranier: Paid consultant	13	5, 37
Boachie-Adjei, Oheneba	Submitted 04/06/2015 DePuy, A Johnson & Johnson Company: IP royalties; Paid consultant; Research support K2M: Research support; IP royalties; Other financial or material support; Paid consultant; Paid presenter or speaker Medtronic: Research support SRS: Board or committee member Trans1: Paid consultant; Paid presenter or speaker	63	23
Bohl, Daniel D	No Conflicts to Disclose; Submitted 05/28/2015	15, 54, 88 P, 91 P, 92 P	21
Bohm, Parker	No Conflicts to Disclose; Submitted 05/04/2015		28
Bonassar, Lawrence J	Submitted 05/07/2015 3D BioCorp: Stock or stock options Abbott: Research support Fidia, SpA: Research support Histogenics: Paid consultant; Research support	16	
Branch, Charles L	Submitted 05/01/2015 AANS, NASS, SRS: Board or committee member Council of Surgical Spine Societies: Board or committee member Journal of Neurosurgery Spine: Editorial or governing board	39	

Name	Received	Presentation	E-Poster
Branch, Charles L (cont.)	Medtronic Sofamor Danek: IP royalties; Paid consultant; Paid presenter or speaker SLACK Incorporated: Editorial or governing board The Spine Journal: Editorial or governing board	39	
Bransford, Richard J	Submitted 03/22/2015 DePuy, A Johnson & Johnson Company: Research support Globus Medical: Paid presenter or speaker	66	
Bratcher, Kelly R	No Conflicts to Disclose; Submitted 04/27/2015		43
Brodke, Darrel S [m,s]	Submitted 05/27/2015 Amedica: IP royalties; Paid consultant; Stock or stock options CSRS: Board or committee member DePuy Synthes: IP royalties Evidence-Based Spine Journal: Editorial or governing board Journal of Spinal Disorders and Techniques: Editorial or governing board LSRS: Board or committee member Medtronic: IP royalties	62	
Brown, Christopher R	Submitted 04/08/2015 NuVasive: IP royalties; Paid consultant	58	
Buchowski, Jacob M [m p,rc]	Submitted 04/24/2015 Advance Medical: Paid consultant AOA: Board or committee member AO Foundation: Other financial or material support Broadwater/Vertical Health: Paid presenter or speaker CSRS: Board or committee member CoreLink: Paid consultant DePuy Synthes: Paid presenter or speaker Globus Medical: IP royalties; Paid consultant; Paid presenter or speaker K2M: Paid consultant Medtronic: Paid consultant; Paid presenter or speaker NASS: Board or committee member OrthoFix: Paid consultant SRS: Board or committee member; Other financial or material support Stryker: Paid consultant; Paid presenter or speaker Wolters Kluwer Health – Lippincott Williams & Wilkins: Publishing royalties, financial or material support		33
Bumpass, David B	No Conflicts to Disclose; Submitted 04/29/2015		20, 33
Burch, Shane	Submitted 05/05/2015 Covidien: Research support Eli Lilly: Research support; Unpaid consultant Medtronic: Paid consultant; Paid presenter or speaker NuVasive: Research support	63	23
Buser, Zorica	Submitted 04/21/2015 Biogen: Stock or stock options Gilead: Stock or stock options		19, 31

Name	Received	Presentation	E-Poster
Bydon, Mohamad	No Conflicts to Disclose; Submitted 04/30/2015	40	19, 20
Cahill, Patrick J	Submitted 09/16/2015 AAOS: Board or committee member DePuy Synthes Spine: Other financial or material support DePuy, A Johnson & Johnson Company: Paid consultant; Paid presenter or speaker Ellipse Technologies,: Paid consultant; Paid presenter or speaker Globus Medical: Paid presenter or speaker JBJS: Editorial or governing board Medtronic: Other financial or material support; Paid consultant; Paid presenter or speaker POSNA: Board or committee member SRS: Board or committee member Spine Deformity: Editorial or governing board	80	
Cancienne, Jourdan M	No Conflicts to Disclose; Submitted 05/17/2015	36, 55	
Carandang, Gerard	No Conflicts to Disclose; Submitted 04/29/2015	83 P	
Caridi, John M	Submitted 04/30/2015 Stryker: Paid consultant Zimmer: Paid consultant		4, 35
Carreon, Leah Y	Submitted 04/24/2015 AOSpine: Research support Spine, The Spine Journal: Editorial or governing board Norton Healthcare: Employee; Research support OREF: Research support SRS: Board or committee member; Research support OREF, Department of Defense, Assoc for Collaborative Spine Research and Center for Spine Surgery and Research, Region of Southern Denmark: Other financial or material support University of Louisville Institutional Review Board: Other financial or material support National Institutes of Health: Other financial or material support Children's Tumor Foundation, participation in Global Evidence Advisory Board Medtronic. Medtronic, NuVasive: Other financial or material support Univ. of Louisville Institutional review Board: Board or committee member		43
Cassinelli, Ezaequiel H [p]	Submitted 02/06/2015 AAOS: Board or committee member Stryker: Paid consultant; Paid presenter or speaker		
Chang, Douglas G	Submitted 05/04/2015 Kimberly Clark: Research support Merck: Stock or stock options	17	

a = Awards Committee • c = CSRS Staff • df = Dinner Symposium • lf = Lunch Symposium • m = Moderator • p = Program Committee • rc = Research Committee • rs = Research Session • s = Symposium Presenter • sp = Special Presenter

Name	Received	Presentation	E-Poster
Chapman, Jens R [ds]	Submitted 05/04/2015 AOSpine, AOSpine Foundation, CSRS: Board or committee member Evidence Based Spine Journal, Spine, Global Spine Journal, Journal of Spine: Editorial or governing board Evidence Based Spine Journal: Publishing royalties, financial or material support Global Spine Journal: Publishing royalties, financial or material support Renovis Medical: Stock or stock options		
Chen, Thomas C	No Conflicts to Disclose; Submitted 10/27/2015		31
Cheng, Ivan [a,m]	Submitted 04/02/2015 AAOS: Board or committee member CSRS: Board or committee member Globus Medical: Paid consultant NuVasive: IP royalties Spinal Cyte: Stock or stock options Spine Wave: Stock or stock options SpineThe Spine Journal: Editorial or governing board Stryker: Paid consultant	27 P	
Cheng, Joseph S	Submitted 04/30/2015 AANS, NASS: Board or committee member	8, 23 P	
Chiba, Kazuhiro [ds]	Submitted 10/23/2015 Asahi Kasei Pharma: Research support Astellas Pharma: Paid presenter or speaker CSRS Asia-Pacific Section: Board or committee member Dentsu Sudler & Hennessey: Paid consultant Eastern Japan Assoc of Orthopedics and Traumatology: Board or committee member Eisai: Research support European Spine Journal: Editorial or governing board General Insurance Assoc of Japan Non-life Insurance Rating Organization of Japan: Paid consultant Health Insurance Claimas Review and Reimbursement Sevices: Paid consultant Hisamitsu Pharmaceutical: Paid presenter or speaker Japan Broadcasting Corporation (NHK): Publishing royalties, financial or material support Japanese Orthopedic Assoc: Board or committee member Japanese Society for Spine Surgery and Related Research: Board or committee member Journal of Ortho Research: Editorial or governing board Kaken Pharmaceutical: Paid presenter or speaker Kanto Society of Orthopedics and Traumatology: Board or committee member Medicalview: Publishing royalties, financial or material support		

Name	Received	Presentation	E-Poster
Chiba, Kazuhiro [ds] (cont.)	Pfeizer Japan: Paid presenter or speaker Seikagaku Paid consultant Showa Yakuhin Kako: Paid presenter or speaker Spine: Editorial or governing board Sumitomo Dainippon Pharma Co. Ltd.: Paid presenter or speaker; Publishing royalties, financial or material support The Study Group for Nerve and Spine: Board or committee member		
Chikuda, Hirotaka	No Conflicts to Disclose; Submitted 04/29/2015	4	
Childs, Benjamin R	Submitted 04/25/2015 Edwards Life Sciences: Stock or stock options		44
Cho, Jae Hwan	No Conflicts to Disclose; Submitted 05/01/2015	46, 84 P, 93 P	
Cho, Samuel Kang-Wook	Submitted 04/08/2015 CSRS: Board or committee member SRS: Board or committee member Stryker: Paid consultant Zimmer: Research support	40	4, 20, 35
Cho, Woojin	No Conflicts to Disclose; Submitted 08/24/2015	96 P	
Choi, Sung Hoon	No Conflicts to Disclose; Submitted 04/30/2015	46, 84 P, 93 P	
Chotai, Silky	No Conflicts to Disclose; Submitted 04/29/2015	7, 8, 9, 10, 22 P, 23 P, 24 P, 37, 39, 65	
Chou, Dean	Submitted 04/21/2015 Globus Medical: Paid consultant Medtronic: Paid consultant Orthofix: Paid consultant		20
Christie, Sean	Submitted 05/06/2015 AANS/CNS, NASS: Board or committee member Canadian Spine Society: Board or committee member Journal of Spine and Neurosurgery: Editorial or governing board Medtronic: Paid consultant; Paid presenter or speaker; Research support	30 P	
Clout, Jerri M	No Conflicts to Disclose; Submitted 05/03/2015		29
Coe, Jeffrey D [m,p]	Submitted 07/16/2015 Alphatec Spine: Stock or stock options Benvenue: Paid consultant; Research support; Stock or stock options California Orthopaedic Assoc, CSRS, LSRS, SRS: Board or committee member Medtronic Sofamor Danek: Research support		

a = Awards Committee • c = CSRS Staff • df = Dinner Symposium • lf = Lunch Symposium • m = Moderator • p = Program Committee • rc = Research Committee • rs = Research Session • s = Symposium Presenter • sp = Special Presenter

Name	Received	Presentation	E-Poster
Coe, Jeffrey D [m,p] (cont.)	NuVasive: Paid consultant; Research support Phygen: Stock or stock options SI Bone: Paid consultant; Research support		
Cohen, Jeremiah R	No Conflicts to Disclose; Submitted 04/23/2015		31
Como, John J	No Conflicts to Disclose; Submitted 05/06/2015		44
Coric, Domagoj	Submitted 04/29/2015 Globus Medical: Paid consultant; Research support ISASS: Board or committee member ISASS Journal: Editorial or governing board Isto Technologies: Research support Medtronic: Paid consultant Mesoblast: Research support NuTech: Research support Premia Spine: Paid consultant; Stock or stock options RTI Surgical: IP royalties Southern Neurosurgical Society: Board or committee member Spinal Kinetics: Research support Spine Wave: IP royalties; Stock or stock options	25 P, 83 P	38
Corriveau, Mark	No Conflicts to Disclose; Submitted 04/28/2015		20
Cote, Pierre	Submitted 05/04/2015 European Spine Journal: Editorial or governing board	60, 72	
Cunningham, Matthew E	Submitted 05/04/2015 DePuy, A Johnson & Johnson Company: Other financial or material support	76	
Currier, Bradford L [m]	Submitted 04/30/2015 Council for Value in Spine Surgery: Board or committee member DePuy, A Johnson & Johnson Company: IP royalties LSRS: Board or committee member Spine Study Group: Board or committee member SpinologyTenex: Stock or stock options Stryker: IP royalties Wolters Kluwer Health – Lippincott Williams & Wilkins: Publishing royalties, financial or material support Zimmer: IP royalties; Paid consultant		
Daffner, Scott D [rc,rs]	Submitted 04/30/2015 Amgen: Stock or stock options Bioventus: Research support CSRS, NASS: Board or committee member Orthopedic & Muscular System: Current Research: Editorial or governing board Pfizer: Stock or stock options World Journal of Orthopedics: Editorial or governing board		
Dang, Gengting	No Conflicts to Disclose; Submitted 05/06/2015	86 P	
Dang, Lei	No Conflicts to Disclose; Submitted 05/06/2015	86 P	

Name	Received	Presentation	E-Poster
Darden, Bruce V	Submitted 05/04/2015 4Web: Paid consultant; Stock or stock options BioMedFlex: Stock or stock options CSRS, LSRS: Board or committee member DePuy, A Johnson & Johnson Company: Research support Journal of Spinal Disorders and techniques, Journal of Spinal Cord Medicine, JAAOS: Editorial or governing board Spineguard: Paid consultant Stryker: IP royalties; Paid consultant; Paid presenter or speaker Synthes: Paid presenter or speaker; Research support	14	
De Giacomo, Anthony	No Conflicts to Disclose; Submitted 05/04/2015		18, 20
De La Garza-Ramos, Rafael D	No Conflicts to Disclose; Submitted 04/29/2015	40	
Defino, Helton	No Conflicts to Disclose; Submitted 05/01/2015	2	
Derakhshan, Adeeb	No Conflicts to Disclose; Submitted 04/20/2015		20
Derman, Peter	No Conflicts to Disclose; Submitted 04/29/2015		15
Devin, Clinton J [p,rc]	Submitted 05/22/2015 CSRS, NASS: Board or committee member DePuy, A Johnson & Johnson Company: Paid consultant; Research support Exparel: Paid consultant Stryker: Research support	7, 8, 9, 10, 22 P, 23 P, 24 P, 37, 39, 65	13
Deviren, Vedat	Submitted 04/27/2015 Guidepoint: Paid consultant NuVasive: IP royalties; Paid consultant; Research support OREF, Omega, Globus and AOSpine: Research support Stryker: Paid consultant	63	23
Diaz-Collado, Pablo J	Submitted 04/03/2015 Abbott: Employee		21
Diebo, Bassel G	No Conflicts to Disclose; Submitted 05/03/2015	78	
Dimmig, Thomas A	Submitted 05/01/2015 Aegis: Paid consultant Spinal Kinetics: Stock or stock options	83 P	
Dohzono, Sho	No Conflicts to Disclose; Submitted 05/02/2015	3	
Donaldson, William F	Submitted 04/06/2015 AAOS: Board or committee member IEP: Paid presenter or speaker	50	
Drew, Brian	No Conflicts to Disclose; Submitted 05/01/2015	30 P	
Duhancioglu, Gabriel	No Conflicts to Disclose; Submitted 04/17/2015	54	
Dunn, Conor	No Conflicts to Disclose; Submitted 05/05/2015		17

Name	Received	Presentation	E-Poster
Dvorak, Marcel F	Submitted 04/30/2015 AOSpine: Other financial or material support Arcus: Research support DePuy, A Johnson & Johnson Company: Other financial or material support; Research support Medtronic: IP royalties Medtronic Sofamor Danek: IP royalties; Other financial or material support; Paid consultant; Paid presenter or speaker; Resea Synthes: Other financial or material support; Paid presenter or speaker; Research support Thieme: Publishing royalties, financial or material support	26 P, 30 P	42
Emami, Arash	Submitted 05/04/2015 DePuy, A Johnson & Johnson Company: Paid consultant		17
Emery, Sanford E [m,rs]	Submitted 08/21/2015 ABOS, AOA: Board or committee member		
Endriga, David T	No Conflicts to Disclose; Submitted 05/03/2015		43
Errico, Thomas J	Submitted 08/13/2015 DePuy, A Johnson & Johnson Company: Paid presenter or speaker Fastenetix: Stock or stock options Harms Study Group: Board or committee member ISSG: Board or committee member K2M: Other financial or material support; Paid presenter or speaker K2M Fastenetix: IP royalties OMEGA, AOSpine: Research support Paradigm Spine: Research support Pfizer: Research support	78	
Fallah, Nader	No Conflicts to Disclose; Submitted 05/04/2015	26 P	42
Faloon, Michael	Submitted 04/02/2015 DePuy, A Johnson & Johnson Company: Paid presenter or speaker K2M: Paid presenter or speaker SRS: Board or committee member		17
Faour, Mhamad	No Conflicts to Disclose; Submitted 04/18/2015	21 P	
Fehlings, Michael G [lf,sp]	Submitted 10/6/2015 CSRS, Spine, EBSJ, Journal of Neurosurgery Spine: Editorial or governing board	1, 2, 19, 30 P, 40, 45, 56, 57, 60, 71, 72, 94 P, 95 P	8, 18, 19, 20, 28, 29
Fineberg, Steven J	No Conflicts to Disclose; Submitted 04/03/2015	68	
Fink, Kyle	No Conflicts to Disclose; Submitted 04/27/2015	68	
Finkelstein, Joel A	No Conflicts to Disclose; Submitted 05/01/2015	30 P	

Name	Received	Presentation	E-Poster
Fischgrund, Jeffrey S [rs]	Submitted 10/01/2015 Baxter: Paid consultant CSRS, LSRS: Board or committee member FzioMed: Paid consultant ISTO Technologies: Paid consultant JAAOS: Editorial or governing board Relievant: Paid consultant Smith & Nephew: Research support Stryker: IP royalties; Paid consultant; Research support understand.com: Stock or stock options		
Fish, David E	No Conflicts to Disclose; Submitted 04/28/2015		19
Fisher, Charles G	Submitted 04/22/2015 Canadian Spine Society: Board or committee member Journal of Neurosurgery Spine: Editorial or governing board Medtronic: IP royalties Medtronic Sofamor Danek: Paid consultant NuVasive: Paid consultant Spine: Editorial or governing board	26 P	42
Forner, Stefania	No Conflicts to Disclose; Submitted 05/01/2015	57	
Fourney, Daryl R	Submitted 05/04/2015 Canadian Journal of Neurological Sciences: Editorial or governing board Neurosurgery: Editorial or governing board Spine: Editorial or governing board	30 P	
Frale, Liz [c]	No Conflicts to Disclose; Submitted 10/12/2015		
France, John C [rs,s]	Submitted 04/04/2015 AAOS, CSRS, SRS: Board or committee member		
Frempong-Boadu, Anthony K	Submitted 04/30/2015 Medtronic Sofamor Danek: Paid consultant; Paid presenter or speaker Vertera: Stock or stock options	39	
Fu, Michael C	No Conflicts to Disclose; Submitted 04/02/2015	76, 92 P	21
Fujii, Kengo	No Conflicts to Disclose; Submitted 04/21/2015		12
Fujiwara, Hiroyasu	No Conflicts to Disclose; Submitted 04/27/2015	42	
Fujiyoshi, Kanehiro	No Conflicts to Disclose; Submitted 10/23/2015	28 P	
Fukusumi, Hayato	No Conflicts to Disclose; Submitted 04/22/2015		6
Fukuzawa, Ryuji	No Conflicts to Disclose; Submitted 04/22/2015		6
Gallizzi, Michael A	Submitted 04/07/2015 Arthrex: Paid consultant; Research support	58	
Gerling, Michael C	Submitted 05/31/2015 AAOS, Brooklyn Orthopedic Society, CSRS: Board or committee member		39

Name	Received	Presentation	E-Poster
Ghanayem, Alexander J [m]	Submitted 10/01/2015 AAOS, AOA, CSRS, LSRS, OMeGA Medical Grants Assoc: Board or committee member Journal of Spinal Disorders and Techniques: Editorial or governing board		
Ghogawala, Zoher [ls,p,rc,sp]	No Conflicts to Disclose; Submitted 05/04/2015		
Ghosh, Anjan	No Conflicts to Disclose; Submitted 05/01/2015	20	
Girardi, Federico P	Submitted 05/03/2015 Centinel Spine: Stock or stock options DePuy, A Johnson & Johnson Company: IP royalties; Paid consultant Lanx: IP royalties NuVasive: Paid consultant; IP royalties Ortho Development: IP royalties Spinal Kinetics: Stock or stock options		15
Githens, Michael	No Conflicts to Disclose; Submitted 09/16/2015	27 P	
Glassman, Steven D	Submitted 04/02/2015 Medtronic: IP royalties NuVasive: Research support SRS: Board or committee member		43
Gokaslan, Ziya L	Submitted 04/27/2015 AOSpine: Research support; Board or committee member DePuy, A Johnson & Johnson Company: Research support European Spine Journal: Editorial or governing board JNS: Editorial or governing board Journal of Spinal Disorders: Editorial or governing board Journal of Spinal Disorders & Techniques, The Spine Journal, The Journal of Neurosurgery: Spine, The European Spine Journal, Nature Reviews in Neurology, Journal of Surgical Oncology, World Neurosurgery: Board or committee member Journal of Surgical Oncology: Editorial or governing board Nature Review World Neurosurgery: Editorial or governing board NREF: Research support Spinal Kinetics: Stock or stock options Spine Journal: Editorial or governing board	40	19, 20
Golden, M Leslie	No Conflicts to Disclose; Submitted 05/01/2015	38	
Goldstein, Jeffrey A [p]	Submitted 05/31/2015 AxioMed: Research support Bulletin of the Hospital for Joint Diseases: Editorial or governing board ISASS: Board or committee member Johnson & Johnson: Stock or stock options Journal of the ISASS: Editorial or governing board K2M: Paid consultant		

Name	Received	Presentation	E-Poster
Goldstein, Jeffrey A [p] (cont.)	Magellan Health: Paid consultant Medtronic: Paid consultant NLT Spine: Paid consultant NuVasive: IP royalties; Paid consultant Regeneration Technologies,: IP royalties; Paid consultant Spine, Spine Journal, Spine Surgery Today: Editorial or governing board		
Gosgnach, Simon	No Conflicts to Disclose; Submitted 05/06/2015		8
Grauer, Jonathan N [m,sp]	Submitted 04/25/2015 AAOS: Board or committee member Amer Journal of Orthopedics: Editorial or governing board Bioventus: Paid consultant CSRS: Board or committee member Contemporary Spine Surgery: Editorial or governing board ISTO Technologies: Paid consultant Medtronic: Paid consultant Stryker: Paid consultant The Spine Sournal: Editorial or governing board Vertex: Paid consultant	15, 88 P, 91 P, 92 P	21
Greenberg, Aaron J	No Conflicts to Disclose; Submitted 05/03/2015	48	
Gruber, Helen E [rs]	Submitted 03/11/2015 Biotechnic & Histochemistry: Editorial or governing board Spine: Editorial or governing board		
Grunert, Peter	No Conflicts to Disclose; Submitted 05/07/2015	16	
Gupta, Munish C	Submitted 05/04/2015 DePuy Synthes, A Johnson & Johnson Company: Paid consultant DePuy, A Johnson & Johnson Company: IP royalties FOSA Treasurer: Board or committee member Johnson & Johnson, Pioneer, PFizer, Proctor and Gamble: Stock or stock options Medicrea: Paid consultant Medtronic: Research support; Paid consultant Osteotech: Paid consultant; Stock or stock options	77	
Guyer, Richard D	Submitted 04/12/2015 Alphatec: IP royalties DePuy, A Johnson & Johnson Company: Paid presenter or speaker Spinal Kinetics: Stock or stock options Synthes: Paid presenter or speaker		5, 37
Guzman Tejero, Javier Z	No Conflicts to Disclose; Submitted 04/28/2015		4, 35
Ha, Jung-Ki	No Conflicts to Disclose; Submitted 04/23/2015	46, 84 P, 93 P	
Hamasaki, Takahiko	No Conflicts to Disclose; Submitted 05/01/2015	5	

a = Awards Committee • c = CSRS Staff • df = Dinner Symposium • lf = Lunch Symposium • m = Moderator • p = Program Committee • rc = Research Committee • rs = Research Session • s = Symposium Presenter • sp = Special Presenter

Name	Received	Presentation	E-Poster
Hamilton, D. Kojo	Submitted 04/27/2015 European Spine Journal: Editorial or governing board	82 P	
Han, Patrick	Submitted 05/05/2015 Microvention: Paid presenter or speaker NuVasive: IP royalties; Paid consultant		9
Hanley, Edward N [rs]	Submitted 04/10/2015 Medtronic: Stock or stock options		
Hargens, Alan R	Submitted 05/06/2015 Luna Innovations: Research support	17	
Harris, Jeffrey E	Submitted 05/05/2015 NuVasive: Employee; Stock or stock options		9
Harris, Mitchel B [m,p]	Submitted 04/29/2015 NASS: Board or committee member		
Harrop, James S [m,sp]	Submitted 05/28/2015 Asterias: Other financial or material support; Unpaid consultant Axiomed: Stock or stock options Bioventus: Other financial or material support; Unpaid consultant DePuy, A Johnson & Johnson Company: Paid consultant; Paid presenter or speaker Spine Universe, CNS quarterly, Congress of Neurosurgeons Executive Board, CSRS,PNS, Jefferson University Physicians, LSRS, COSSS: Board or committee member; Editorial or governing board Tejin: Unpaid consultant Tejjin: Other financial or material support		
Hart, Robert A	Submitted 05/02/2015 AAOS, AOA, CSRS, ISSG, LSRS, NASS, Oregon Assoc of Orthopaedics. SRS: Board or committee member AAOS: Editorial or governing board DePuy, A Johnson & Johnson Company: IP royalties; Paid consultant; Paid presenter or speaker; Research support Medtronic: Paid consultant; Paid presenter or speaker SeaSpine: IP royalties Spine Connect: Stock or stock options		20, 22
Härtl, Roger	Submitted 05/04/2015 AOSpine: Board or committee member; Paid presenter or speaker Baxter: Research support Brainlab: Paid consultant DePuy-Synthes: Paid consultant Lanx: Paid consultant	16	
Hashimoto, Kazuki	No Conflicts to Disclose; Submitted 05/05/2015		14
Hashizume, Hiroshi	No Conflicts to Disclose; Submitted 05/01/2015		1
Hassanzadeh, Hamid	No Conflicts to Disclose; Submitted 05/26/2015	36, 55	

Name	Received	Presentation	E-Poster
Havey, Robert M	No Conflicts to Disclose; Submitted 04/28/2015	83 P	
Hayashi, Kazunori	No Conflicts to Disclose; Submitted 05/02/2015	3	
Hayashi, Tetsuo	No Conflicts to Disclose; Submitted 05/01/2015	70	
Healey, Robert M	No Conflicts to Disclose; Submitted 05/07/2015	17	
Healy, Andrew T	No Conflicts to Disclose; Submitted 05/03/2015	89 P	
Heary, Robert F [ds,m,sp]	Submitted 02/26/2015 CSRS: Board or committee member DePuy, A Johnson & Johnson Company: IP royalties Journal of Neurosurgery:Spine editorial board chairman: Editorial or governing board LSRS: Board or committee member Thieme Medical Publishers: Publishing royalties, financial or material support Zimmer: IP royalties		
Hedayat, Hirad	No Conflicts to Disclose; Submitted 05/02/2015	39	
Heller, John G	Submitted 05/04/2015 CSRS: Board or committee member Medtronic: IP royalties; Paid consultant; Stock or stock options	38, 51	
Henry, Jensen K	No Conflicts to Disclose; Submitted 05/03/2015	78	
Herzog, Richard J	Submitted 04/26/2015 Spine: Editorial or governing board		24
Hida, Tetsuro	Submitted 04/19/2015 Asahi Kasei Pharma: Other financial or material support	87 P	
Higgins, Brendan T	Submitted 04/27/2015 Dartmouth Ortho Journal: Editorial or governing board	6	
Hilibrand, Alan S [p,sp]	Submitted 04/16/2015 AAOS, CSRS, NASS: Board or committee member Aesculap/B.Braun: IP royalties Amedica: IP royalties; Stock or stock options Benvenue Medical: Stock or stock options Biomet: IP royalties Lifespine: Stock or stock options Nexgen: Stock or stock options Paradigm Spine: Stock or stock options PSD: Stock or stock options Spinal ventures: Stock or stock options Stryker: IP royalties Vertiflex: Stock or stock options	49, 98 P	3, 19, 26
Hirai, Takashi	No Conflicts to Disclose; Submitted 04/28/2015	97 P	
Hirata, Hiroaki	No Conflicts to Disclose; Submitted 04/30/2015	35 P, 41	32

Name	Received	Presentation	E-Poster
Hisey, Michael S	Submitted 05/06/2015 4WEB: Paid consultant LDR Medical: IP royalties; Paid consultant; Paid presenter or speaker NASS: Board or committee member Zimmer: IP royalties; Paid consultant	13, 64	
Holt, Jacquelyn A	No Conflicts to Disclose; Submitted 05/04/2015	17	
Hong, Chul Gie	No Conflicts to Disclose; Submitted 04/30/2015	46, 84 P, 93 P	
Hong, Jae Taek	Submitted 05/04/2015 Korean Neurosurgical Spine Society: Board or committee member	31 P, 52	
Horne, Phillip H	No Conflicts to Disclose; Submitted 04/22/2015		24
Horodyski, MaryBeth	Submitted 05/04/2015 Exactech: Research support National Athletic Trainers' Assoc: Board or committee member; Research support	67	
Hoshino, Masatoshi	No Conflicts to Disclose; Submitted 05/03/2015	3	
Hsieh, Patrick C	Submitted 05/15/2015 DePuy, A Johnson & Johnson Company: Paid consultant; Paid presenter or speaker Medtronic Sofamor Danek: Paid consultant; Paid presenter or speaker		31, 39
Hsu, Erin L	Submitted 04/13/2015 AAOS, CSRS, LSRS: Board or committee member Journal of Spinal Disorders and Techniques: Editorial or governing board Lifenet: Unpaid consultant Medtronic Sofamor Danek: Paid consultant Pioneer Surgical: Paid consultant RMEC: Board or committee member Spinesmith: Paid consultant Stryker: Paid consultant Terumo: Paid consultant Zimmer: Paid consultant	20	
Hsu, Wellington K [rc]	Submitted 04/17/2015 AAOS: Board or committee member AONA: Paid consultant; Paid presenter or speaker Bacterin: Paid consultant Bioventus: Paid consultant CeramTec: Paid consultant CSRS: Board or committee member Globus: Paid consultant Graftys: Paid consultant Journal of Spinal Disorders and Techniques: Editorial or governing board Lifenet: Paid consultant	20, 40	18, 19, 20, 40

Name	Received	Presentation	E-Poster
Hsu, Wellington K [rc] (cont.)	LSRS: Board or committee member Medtronic: Paid consultant; Research support NASS: Board or committee member Pioneer: Paid consultant Relievant: Paid consultant Stryker Spine: Paid consultant Synthes: Paid consultant	20, 40	18, 19, 20, 40
Hu, Serena S [m,p]	Submitted 06/02/2015 NuVasive: IP royalties; Paid consultant; Stock or stock options SRS: Board or committee member Stryker: Paid presenter or speaker		
Huang, Ronald	No Conflicts to Disclose; Submitted 05/03/2015		3
Hughes, Alexander P	Submitted 04/22/2015 MiMedx Group: Research support NuVasive: Research support		15
Hung, Man	No Conflicts to Disclose; Submitted 05/03/2015	62	
Hurlbert, R John	No Conflicts to Disclose; Submitted 04/30/2015	30 P	
Hwang, Chang Ju	No Conflicts to Disclose; Submitted 05/02/2015	46, 84 P, 93 P	
Hwang, Ki Soo	No Conflicts to Disclose; Submitted 05/04/2015		17
Hwang, Sang-Phil	No Conflicts to Disclose; Submitted 05/05/2015	81 P	25
Hyldmo, Per Kristian	No Conflicts to Disclose; Submitted 05/02/2015	67	
Hyun, Seung-Jae	Submitted 05/03/2015 AEGIS Spine: Paid consultant Medtronic: Unpaid consultant		2
Ikeda, Terumasa	No Conflicts to Disclose; Submitted 05/10/2015		14
Im, Sung Hoon	No Conflicts to Disclose; Submitted 05/05/2015	52	
Imagama, Shiro	No Conflicts to Disclose; Submitted 04/24/2015	32 P, 87 P, 90 P	
International Spine Study Group (ISSG)	Submitted 04/27/2015 Biomet: Research support DePuy, A Johnson & Johnson Company: Other financial or material support; Research support Innovasis: Other financial or material support Medtronic Sofamor Danek: Research support Stryker: Research support	77, 82 P	22
Isaacs, Robert E	Submitted 04/21/2015 NuVasive: IP royalties; Paid consultant; Research support Providence: Stock or stock options Saferay Spine, LLC: Stock or stock options	39, 58	19, 20, 39

Name	Received	Presentation	E-Poster
Isaacs, Robert E (cont.)	Safewire: Stock or stock options Vertera: Stock or stock options Vilaspine: Stock or stock options	39, 58	19, 20, 39
Ishiguro, Naoki	Submitted 10/07/2015 Abbott: Paid presenter or speaker Astellas Pharma: Paid presenter or speaker Bristol-Myers Squibb: Paid presenter or speaker Chugai Pharmaceutical: Paid presenter or speaker Daiichi-Sankyo: Paid presenter or speaker Eisai: Paid presenter or speaker Hisamitsu Pharmaceutical: Paid presenter or speaker Janssen Pharmaceutical K.K: Paid presenter or speaker Kaken Pharmaceutical: Paid presenter or speaker Mitsubishi Tanabe Pharmaceutical: Paid presenter or speaker Otsuka Pharmaceutical: Paid presenter or speaker Pfizer: Paid presenter or speaker Taisho Toyama Pharmaceutical: Paid presenter or speaker Takeda Pharmaceutical: Paid presenter or speaker	32 P	
Isoda, Miho	Submitted 04/22/2015 Sumitomo Dainippon Pharma: Employee; Stock or stock options		6
Issa, Kimona	No Conflicts to Disclose; Submitted 04/02/2015		17
Itakura, Go	No Conflicts to Disclose; Submitted 05/01/2015	18	7
Ito, Kenyu	No Conflicts to Disclose; Submitted 04/26/2015	87 P	
Iwai, Hiroki	No Conflicts to Disclose; Submitted 05/02/2015	28 P	7
Iwanami, Akio	No Conflicts to Disclose; Submitted 05/01/2015	18, 28 P	6, 7
Iwasaki, Hiroshi	No Conflicts to Disclose; Submitted 05/01/2015		1
Iyer, Sravisht	No Conflicts to Disclose; Submitted 04/16/2015	63, 76, 77	23
Jain, Amit	No Conflicts to Disclose; Submitted 05/02/2015	82 P	
Jurová-Jakubcova, Barbora	No Conflicts to Disclose; Submitted 10/22/2015	43	
Jalai, Cyrus M	No Conflicts to Disclose; Submitted 04/27/2015		22, 39
Jang, Soo-Jin	No Conflicts to Disclose; Submitted 05/05/2015	81 P	25
Janssen, Michael E	Submitted 05/04/2015 Cerapedics: Paid consultant; Stock or stock options; Research support InSpine: Editorial or governing board Synthes: Paid presenter or speaker; Research support	14	
Jenis, Louis G [m,p]	Submitted 10/05/2015 JOAAS: Editorial or governing board NuVasive: Paid consultant Stryker: IP royalties; Paid consultant The Spine Journal: Editorial or governing board		
Jiang, Liang	No Conflicts to Disclose; Submitted 05/06/2015	86 P	

Name	Received	Presentation	E-Poster
Jin, Sung-Yub	No Conflicts to Disclose; Submitted 05/06/2015	47	
Jobse, Bruce C	No Conflicts to Disclose; Submitted 05/04/2015		18, 20
Johnson, Daniel J	No Conflicts to Disclose; Submitted 04/30/2015	54	
Johnston, Tyler	No Conflicts to Disclose; Submitted 10/21/2015	27 P	
Joo, Youn-Suk	No Conflicts to Disclose; Submitted 05/02/2015	46, 84 P, 93 P	
Kadanka Sr, Zdenek	No Conflicts to Disclose; Submitted 04/27/2015	43, 75	
Kadanka Jr, Zdenek	No Conflicts to Disclose; Submitted 04/22/2015	43, 75	
Kaito, Takashi	No Conflicts to Disclose; Submitted 04/29/2015	42	
Kale, Shashank	No Conflicts to Disclose; Submitted 05/06/2015	2	
Kalsi-Ryan, Sukhvinder K	Submitted 05/06/2015 Asterias: Paid consultant Bioaxonne: Paid consultant Stem Cells: Paid consultant	45, 56	29
Kamath, Rahul	No Conflicts to Disclose; Submitted 04/15/2015	54	
Kanemura, Aritetsu	No Conflicts to Disclose; Submitted 05/03/2015	35 P	
Kanemura, Yonehiro	Submitted 04/22/2015 Kaneka, Japan: Research support		6
Kaneyama, Shuichi	No Conflicts to Disclose; Submitted 05/03/2015	33 P, 35 P	
Kang, Daniel G	No Conflicts to Disclose; Submitted 04/08/2015	34 P	
Kang, James D	No Conflicts to Disclose; Submitted 04/04/2015	50	
Kang, Kyung-Chung	No Conflicts to Disclose; Submitted 05/04/2015	81 P	
Kannan, Abhishek S	No Conflicts to Disclose; Submitted 04/29/2015	20	
Kanter, Adam	Submitted 04/23/2015 Biomet: IP royalties NuVasive: Research support Physician and Sports Medicine: Editorial or governing board		19, 20
Karadimas, Spyridon K	No Conflicts to Disclose; Submitted 05/03/2015	19, 45, 56, 57	8
Kasahara, Koichi	No Conflicts to Disclose; Submitted 05/03/2015	35 P	
Kashii, Masafumi	No Conflicts to Disclose; Submitted 04/29/2015	42	
Kato, Tsuyoshi	No Conflicts to Disclose; Submitted 05/03/2015	97 P	30
Kawabata, Shigenori	No Conflicts to Disclose; Submitted 05/03/2015	97 P	30
Kawabata, Soya	No Conflicts to Disclose; Submitted 05/03/2015	18	
Kawakami, Noriaki	Submitted 05/06/2015 DePuy, A Johnson & Johnson Company: Paid consultant Medtronic Sofamor Danek: Paid consultant NPO Japanese Spinal Deformity Institute: Board or committee member		27

a = Awards Committee • c = CSRS Staff • df = Dinner Symposium • lf = Lunch Symposium • m = Moderator • p = Program Committee • rc = Research Committee • rs = Research Session • s = Symposium Presenter • sp = Special Presenter

Name	Received	Presentation	E-Poster
Kay, Harrison F	No Conflicts to Disclose; Submitted 04/29/2015	7, 10, 22 P, 37	
Kelly, Michael P [a]	No Conflicts to Disclose; Submitted 05/01/2015	77	
Kepler, Christopher K [rs]	Submitted 04/16/2015 Healthgrades: Paid consultant	98 P	26
Kerkovský, Miloš	No Conflicts to Disclose; Submitted 04/23/2015	43, 75	
Khair, Thamina	No Conflicts to Disclose; Submitted 05/06/2015	16	
Khazaei, Mohamad	No Conflicts to Disclose; Submitted 05/06/2015		8
Kim, Chulmin	No Conflicts to Disclose; Submitted 05/04/2015	85 P	
Kim, Hak-Sun	No Conflicts to Disclose; Submitted 05/06/2015	47	
Kim, Han-Jo	Submitted 05/31/2015 Biomet: Paid consultant DePuy, A Johnson & Johnson Company: Paid presenter or speaker HSS Journal, Asian Spine Journal: Editorial or governing board K2M: Paid consultant Medtronic – Spine Innovation Advisory Board: Paid consultant SRS: Board or committee member Stryker: Paid presenter or speaker	25 P, 63, 76, 77, 82 P	22, 23, 38
Kim, Il Sup	No Conflicts to Disclose; Submitted 05/05/2015	52	
Kim, Jin Young	No Conflicts to Disclose; Submitted 05/03/2015		11
Kim, Jun Young	No Conflicts to Disclose; Submitted 05/05/2015	52	
Kim, Kee D	Submitted 04/30/2015 Biomet: Paid consultant Globus Medical: IP royalties; Paid consultant LDR: IP royalties Molecular Matrix International: Stock or stock options Spinal USA: IP royalties	11	
Kim, Ki-Jeong	No Conflicts to Disclose; Submitted 05/03/2015		2
Kim, Ki-Tack	No Conflicts to Disclose; Submitted 05/05/2015	81 P	25
Kim, Sangbum	No Conflicts to Disclose; Submitted 05/03/2015	85 P	
Kim, Seong Hwan	No Conflicts to Disclose; Submitted 05/05/2015		10
Kiskaddon, Eric M	No Conflicts to Disclose; Submitted 04/26/2015		43
Kitamura, Kazuya	No Conflicts to Disclose; Submitted 05/02/2015	28 P	
Klineberg, Eric O	Submitted 04/27/2015 AOSpine: Paid presenter or speaker; Research support DePuy Synthes Spine: Research support DePuy, A Johnson & Johnson Company: Paid consultant OREF: Research support	63, 77, 82 P	22, 23
Ko, Jong-Hyun	No Conflicts to Disclose; Submitted 05/03/2015		34
Kobayashi, Yoshiomi	No Conflicts to Disclose; Submitted 05/01/2015	18	7

Name	Received	Presentation	E-Poster
Koerner, John D [rs]	Submitted 05/12/2015 Journal of Spinal Disorders and Techniques: Editorial or governing board Medtronic: Research support Novartis: Employee		
Koh, Akihiro	No Conflicts to Disclose; Submitted 05/02/2015	35 P	
Kohyama, Jun	No Conflicts to Disclose; Submitted 04/22/2015		6, 7
Komatsu, Miki	No Conflicts to Disclose; Submitted 05/03/2015		41
Koo, Seung Bum	No Conflicts to Disclose; Submitted 05/05/2015		10
Kopjar, Branko [rc]	Submitted 04/20/2015 Cerapedics: Paid consultant Smith & Nephew: Paid consultant	1, 2, 60, 72, 95 P	28
Kothari, Parth	No Conflicts to Disclose; Submitted 04/28/2015		4, 35
Kovalová, Ivana	No Conflicts to Disclose; Submitted 04/28/2015	43, 75	
Krauthammer, Charles [sp]	No Conflicts to Disclose; Submitted 10/28/2015		
Krishnamoorthy, Bala	No Conflicts to Disclose; Submitted 05/02/2015	69	
Krishnaney, Ajit A	No Conflicts to Disclose; Submitted 04/29/2015	74	
Kueper, Janina	No Conflicts to Disclose; Submitted 04/22/2015		15
Kumar, Priyanka	No Conflicts to Disclose; Submitted 05/01/2015	98 P	
Kurd, Mark F	No Conflicts to Disclose; Submitted 04/17/2015	98 P	26
Kwon, Brian K [m,p]	Submitted 05/01/2015 Acorda Therapeutics: Paid consultant	26 P, 30 P	42
Lafage, Renaud	No Conflicts to Disclose; Submitted 08/11/2015	78, 82 P	22
Lafage, Virginie C	Submitted 04/28/2015 DePuy, A Johnson & Johnson Company: Research support Medicrea: Paid presenter or speaker Medtronic, DepuySpine, K2M: Paid presenter or speaker Nemaris: Stock or stock options	78, 82 P	22
Laliberte, Alex	No Conflicts to Disclose; Submitted 05/03/2015	45, 56, 57	
Lampe, Lukas P	No Conflicts to Disclose; Submitted 04/22/2015		15, 24
Lauryssen, Carl	Submitted 04/29/2015 Alphatec Spine: Stock or stock options DePuy, A Johnson & Johnson Company: IP royalties Globus Medical: IP royalties Medtronic Sofamor Danek: IP royalties Spinal Motion: Stock or stock options Spinevision: Stock or stock options	83 P	
Lawrence, Brandon D [a]	Submitted 05/04/2015 AOSpine: Board or committee member; Paid presenter or speaker CSRS: Research support	62	

a = Awards Committee • c = CSRS Staff • df = Dinner Symposium • lf = Lunch Symposium • m = Moderator • p = Program Committee • rc = Research Committee • rs = Research Session • s = Symposium Presenter • sp = Special Presenter

Name	Received	Presentation	E-Poster
Lebl, Darren R [s]	Submitted 06/01/2015 AOA, NASS: Board or committee member Medtronic: Paid consultant		
Leckie, Steven K	No Conflicts to Disclose; Submitted 05/02/2015	38, 51	
Lee, Chang-Hyun	No Conflicts to Disclose; Submitted 04/30/2015		2
Lee, Choon Sung	No Conflicts to Disclose; Submitted 05/02/2015	46, 84 P, 93 P	
Lee, Dong-Ho	No Conflicts to Disclose; Submitted 05/02/2015	46, 84 P, 93 P	
Lee, Ho Jin	No Conflicts to Disclose; Submitted 05/06/2015	31 P	
Lee, Hwan-Mo	No Conflicts to Disclose; Submitted 05/06/2015	47	
Lee, Joon Yung [p]	Submitted 04/22/2015 Stryker: Research support	50	
Lee, Ju-Rang	No Conflicts to Disclose; Submitted 05/03/2015		34
Lee, Jung-Hee	No Conflicts to Disclose; Submitted 05/05/2015	81 P	
Lee, Nathaniel J	No Conflicts to Disclose; Submitted 04/28/2015		4, 35
Lee, Sang-Hun	Submitted 05/04/2015 Medtronic: Paid consultant; Paid presenter or speaker	81 P	25
Lee, Sungho	No Conflicts to Disclose; Submitted 04/28/2015		20
Lehman, Ronald A [m]	Submitted 04/06/2015 AOSpine: Board or committee member; Research support Associate Editor–Spine Deformity: Editorial or governing board Centinel Spine: Research support CSRS: Board or committee member Deputy Editor for Deformity–The Spine Journal: Editorial or governing board DePuy, A Johnson & Johnson Company: Paid presenter or speaker Medtronic: Paid consultant; Paid presenter or speaker NASS: Board or committee member SRS: Board or committee member Stryker: Paid presenter or speaker Wolters Kluwer Health–Lippincott Williams & Wilkins: Publishing royalties, financial or material support	34 P	
Lenke, Lawrence G	Submitted 05/05/2015 AAOS: Board or committee member Axial Biotech: Research support Backtalk (Scoliosis Assn): Editorial or governing board DePuy, A Johnson & Johnson Company: Paid consultant; Research support Journal of Neurosurgery: Spine: Editorial or governing board K2M: Paid consultant Medtronic: IP royalties; Paid consultant	63, 76	23

Name	Received	Presentation	E-Poster
Lenke, Lawrence G (cont.)	OREF: Board or committee member Quality Medical Publishing: Publishing royalties, financial or material support Scoliosis: Editorial or governing board SRS: Board or committee member Spine Deformity Journal, Spine, Journal of Spinal Disorders & Techniques, www.iscoliosis.com, www.spineuniverse.com: Editorial or governing board	63, 76	23
Lerner, Jason H	Submitted 04/07/2015 DePuy, A Johnson & Johnson Company: Employee	12	
Leven, Dante M	No Conflicts to Disclose; Submitted 04/28/2015		4, 35
Liabaud, Barthelemy	No Conflicts to Disclose; Submitted 05/03/2015	78	
Lieberman, Isador H	Submitted 08/30/2015 AAOS: Board or committee member Bioniks Laboratories: Stock or stock options DePuy, A Johnson & Johnson Company: Paid presenter or speaker European Spine Journal: Editorial or governing board Globus Medical: Paid consultant International Society for Advancement of Spine Surgery: Board or committee member Journal of Spinal Disorders & Techniques: Editorial or governing board MAZOR Surgical Technologies: Paid consultant; Stock or stock options NASS: Board or committee member SRS: Board or committee member Society for Minimally Invasive Spine Surgery: Board or committee member Spine: Editorial or governing board SpineUniverse.Com: Editorial or governing board Stryker: IP royalties	39	
Lind, Bengt I m sp	No Conflicts to Disclose; Submitted 10/24/2015		
Liu, John C	Submitted 05/15/2015 AOSpine: Other financial or material support Medtronic: Paid consultant		31
Liu, Xiaoguang	No Conflicts to Disclose; Submitted 05/06/2015	86 P	
Liu, Zhongjun	No Conflicts to Disclose; Submitted 05/06/2015	86 P	
Lonergan, Timothy M	No Conflicts to Disclose; Submitted 05/03/2015		45
Lord, Elizabeth	No Conflicts to Disclose; Submitted 04/30/2015		19
Lotz, Jeffrey C	Submitted 05/06/2015 ISTO Technologies: Other financial or material support; Stock or stock options	17	

Name	Received	Presentation	E-Poster
Lotz, Jeffrey C (cont.)	Spinal Motion, Relievant, Nocimed, Simperica, Spinal Restoration, SMC Biotech: Stock or stock options Orthofix, Relievant: Research support Spine: Editorial or governing board The Spine Journal: Editorial or governing board	17	
Lubelski, Daniel	No Conflicts to Disclose; Submitted 04/02/2015	74, 89 P	16, 20
Lukasiewicz, Adam M	No Conflicts to Disclose; Submitted 05/03/2015	15, 88 P, 92 P	21
Luksanapruksa, Panya	No Conflicts to Disclose; Submitted 04/26/2015		33
Lyman, Stephen	Submitted 04/07/2015 HSS Journal: Editorial or governing board International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine: Board or committee member ISAKOS Journal, JBJS: Editorial or governing board		15
Machado, Andre	Submitted 04/30/2015 ATI: Other financial or material support Cardionomics: Other financial or material support Enspire: Other financial or material support Functional Neuromodulation: Paid consultant Medtronic: Research support Neuromodulation: Editorial or governing board Neurosurgery: Editorial or governing board Spinal Modulation: Paid consultant	74	
Machino, Masaaki	No Conflicts to Disclose; Submitted 04/27/2015	79, 90 P	
Macias, Brandon R	No Conflicts to Disclose; Submitted 05/06/2015	17	
Maeda, Takashi	Submitted 05/01/2015 DePuy, A Johnson & Johnson Company: Paid presenter or speaker Medtronic Sofamor Danek: Paid presenter or speaker Stryker: Paid presenter or speaker	70	
Makino, Takahiro	No Conflicts to Disclose; Submitted 04/28/2015	42	
Markova, Dessislava Z rs	No Conflicts to Disclose; Submitted 10/21/2015		
Marshall, Kyle	Submitted 05/02/2015 LDR Spine: Employee; Stock or stock options	25 P	38
Massel, Dustin H	No Conflicts to Disclose; Submitted 04/12/2015	54, 91 P	
Massicotte, Eric M	Submitted 05/01/2015 AOSpine: Paid presenter or speaker Watermark Research Partners: Paid consultant	45, 56	18, 20, 29
Matsubayashi, Yoshitaka	No Conflicts to Disclose; Submitted 05/03/2015	4	
Matsumoto, Morio	Submitted 04/30/2015 None: Board or committee member; Editorial or governing board; Publishing royalties, financial or material	18, 28 P	6, 7
Matsumoto, Satoko	No Conflicts to Disclose; Submitted 05/03/2015		41

Name	Received	Presentation	E-Poster
Mayo, Benjamin C	No Conflicts to Disclose; Submitted 10/21/2015	91 P	
Mazmudar, Aditya S	No Conflicts to Disclose; Submitted 04/30/2015		36
McGirt, Matthew J	Submitted 05/03/2015 DePuy, A Johnson & Johnson Company: Paid consultant Pacira: Paid consultant Stryker: Paid consultant	7, 8, 9, 10, 22 P, 23 P, 24 P, 39, 65	13
McGraw, Katlyn E	No Conflicts to Disclose; Submitted 04/27/2015		43
Mead, Loren B	No Conflicts to Disclose; Submitted 04/30/2015	98 P	
Mella, Pierre M	No Conflicts to Disclose; Submitted 05/06/2015	47	
Mendoza, Marco C	No Conflicts to Disclose; Submitted 04/20/2015	20	
Metz, Lionel N	No Conflicts to Disclose; Submitted 04/11/2015	76	
Miller, Jacob A	No Conflicts to Disclose; Submitted 04/01/2015	74	
Millhouse, Paul W	Submitted 05/04/2015 Globus Medical: Stock or stock options Pacira: Paid consultant	49, 98 P	
Minamide, Akihito	No Conflicts to Disclose; Submitted 05/01/2015		1
Minhas, Shobhit V	No Conflicts to Disclose; Submitted 06/01/2015		36
Mitchell, Sean M	No Conflicts to Disclose; Submitted 04/06/2015	20	
Miura, Kousei	No Conflicts to Disclose; Submitted 04/30/2015		12
Miyamoto, Hiroshi	No Conflicts to Disclose; Submitted 05/01/2015		14
Mizutani, Jun	No Conflicts to Disclose; Submitted 05/05/2015	63	23
Moatz, Bradley W	Submitted 04/28/2015 Globus Medical, Vertebral Technologies: Other financial or material support	51	
Mojica-Santiago, Jorge	No Conflicts to Disclose; Submitted 05/07/2015	16	
Montesano, Pasquale X [m]	Submitted 09/28/2015 Cytonics: Stock or stock options Sintea: IP royalties; Other financial or material support Spinial Usa: IP royalties		
Moon, Seong-Hwan	No Conflicts to Disclose; Submitted 05/06/2015	47	
Moore, Timothy A	No Conflicts to Disclose; Submitted 05/20/2015		44
Moriguchi, Yu	No Conflicts to Disclose; Submitted 06/01/2015	16	
Morishita, Yuichiro	No Conflicts to Disclose; Submitted 05/03/2015	70	
Morris, Jonathan	No Conflicts to Disclose; Submitted 04/19/2015	96 P	
Mroz, Thomas E [rc]	Submitted 04/08/2015 AOSpine: Paid presenter or speaker; Board or committee member Ceramtec: Paid consultant NASS: Board or committee member Pearl Diver: Stock or stock options	40, 74	16, 18, 19, 20

a = Awards Committee • c = CSRS Staff • df = Dinner Symposium • lf = Lunch Symposium • m = Moderator • p = Program Committee • rc = Research Committee • rs = Research Session • s = Symposium Presenter • sp = Special Presenter

Name	Received	Presentation	E-Poster
Mroz, Thomas E [rc] (cont.)	SpineLine, Global Spine Journal: Editorial or governing board Stryker: Paid consultant	40, 74	16, 18, 19, 20
Mummaneni, Praveen V [p]	Submitted 04/17/2015 AANS/CNS Spine Section and SRS: Board or committee member DePuy, A Johnson & Johnson Company: IP royalties; Paid presenter or speaker Globus Medical: Paid presenter or speaker spinicty: Stock or stock options Springer: Publishing royalties, financial or material support Taylor and Francis: Publishing royalties, financial or material support Thieme: Publishing royalties, financial or material support	48	20
Mundis, Gregory M	Submitted 05/04/2015 ISSGF: Research support K2M: IP royalties; Paid consultant; Paid presenter or speaker Medicrea: Paid consultant Misonix: Paid consultant NuVasive: IP royalties; Paid consultant; Paid presenter or speaker; Research support	77, 82 P	9
Murray, Michael R	No Conflicts to Disclose; Submitted 04/30/2015	51	
Musante, David B	Submitted 04/28/2015 Amendia: Paid consultant AxioMed: Research support Orthofix,: Paid consultant; Research support Spinal Kinetics: Research support Spinal Motion: Research support Vertiflex: Research support	83 P	
Nagoshi, Narihito	No Conflicts to Disclose; Submitted 04/22/2015	71, 94 P	18
Nakagawa, Yukihiro	No Conflicts to Disclose; Submitted 05/03/2015		1
Nakamura, Hiroaki	No Conflicts to Disclose; Submitted 05/02/2015	3	
Nakamura, Masaya	No Conflicts to Disclose; Submitted 05/01/2015	18, 28 P	6, 7
Nakashima, Hiroaki	No Conflicts to Disclose; Submitted 04/22/2015	71, 94 P	18
Nakayama, Keita	No Conflicts to Disclose; Submitted 04/26/2015		12
Nassr, Ahmad [p]	Submitted 05/26/2015 AOSpine: Research support CSRS: Board or committee member JBJS: Publishing royalties, financial or material support Magnifi group: Paid presenter or speaker SRS: Board or committee member Synthes: Research support		19, 20
Navarro-Ramirez, Rodrigo	No Conflicts to Disclose; Submitted 05/06/2015	16	
Neese, Ashley M	No Conflicts to Disclose; Submitted 05/03/2015	62	

Name	Received	Presentation	E-Poster
Nemani, Venu M	No Conflicts to Disclose; Submitted 04/03/2015	63, 76	23
Neuman, Brian J	Submitted 05/01/2015 DePuy, A Johnson & Johnson Company: Research support	82 P	
Nguyen, Emily C	No Conflicts to Disclose; Submitted 04/07/2015		19
Nguyen, Joseph T	No Conflicts to Disclose; Submitted 04/22/2015		24
Nicholson, Kristen	No Conflicts to Disclose; Submitted 05/04/2015	98 P	
Nishimura, Soraya	No Conflicts to Disclose; Submitted 05/02/2015		7
Nishiyama, Yuichiro	No Conflicts to Disclose; Submitted 04/29/2015		7
Nohara, Ayato	No Conflicts to Disclose; Submitted 05/06/2015		27
Noonan, Vanessa K	No Conflicts to Disclose; Submitted 05/05/2015	30 P	42
Norton, James H [rs]	No Conflicts to Disclose; Submitted 10/21/2015		
Nouri, Aria	Submitted 04/22/2015 Rexahn Pharmaceuticals: Stock or stock options	45, 60, 71, 94 P, 95 P	
Nowacki, Amy	No Conflicts to Disclose; Submitted 05/06/2015		16
Nunley, Pierce D [rc]	Submitted 04/29/2015 Amer Board of Spine Surgery: Board or committee member Amedica: Stock or stock options AxioMed: Research support Biomet: IP royalties; Paid presenter or speaker K2M: IP royalties; Paid presenter or speaker; Research support LDR Spine: IP royalties; Paid consultant; Research support Medtronic: Research support Nanovis: Paid consultant OKO: Stock or stock options Orthofix: Research support Osprey: Stock or stock options Spinal Motion: Paid consultant; Research support Spineology: Stock or stock options Vertiflex: Paid consultant; Research support	11	
O'Boynick, Christopher P	No Conflicts to Disclose; Submitted 05/03/2015		45
O'Brien, Joseph R [m]	Submitted 10/01/2015 Alphatec Spine: Stock or stock options Globus: IP royalties Globus Medical: Paid consultant; Research support K2M: Stock or stock options NuVasive: IP royalties Regeneration Technologies: IP royalties; Paid consultant; Research support; Stock or stock options Spinicity/ISD: Stock or stock options		

Name	Received	Presentation	E-Poster
O'Brien, Michael F	Submitted 04/07/2015 DePuy, A Johnson & Johnson Company: IP royalties; Paid consultant; Research support DJ Orthopaedics: Research support K2M: Research support NuVasive: Research support Seeger: Research suppor	77	
Oh, Cheongeun	No Conflicts to Disclose; Submitted 05/01/2015		22
Ohara, Tetsuya	No Conflicts to Disclose; Submitted 05/06/2015		27
Ohnmeiss, Donna D	Submitted 04/10/2015 Int'l J Spine Surgery (ISASS): Editorial or governing board ISASS, NASS: Board or committee member Spine: Editorial or governing board	64	5, 37
Ohta, Shigeki	No Conflicts to Disclose; Submitted 04/25/2015		6
Oichi, Takeshi	No Conflicts to Disclose; Submitted 05/03/2015	4, 29 P	
Oka, Hiroyuki	Submitted 05/01/2015 OsteoArthritis Research Society International: Board or committee member		1
Okano, Hideyuki	No Conflicts to Disclose; Submitted 05/02/2015	18, 28 P	6, 7
Okawa, Atsushi	Submitted 05/04/2015 Asah-Kasei: Research support Asteras: Research support Dai-ichi Sankyo: Research support Dainihon-Sumitomo, Chugai: Research support Eizai: Research support Eli Lilly: Research support HOYA: Research support Janssen: Research support Kyphon: Research support Medtronic Sofamor Danek: Research support Pfizer: Research support Stryker: Research support Teijin: Research support	97 P	30
Okazaki, Rentaro	No Conflicts to Disclose; Submitted 05/03/2015	29 P	
Olerud, Claes	Submitted 04/28/2015 CSRS European Section: Board or committee member DePuy, A Johnson & Johnson Company: Paid presenter or speaker; Research support Medtronic: Paid presenter or speaker	61	
Ondeck, Nathaniel T	No Conflicts to Disclose; Submitted 10/14/2015	15, 88 P, 91 P	
O'Neill, Kevin R	No Conflicts to Disclose; Submitted 04/30/2015	10, 37	13, 20

Name	Received	Presentation	E-Poster
Öner, F Cumhur	Submitted 05/06/2015 AOSpine: Board or committee member DePuy, A Johnson & Johnson Company: Research support European Spine Journal: Editorial or governing board Spine: Editorial or governing board		42
Oren, Jonathan H	No Conflicts to Disclose; Submitted 05/03/2015	78	
Orndorff, Douglas G	Submitted 06/03/2015 Globus Medical: Research support Integra/SeaSpine: Research support NuVasive: Paid consultant; Research support SeaSpine: IP royalties; Paid consultant Stryker: Paid consultant Vertiflex: Research support	39	
Oshima, Yasushi	No Conflicts to Disclose; Submitted 04/28/2015	4, 29 P	
Ouchida, Jun	No Conflicts to Disclose; Submitted 05/01/2015	79	
Ozanne, Elissa	No Conflicts to Disclose; Submitted 04/29/2015	6	
Pace, Jonathan	No Conflicts to Disclose; Submitted 04/28/2015		20
Pahys, Joshua M	Submitted 04/02/2015 DePuy, A Johnson & Johnson Company: Paid consultant	80	
Pan, Ting-Jung	No Conflicts to Disclose; Submitted 04/22/2015		15
Paquet, Jerome	Submitted 05/02/2015 Medtronic: Other financial or material support	30 P	
Parent, Stefan	Submitted 05/05/2015 AOSpine: Paid consultant DePuy, A Johnson & Johnson Company: Paid consultant; Research support EOS-Imaging: Paid consultant; Research support OREF: Research support Rick Hansen Institute: Research support SRS: Board or committee member Setting Scoliosis Straight Foundation: Research support Spinologics: Stock or stock options	30 P	
Park, Andrew G	No Conflicts to Disclose; Submitted 04/11/2015		3
Park, Christian	No Conflicts to Disclose; Submitted 05/01/2015	20	
Park, Daniel K [rs]	Submitted 05/26/2015 Johnson and Johnson: Stock or stock options K2M: Paid consultant Stryker: Paid consultant		
Park, Jong-Hwa	No Conflicts to Disclose; Submitted 04/30/2015		2
Park, Kun Young	No Conflicts to Disclose; Submitted 05/15/2015	85 P	
Park, So-Young	No Conflicts to Disclose; Submitted 05/05/2015		25
Parker, Scott L	No Conflicts to Disclose; Submitted 05/05/2015	7, 8, 9, 10, 24 P, 65	

a = Awards Committee • c = CSRS Staff • df = Dinner Symposium • lf = Lunch Symposium • m = Moderator • p = Program Committee • rc = Research Committee • rs = Research Session • s = Symposium Presenter • sp = Special Presenter

Name	Received	Presentation	E-Poster
Passias, Peter G	No Conflicts to Disclose; Submitted 04/04/2015	77, 82 P, 86 P	22, 39
Patel, Alpesh A	Submitted 04/05/2015 AAOS: Board or committee member Amedica: IP royalties; Paid consultant; Stock or stock options Amer College of Surgeons: Board or committee member AOA: Board or committee member AOSpine: Board or committee member Biomet: IP royalties; Paid consultant CSRS: Board or committee member Cytonics: Stock or stock options DePuy, A Johnson & Johnson Company: Paid consultant JOAAS: Editorial or governing board Nocimed: Stock or stock options NASS: Board or committee member Relievant: Paid consultant Springer: Publishing royalties, financial or material support Stryker: Paid consultant Surgical Neurology Int'l: Editorial or governing board Trinity Orthopaedics: Stock or stock options Ulrich Medical USA: IP royalties Wolters Kluwer Health – Lippincott Williams & Wilkins: Editorial or governing board		36, 40
Patt, Joshua C	Submitted 05/30/2015 DePuy, A Johnson & Johnson Company: Paid presenter or speaker	39	
Patwardhan, Avinash G	Submitted 04/28/2015 Centinel Spine: Research support Spinal Kinetics: Paid consultant; Stock or stock options	83 P	
Paul, Gary	Submitted 04/28/2015 Spinal Kinetics: Employee; Stock or stock options	83 P	
Pearson, Adam M	Submitted 04/30/2015 Spine: Editorial or governing board; Publishing royalties, financial or material support	6	
Penrose, Colin T	No Conflicts to Disclose; Submitted 04/07/2015	58	
Phillips, Frank M [a]	Submitted 10/05/2015 CSRS: Board or committee member DePuy, A Johnson & Johnson Company: IP royalties Ellipse: Paid consultant Int. Spine Journal: Editorial or governing board ISASS: Board or committee member Mainstay: Stock or stock options Medtronic: IP royalties NuVasive: IP royalties; Paid consultant; Stock or stock options PearDiver: Stock or stock options		

Name	Received	Presentation	E-Poster
Phillips, Frank M [a] (cont.)	Provident: Stock or stock options SI Bone: Stock or stock options Society of Minimally Invasive Spine Surgery: Board or committee member Spinal Kinetics: Stock or stock options Stryker: IP royalties Theracell: Stock or stock options Vertera: Stock or stock options		
Place, Howard M	Submitted 04/16/2015 SRS: Board or committee member		45
Pourtaheri, Sina	No Conflicts to Disclose; Submitted 05/03/2015	89 P	
Prasarn, Mark L	Submitted 04/29/2015 DePuy, A Johnson & Johnson Company: Paid presenter or speaker Eli Lilly: Paid presenter or speaker	67	
Premkumar, Ajay	No Conflicts to Disclose; Submitted 04/25/2015	51	
Protopsaltis, Themistocles S [sp]	Submitted 05/01/2015 Biomet: Paid consultant Medicrea Int'l: Paid consultant; Paid presenter or speaker Zimmer: Research support	63, 77, 78, 82 P	23
Qureshi, Sheeraz A [p]	Submitted 04/25/2015 AAOS, CSRS: Board or committee member CORR: Editorial or governing board Contemporary Spine Surgery: Editorial or governing board Global Spine Journal: Editorial or governing board Globus Medical: Paid presenter or speaker Medtronic: Paid consultant Medtronic Sofamor Danek: Paid presenter or speaker Musculoskeletal Transplant Foundation: Board or committee member NASS: Board or committee member Orthofix: Paid consultant Spine, Spine Journal: Editorial or governing board Stryker: Paid consultant; Paid presenter or speaker Zimmer: IP royalties; Paid consultant	40	20
Radcliff, Kristen E [a,m,p]	Submitted 04/22/2015 4 Web Medical: Unpaid consultant ACSR: Board or committee member Altus Spine: Paid consultant DePuy, A Johnson & Johnson Company: Paid consultant; Research support; Unpaid consultant Globus Medical: IP royalties; Paid consultant; Research support LDR: Unpaid consultant	12, 14, 25 P, 39, 98 P	26, 38, 39

a = Awards Committee • c = CSRS Staff • df = Dinner Symposium • lf = Lunch Symposium • m = Moderator • p = Program Committee • rc = Research Committee • rs = Research Session • s = Symposium Presenter • sp = Special Presenter

Name	Received	Presentation	E-Poster
Radcliff, Kristen E [a,m,p] (cont.)	Medtronic: Paid consultant; Research support NEXXT Spine: Other financial or material support NuVasive: Other financial or material support Orthofix: Paid consultant Orthopedic Sciences: IP royalties; Paid consultant Pacira Pharmaceuticals: Research support Paradigm Spine: Research support Stryker: Other financial or material support	12, 14, 25 P, 39, 98 P	26, 38, 39
Rechtine, Glenn R	Submitted 04/03/2015 CSRS: Board or committee member Journal of Spinal Cord Medicine, Ortho knowledge online journal, The Spine Journal: Editorial or governing board	67	
Record, Nicole	No Conflicts to Disclose; Submitted 05/04/2015		17
Reddy, Deepak	No Conflicts to Disclose; Submitted 04/26/2015		43
Reilly, Thomas M [m]	No Conflicts to Disclose; Submitted 10/28/2015		
Rhee, Jay Won	No Conflicts to Disclose; Submitted 04/29/2015	40	
Rhee, John M [m,rc]	Submitted 04/11/2015 Alphatec Spine: Stock or stock options Biomet: IP royalties DePuy Biomet: Paid presenter of speaker Biomet synthes: Paid consultant CSRS: Board or committee member DePuy, A Johnson & Johnson CompanyKineflexMedtronic: Research support Phygen: Stock or stock options Wolters Kluwer Health – Lippincott Williams & Wilkins: Publishing royalties, financial or material support Zimmer: Paid presenter or speaker	85 P	
Ricart, Pedro A	No Conflicts to Disclose; Submitted 05/04/2015	68	
Riew, K Daniel [ds,ls,m]	Submitted 04/08/2015 Amedica: Stock or stock options AOSpine: Paid presenter or speaker; Board or committee member; Editorial or governing board Benvenue: Stock or stock options Biomet: IP royalties Broadwater: Other financial or material support Cerapedics: Research support CSRS, Global Spine Journal: Editorial or governing board KASS: Board or committee member Medtronic Sofamor Danek: IP royalties; Research support NASS: Paid presenter or speaker New England Spine Society Group: Paid presenter or speaker Nexgen Spine: Stock or stock options Osprey: IP royalties; Stock or stock options Paradigm Spine: Stock or stock options Spinal Dynamics: Research support	34 P, 40, 44	11, 18, 19, 20

Name	Received	Presentation	E-Poster
Riew, K Daniel [ds,ls,m] (cont.)	Spinal Kinetics: Stock or stock options JBJS, Spine Highlights, Spine: Editorial or governing board Spineology: Stock or stock options Vertiflex: Stock or stock options	34 P, 40, 44	11, 18, 19, 20
Rihn, Jeffrey A [sp]	Submitted 04/30/2015 DePuy, A Johnson & Johnson Company: Research support NASS: Board or committee member Pfizer: Paid consultant The Spine Journal: Editorial or governing board	98 P	26
Rivers, Carly S	No Conflicts to Disclose; Submitted 05/04/2015	30 P	
Roensch, Elizabeth	Submitted 05/03/2015 LDR Spine: Employee; Stock or stock options	25 P	38
Rogers, Roger W	No Conflicts to Disclose; Submitted 04/04/2015		5
Rostami, Pouya	No Conflicts to Disclose; Submitted 10/21/2015		29
Saito, Toshiki	No Conflicts to Disclose; Submitted 05/05/2015		27
Sakai, Hiroaki	No Conflicts to Disclose; Submitted 05/01/2015	70	
Sakai, Yoshihito	No Conflicts to Disclose; Submitted 04/23/2015	87 P	
Sakai, Yusuke	No Conflicts to Disclose; Submitted 04/30/2015	42	
Samdani, Amer F	Submitted 05/12/2015 DePuy, A Johnson & Johnson Company: Paid consultant Globus Medical: Paid consultant SRS: Board or committee member Setting Scoliosis Straight Foundation: Board or committee member Stryker: Paid consultant Zimmer: Paid consultant	80	
Samuel, Andre M	No Conflicts to Disclose; Submitted 04/27/2015	15, 88 P, 92 P	21
Santaguida, Carlo	No Conflicts to Disclose; Submitted 05/02/2015	2	
Sasso, Rick C [ls,p]	Submitted 04/29/2015 Biomet: Stock or stock options Cerapedics: Research support CSRS: Board or committee member Journal of Spinal Disorders and Techniques, Spine arthroplasty society journal: Editorial or governing board Medtronic: IP royalties; Research support Saunders/Mosby-Elsevier: Publishing royalties, financial or material support Smith & Nephew: Research support SpineCor: Stock or stock options Stryker: Research support Trans1: Stock or stock options		19, 20
Satkunendrarajah, Kajana	No Conflicts to Disclose; Submitted 05/05/2015	19	8

a = Awards Committee • c = CSRS Staff • df = Dinner Symposium • lf = Lunch Symposium • m = Moderator • p = Program Committee • rc = Research Committee • rs = Research Session • s = Symposium Presenter • sp = Special Presenter

Name	Received	Presentation	E-Poster
Savage, Jason W	Submitted 04/02/2015 Journal of Spinal Disorders and Techniques: Editorial or governing board Stryker: Paid consultant		26, 40
Sayari, Arash J	No Conflicts to Disclose; Submitted 04/17/2015		31
Scheer, Justin K	No Conflicts to Disclose; Submitted 04/25/2015	63, 82 P	22, 23
Schell, Adam J	No Conflicts to Disclose; Submitted 10/22/2015	51	
Schroeder, Gregory D	Submitted 04/02/2015 Medtronic: Other financial or material support Wolters Kluwer Health – Lippincott Williams & Wilkins: Editorial or governing board	98 P	19, 26
Schwab, Frank J	Submitted 04/28/2015 AO: Research support Biomet: Paid consultant; Paid presenter or speaker DePuy, A Johnson & Johnson Company: Research support K2M: IP royalties; Paid consultant; Paid presenter or speaker Medicrea: Paid presenter or speaker; Unpaid consultant Medtronic: Paid consultant Medtronic Sofamor Danek: IP royalties; Paid presenter or speaker; Research support Nemaris: Stock or stock options NuVasive: Paid consultant; Paid presenter or speaker SRS: Board or committee member Spine deformity: Editorial or governing board ISSG: Board or committee member	78	
Sciubba, Daniel M	Submitted 04/28/2015 DePuy, A Johnson & Johnson Company: Paid consultant Globus Medical: Paid consultant Medtronic: Paid consultant NuVasive: Paid consultant Stryker: Paid consultant	82 P	
Shaffrey, Christopher I [m]	Submitted 04/27/2015 AANS, ABNS: Board or committee member Biomet: IP royalties; Paid consultant; Paid presenter or speaker DePuy, A Johnson & Johnson Company: Research support Globus Medical: Paid presenter or speaker Medtronic: IP royalties; Other financial or material support; Paid consultant Medtronic Sofamor Danek: Paid presenter or speaker NuVasive: IP royalties; Paid consultant; Paid presenter or speaker; Stock or stock options SRS: Board or committee member Spine, Spinal Deformity: Editorial or governing board Stryker: Paid consultant; Paid presenter or speaker		

Name	Received	Presentation	E-Poster
Shah, Suken A	Submitted 09/15/2015 AAOS: Board or committee member Arthrex: IP royalties DePuy Synthes Spine: IP royalties; Paid consultant; Research support Ellipse Technologies: Paid consultant Ethicon Endosurgery: Research support Globus Medical: Stock or stock options K2M: Paid consultant; Research support Orthopaediatrics: Unpaid consultant POSNA: Board or committee member SRS: Board or committee member Setting Scoliosis Straight Foundation: Board or committee member Stryker: Paid consultant	80	
Shamji, Mohammed F	Submitted 05/03/2015 AANS/CNS SpineSection: Board or committee member Canadian Neuromodulation Society: Board or committee member Canadian Spine Society: Board or committee member LSRS: Board or committee member Medtronic: Paid presenter or speaker PLoS One: Editorial or governing board	56	29
Sharan, Alok D	Submitted 08/24/2015 Current Orthopedic Practice: Editorial or governing board Paradigm Spine: Paid consultant	96 P	
Sheets, Charles	No Conflicts to Disclose; Submitted 05/04/2015	58	
Shen, Francis H [rc]	Submitted 05/26/2015 DePuy, A Johnson & Johnson Company: Other financial or material support; Paid consultant European Spine Journal: Editorial or governing board Globus Medical: IP royalties Medtronic: Research support Musculoskeletal Transplant Foudation: Board or committee member, Research support Saunders/Mosby-Elsevier: Publishing royalties, financial or material support Spine, SpineLine, The Spine Journal: Editorial or governing board Synthes: Other financial or material support; Paid consultant	36, 55	
Shiba, Keiichiro	No Conflicts to Disclose; Submitted 05/05/2015	70	
Shifflett, Grant D	No Conflicts to Disclose; Submitted 05/02/2015	76	
Shimer, Adam L	Submitted 05/03/2015 Biomet: Paid presenter or speaker European Spine Journal: Editorial or governing board	36, 55	

Name	Received	Presentation	E-Poster
Shimer, Adam L (cont.)	Submitted 05/03/2015 Biomet: Paid presenter or speaker European Spine Journal: Editorial or governing board Medtronic: Paid consultant NuVasive: IP royalties; Paid consultant Orthobullets.com: Publishing royalties, financial or material support	36, 55	
Shin, John I	No Conflicts to Disclose; Submitted 04/29/2015		4, 35
Shin, Jun-Jae	No Conflicts to Disclose; Submitted 05/06/2015	73	
Shinomiya, Kenichi	No Conflicts to Disclose; Submitted 10/22/2015	97 P	
Shinseki, Matthew S	No Conflicts to Disclose; Submitted 05/04/2015	69	
Shofuda, Tomoko	Submitted 04/22/2015 Takeda Pharmaceutical Company Limited: Employee		6
Shriver, Michael	No Conflicts to Disclose; Submitted 04/22/2015		16
Sides, Brenda A	No Conflicts to Disclose; Submitted 05/04/2015	76	
Sielatycki, J Alex	No Conflicts to Disclose; Submitted 05/25/2015	7, 10, 24 P, 37, 65	13
Silverberg, Arnold	No Conflicts to Disclose; Submitted 05/01/2015		13
Singh, Anoushka	No Conflicts to Disclose; Submitted 05/04/2015	95 P	
Singh, Gurmit	No Conflicts to Disclose; Submitted 05/02/2015	20	
Singh, Kern [p,sp]	Submitted 04/02/2015 DePuy, A Johnson & Johnson Company: Paid consultant Pioneer: IP royalties Stryker: IP royalties Stryker, Zimmer: Paid consultant Wolters Kluwer Health – Lippincott Williams & Wilkins: Editorial or governing board; Publishing royalties, financial or material support Zimmer: IP royalties	15, 54, 88 P, 91 P	
Singla, Anuj	No Conflicts to Disclose; Submitted 10/15/2015	36, 55	
Sinha, Kumar G	No Conflicts to Disclose; Submitted 05/03/2015		17
Sivaganesan, Ahilan	No Conflicts to Disclose; Submitted 05/06/2015	7, 8, 9, 10, 24 P, 65	
Skeppholm, Martin	Submitted 04/30/2015 DePuy, A Johnson & Johnson Company: Research support	61	
Skovrlj, Branko	No Conflicts to Disclose; Submitted 04/28/2015		4, 35
Smith, Gabriel	No Conflicts to Disclose; Submitted 04/17/2015		20
Smith, Justin S [m,rc]	Submitted 05/31/2015 Biomet: IP royalties; Paid consultant; Paid presenter or speaker Cerapedics: Paid consultant CSRS: Board or committee member DePuy: Research support NuVasive: Paid consultant; Paid presenter or speaker	63, 77	20, 22, 23

Name	Received	Presentation	E-Poster
Smith, R Lane	No Conflicts to Disclose; Submitted 10/21/2015	27 P	
Smith, Zachary A	No Conflicts to Disclose; Submitted 04/30/2015	40	18, 19, 20
Song, Kwang-Sup	Submitted 05/04/2015 GENOSS: Unpaid consultant L&K company: Stock or stock options	44	10
Song, Kyung-Jin	No Conflicts to Disclose; Submitted 05/03/2015		34
Sonn, Kevin A	No Conflicts to Disclose; Submitted 05/02/2015	20	
Spector, Leo R [p]	Submitted 06/01/2015 Stryker: Paid consultant; Paid presenter or speaker		
Spiegel, Matthew A	No Conflicts to Disclose; Submitted 04/27/2015	78	
Spiker, W Ryan	Submitted 04/22/2015 DePuy, A Johnson & Johnson Company: Research support NEXXT Orthopaedics: Paid consultant Synthes: Research support	62	
Spivak, Jeffrey M	Submitted 05/31/2015 Etex: Stock or stock options NASS: Board or committee member Paradigm Spine: Stock or stock options Synthes: Paid consultant; Research support Titan Spine: IP royalties; Other financial or material support; Paid consultant; Stock or stock options Vertibron: Paid consultant	14	
Spoonamore, Mark J	No Conflicts to Disclose; Submitted 04/28/2015		31
Stawicki, Christie E	No Conflicts to Disclose; Submitted 04/21/2015	98 P	
Steinberger, Jeremy	No Conflicts to Disclose; Submitted 04/28/2015		4, 35
Steinmetz, Michael P [a]	Submitted 04/20/2015 Biomet: IP royalties; Unpaid consultant Biomet Synthese Spine: Paid presenter or speaker Congress of Neurological Surgeons, Council of State Neurosurgical Societies, AANS: Board or committee member DePuy, A Johnson & Johnson Company: Paid presenter or speaker Intellirod: Paid consultant Stryker: Paid presenter or speaker		16, 20
Stock, Stuart R	No Conflicts to Disclose; Submitted 05/02/2015	20	
Stone, Marcus	No Conflicts to Disclose; Submitted 05/01/2015	11	
Stonko, David P	No Conflicts to Disclose; Submitted 04/30/2015	9, 22 P, 23 P, 24 P, 37	

Name	Received	Presentation	E-Poster
Street, John	Submitted 05/03/2015 Medtronic: Research support; Unpaid consultant Medtronic Sofamor Danek: Paid presenter or speaker Synthes: Paid presenter or speaker; Research support	26 P	42
Streijger, Femke	No Conflicts to Disclose; Submitted 05/04/2015	26 P	
Suda, Kota	No Conflicts to Disclose; Submitted 04/26/2015		41
Sugai, Keiko	No Conflicts to Disclose; Submitted 10/21/2015		6
Sugawara, Taku	No Conflicts to Disclose; Submitted 05/04/2015	33 P	
Sugiyama, Daisuke	No Conflicts to Disclose; Submitted 05/04/2015	41	
Suk, Kyung-Soo	Submitted 05/05/2015 CSRS Asia-Pacific: Board or committee member CG Bio: IP royalties Clinics in Orthopaedic Surgery: Editorial or governing board Eli Lilly: Paid presenter or speaker Journal of Koean Society of Spine Surgery: Editorial or governing board Korean Orthopaedic Assoc, Korean Society of Spine Surgery: Board or committee member Medtronic Sofamor Danek: Paid presenter or speaker Pfizer: Paid presenter or speaker	47	
Sumi, Masatoshi	No Conflicts to Disclose; Submitted 04/30/2015	33 P, 35 P, 41	32
Sumiya, Satoshi	No Conflicts to Disclose; Submitted 05/01/2015	97 P	30
Suzuki, Akinobu	No Conflicts to Disclose; Submitted 05/01/2015	3	
Suzuki, Yoshitaka	No Conflicts to Disclose; Submitted 05/04/2015		27
Swift, Carol [c]	No Conflicts to Disclose; Submitted 04/20/2015		
Tabaraee, Ehsan	No Conflicts to Disclose; Submitted 04/28/2015	54	
Takabatake, Masato	No Conflicts to Disclose; Submitted 05/03/2015	35 P	
Takahashi, Shinji	No Conflicts to Disclose; Submitted 05/02/2015	3	
Takano, Morito	No Conflicts to Disclose; Submitted 05/03/2015	18	
Takeshita, Katsushi	Submitted 04/28/2015 DePuy, A Johnson & Johnson Company: Paid presenter or speaker Johnson & Johnson: Paid presenter or speaker Medtronic: Paid consultant Pfizer: Paid presenter or speaker	4	
Tamia, Koji	No Conflicts to Disclose; Submitted 05/02/2015	3	
Tanaka, Sakae	Submitted 04/28/2015 Amgen: Paid consultant Bristol-Myers Squibb: Paid consultant Chugai Pharmaceutical: Paid presenter or speaker; Paid consultant Daiichi Sankyo: Paid consultant; Paid presenter or speaker Eli Lilly: Paid presenter or speaker	4	

Name	Received	Presentation	E-Poster
Tanaka, Sakae (cont.)	Janssen Pharmaceutical K.K.: Paid consultant KYOCERA Medical Corporation: Paid consultant MSD K.K.: Paid consultant Ono Pharmaceutical: Paid consultant TeijinPharma: Paid consultant	4	
Taniguchi, Yuki	No Conflicts to Disclose; Submitted 04/28/2015	4	
Tannoury, Chadi	No Conflicts to Disclose; Submitted 04/06/2015		18, 20
Tannoury, Tony Y	Submitted 05/05/2015 Johnson & Johnson: IP royalties; Paid consultant; Paid presenter or speaker		18, 20
Tanzi, Elizabeth M	No Conflicts to Disclose; Submitted 05/01/2015	78	
Tatsumura, Masaki	No Conflicts to Disclose; Submitted 04/30/2015		12
Tauchi, Ryoji	No Conflicts to Disclose; Submitted 04/22/2015		27
Tay, Bobby K m,p	Submitted 10/05/2015 AOSpine: Research support Biomet: Paid presenter or speaker Globus Medical: Research support NuVasive: Research support Stryker: Paid presenter or speaker Synthes: Paid presenter or speaker		
Tee, Jin W	No Conflicts to Disclose; Submitted 10/22/2015	30 P	42
Terai, Hidetomi	No Conflicts to Disclose; Submitted 05/03/2015	3	
Terashima, Yoshiki	No Conflicts to Disclose; Submitted 04/30/2015	41	32
Tetreault, Lindsay	No Conflicts to Disclose; Submitted 05/06/2015	1, 60, 71, 72, 94 P, 95 P	18
Thakkar, Vismay	No Conflicts to Disclose; Submitted 05/06/2015	49	
Than, Khoi Duc	No Conflicts to Disclose; Submitted 04/23/2015		20
Theologis, Alexander A	Submitted 04/04/2015 Globus Medical: Other financial or material support Medtronic: Other financial or material support Stryker: Other financial or material support Synthes: Other financial or material support	63, 80	23
Tosteson, Anna N A	No Conflicts to Disclose; Submitted 04/29/2015	6	
Toy, Jason O	No Conflicts to Disclose; Submitted 05/04/2015	15, 92 P	
Toyama, Yoshiaki	No Conflicts to Disclose; Submitted 10/23/2015	28 P	
Toyoda, Hiromitsu	No Conflicts to Disclose; Submitted 05/03/2015	3	
Traynelis, Vincent C	Submitted 04/19/2015 Amer Board of Neuro Surg: Board or committee member Medtronic: IP royalties; Paid consultant Medtronic Sofamor Danek: IP royalties; Paid consultant		18

Name	Received	Presentation	E-Poster
Traynelis, Vincent C (cont.)	Journal of Spinal Disorders and Techniques, Neurosurgery, Spine, Spine Surgery Today, Surgical Neurology Int'l Spine, World Neurosurgery: Editorial or governing board		18
Tsai, Eve C	Submitted 04/30/2015 AANS/CNS: Board or committee member AANS: Board or committee member Canadian Spine Society: Board or committee member	30 P	
Tsuji, Taichi	No Conflicts to Disclose; Submitted 05/06/2015		27
Tsutsui, Shunji	No Conflicts to Disclose; Submitted 05/01/2015		1
Tuchman, Alexander	No Conflicts to Disclose; Submitted 05/05/2015		31
Turner, Alexander W	Submitted 05/05/2015 NuVasive: Employee; Stock or stock options		9
Ulndreaj, Antigona	No Conflicts to Disclose; Submitted 05/01/2015	57	
Ushiku, Chikara	No Conflicts to Disclose; Submitted 05/06/2015		41
Vaccaro, Alexander R m	Submitted 04/15/2015 Advanced Spinal Intellectual Properties: Board or committee member; Stock or stock options Aesculap: IP royalties AOSpine: Research support Assoc of Collaborative Spine Research: Board or committee member Biomet Spine: IP royalties Bonovo Orthopaedics: Stock or stock options Cerapedics: Research support Computational Biodynamics: Board or committee member; Stock or stock options Crosscurrent: Stock or stock options Cytonics: Stock or stock options DePuy: Paid consultant; IP royalties Electrocore: Stock or stock options Ellipse: Paid consultant Elsevier: Publishing royalties, financial or material support European Spine Journal: Editorial or governing board Flagship surgical: Stock or stock options Flowpharma: Stock or stock options Gamma Spine: Stock or stock options Gerson Lehrman Group: Paid consultant Globus: IP royalties; Paid consultant Globus Medical: Stock or stock options Globus:Stryker: Medtronics: Paid consultant Guidepoint Global: Paid consultant In Vivo: Stock or stock options Innovative Surgical Design: Board or committee member; Stock or stock options J. Neurosurgery Spine: Editorial or governing board Jaypee: Publishing royalties, financial or material support Medacorp: Paid consultant Medtronics: IP royalties	2, 39, 49, 98 P	26, 39, 42

Name	Received	Presentation	E-Poster
Vaccaro, Alexander R [m] (cont.)	Orthobullets: Paid consultant Pan Arab J. Neurosurgery: Editorial or governing board Paradigm Spine: Stock or stock options Progressive spinal technologies: Board or committee member; Stock or stock options R.S.I.: Board or committee member Replication Medica: Stock or stock options RI and related properties: Stock or stock options Rothman Institute and Related Properties: Board or committee member RSI: Stock or stock options Small Bone Technologies: Stock or stock options Spine: Editorial or governing board Spine Medica: Stock or stock options Spinicity: Board or committee member; Stock or stock options Spinology: Stock or stock options Stout Medical: Stock or stock options Stryker Spine: IP royalties Syndicom: Stock or stock options Taylor and Francis: Publishing royalties, financial or material support Thieme: Publishing royalties, financial or material support Vertiflex: Stock or stock options	2, 39, 49, 98 P	26, 39, 42
Vallier, Heather A	Submitted 04/26/2015 AAOS: Board or committee member COTA: Board or committee member Journal of Orthopaedics and Traumatology: Editorial or governing board OTA: Board or committee member		44
Vasquez-Castellanos, Raul A	No Conflicts to Disclose; Submitted 04/30/2015	23 P	
Verma, Ravi	No Conflicts to Disclose; Submitted 05/05/2015	68	
Vidal, Pia M	No Conflicts to Disclose; Submitted 05/03/2015	57	
Vira, Shaleen	No Conflicts to Disclose; Submitted 04/29/2015	78	
Voronov, Leonard I	No Conflicts to Disclose; Submitted 04/28/2015	83 P	
Wada, Eiji	Submitted 05/04/2015 Journal of Spine Research/the Japanese Society for Spine Surgery and Related Research: Editorial or governing board	59	
Wagner, Scott C	No Conflicts to Disclose; Submitted 04/30/2015	34 P	
Wang, Jeffrey C [dl, sp]	Submitted 08/03/2015 AAOS, CSRS, NASS, SRS: Board or committee member Aesculap/B.Braun: IP royalties Alphatec Spine: Stock or stock options Amedica: IP royalties; Stock or stock options	39	19, 25, 31

a = Awards Committee • c = CSRS Staff • df = Dinner Symposium • lf = Lunch Symposium • m = Moderator • p = Program Committee • rc = Research Committee • rs = Research Session • s = Symposium Presenter • sp = Special Presenter

Name	Received	Presentation	E-Poster
Wang, Jeffrey C [dl, sp] (cont.)	AOA, AOSpine, Collaborative Spine Research Foundation: Board or committee member Axiomed: Stock or stock options benevenue: Stock or stock options Biomet: IP royalties bone biologics: Stock or stock options corespine: Stock or stock options curative biosciences: Stock or stock options electrocore: Stock or stock options expanding ortho: Stock or stock options Fziomed: Stock or stock options Nexgen: Stock or stock options Osprey: IP royalties paradigm spine: Stock or stock options pearldiver: Stock or stock options promethean spine: Stock or stock options SeaSpine: IP royalties Stryker: IP royalties Surgitech: Stock or stock options Synthes: IP royalties Evidence Based Spine Journal, The Global Spine Journal, Spine, The Spine Journal, The Journal of Spinal Disorders and Techniques, JOAAS: Editorial or governing board vertiflex: Stock or stock options VG innovations: Stock or stock options	39	19, 25, 31
Webb, Matthew L	No Conflicts to Disclose; Submitted 04/30/2015	15, 88 P, 92 P	21
Wei, Feng	No Conflicts to Disclose; Submitted 05/05/2015	86 P	
Werner, Brian C	No Conflicts to Disclose; Submitted 04/01/2015	36, 55	
West, Tyler	No Conflicts to Disclose; Submitted 05/03/2015	50	
Wick, Joseph B	No Conflicts to Disclose; Submitted 04/29/2015	7, 22 P, 23 P, 37, 65	
Winkelstein, Beth A [rc]	Submitted 04/27/2015 Spine: Editorial or governing board St Jude Medical: Research support Taylor and Francis: Publishing royalties, financial or material support		
Wlezien, Peggy [c]	No Conflicts to Disclose; Submitted 10/01/2015		
Worley, Nancy J	No Conflicts to Disclose; Submitted 04/29/2015		22, 39
Wright, Neill M [p]	Submitted 04/26/2015 CSRS: Board or committee member NuVasive: IP royalties, Paid consultant Ulrich Medical: Paid consultant Vertebral Technologies: Stock or stock options		33
Wu, Fengliang	No Conflicts to Disclose; Submitted 05/06/2015	86 P	

Name	Received	Presentation	E-Poster
Xiao, Roy	No Conflicts to Disclose; Submitted 04/26/2015	74	
Yamada, Hiroshi	No Conflicts to Disclose; Submitted 05/01/2015		1
Yamada, Katsuhisa	No Conflicts to Disclose; Submitted 05/03/2015		41
Yamane, Jun-ichi	No Conflicts to Disclose; Submitted 05/02/2015	28 P	
Yamazaki, Masashi	No Conflicts to Disclose; Submitted 08/25/2015		12
Yang, Chao	Submitted 04/06/2015 Johnson & Johnson: Employee; Stock or stock options	12	
Yang, Jae-Ho	No Conflicts to Disclose; Submitted 05/06/2015	47	
Yang, Jae Jun	No Conflicts to Disclose; Submitted 05/04/2015		10
Yang, Zhuo	No Conflicts to Disclose; Submitted 05/04/2015	11	
Yeom, Jin-Sup [m,sp]	Submitted 04/05/2015 Asian Spine Journal, Clinics in Ortho Surgery, Journal of Korean Ortho Assoc: Editorial or governing board CSRS Asia Pacific, Korean Society of Spine Sugery, Koean Ortho Assoc, Computer Assisted Ortho Surgery Korea: Board or committee member Medtronic Sofamor Danek: Paid presenter or speaker		2
Yonenobu, Kazuo	No Conflicts to Disclose; Submitted 04/29/2015	42	
Yoo, Jung U [rc]	Submitted 04/02/2015 Osiris Therapeutics: IP royalties	69	
Yoon, S Tim [rc]	Submitted 04/03/2015 Alphatec Spine: Stock or stock options Biomet: Paid consultant; Research support International Society for the Study of the Lumbar Spine: Board or committee member Meditech: Paid consultant Meditech Advisors: IP royalties; Stock or stock options Medyssey: Stock or stock options NuVasive: Research support Phygen: Stock or stock options Spine: Editorial or governing board Stryker: IP royalties; Paid consultant Amer Journal of Orthopedics, JBJS, Journal of Orthopaedic Research, The Spine Journal: Editorial or governing board	2, 48	
Yoshida, Munehito	No Conflicts to Disclose; Submitted 05/03/2015		1

Name	Received	Presentation	E-Poster
Yoshii, Toshitaka	Submitted 05/04/2015 Amer Journal of Tissue Engineering & Stem Cell: Editorial or governing board Int'l Journal of Orthopedics and Rehabilitation: Editorial or governing board Olympus biomaterial: Research support Stryker: Research support	97 P	30
Youssef, Jim A	Submitted 04/30/2015 Amedica: IP royalties; Paid consultant; Stock or stock options AOSpine: Editorial or governing board Benvenue: Stock or stock options CSRS: Editorial or governing board Globus Medical: Research support Integra: IP royalties; Paid consultant; Research support ISASS: Editorial or governing board ISD: Stock or stock options JOASS: Editorial or governing board NuVasive: IP royalties; Paid consultant; Research support Osprey: IP royalties Paradigm Spine: Stock or stock options Promethean Surgical: Stock or stock options Providence Medical: Stock or stock options Spinal Ventures: Stock or stock options Evidence Based Spine Care Journal, Spine, Spine Arthroplasty Society Journal: Editorial or governing board Spinicity: Stock or stock options Vertiflex: Research support; Stock or stock options	39	
Yu, Miao	No Conflicts to Disclose; Submitted 05/06/2015	86 P	
Yukawa, Yasutsugu	No Conflicts to Disclose; Submitted 04/26/2015	79, 90 P	
Yun, Chawon	No Conflicts to Disclose; Submitted 05/03/2015	20	
Yurube, Takashi	No Conflicts to Disclose; Submitted 04/29/2015	41	32
Zdeblick, Thomas A [m]	Submitted 10/21/2015 LSRS: Board or committee member Medtronic Sofamor Danek: IP royalties		
Zebala, Lukas P	Submitted 04/28/2015 AOSpine/Omega: Other financial or material support Broadwater LLC: Paid presenter or speaker DePuy, A Johnson & Johnson Company: Paid presenter or speaker; Institutional Educational Grant: Other financial or material support Medtronic Sofamor Danek: Other financial or material support Ulrich: Paid consultant	82 P	
Zhou, Qiang	No Conflicts to Disclose; Submitted 05/06/2015	2	

Name	Received	Presentation	E-Poster
Zigler, Jack E [m]	Submitted 05/04/2015 Coluna: Editorial or governing board DePuy, A Johnson & Johnson Company: Paid consultant Expanding Orthopedics: Stock or stock options Flexuspine: Stock or stock options ISASS: Board or committee member Journal of ISASS: Editorial or governing board K2M: IP royalties Osprey: IP royalties Zimmer: IP royalties	12, 13, 14, 64	5, 37
Zusman, Natalie L	No Conflicts to Disclose; Submitted 05/01/2015	69	

The names of authors presenting papers are printed in boldface. All presenters, secondary authors, and any other participant in the Annual Meeting have been asked to disclose if he/she, or a member of his/her immediate family has a financial interest in or other relationship with a commercial company or institution within the last twelve months.

An indication of the participant's disclosure as well as the commercial company or institution that provided the support appears in the disclosure index.

The CSRS does not view the existence of these disclosed interests or commitments as necessarily implying bias or decreasing the value of their participation in this activity.

Podium Presentation Abstracts

See Disclosure Index pages 40–88.

Presentation #1

Is Preoperative Duration of Symptoms a Significant Predictor of Functional Status and Quality of Life Outcomes in Patients Undergoing Surgery for the Treatment of Degenerative Cervical Myelopathy?

***Lindsay Tetreault, hBSC, HBSc**, Toronto, ON, Canada*
Branko Kopjar, MD, PhD, Seattle, WA
Paul M. Arnold, MD, Kansas City, KS
Michael G. Fehlings, MD, PhD, Toronto, ON, Canada

Introduction: Longstanding compression of the spinal cord in patients with degenerative cervical myelopathy (DCM) may result in irreversible neural tissue damage. This study aims to analyze whether a longer duration of symptoms influences surgical outcomes and to determine the optimal timing for decompressive surgery

Methods: Three hundred and fifty patients with symptomatic DCM were prospectively enrolled in either the CSM-North America or International study at 12 sites in North America. For each patient, extensive demographic information was collected, including age, co-morbidities, and a self-reported estimate of preoperative duration of symptoms. Postoperative functional status and quality of life were evaluated at 6-, 12- and 24-months using the modified Japanese Orthopaedic Association (mJOA), Nurick grade, Neck Disability Index (NDI) and Short-Form-36 (SF-36) Physical (PCS) and Mental (MCS) Component Scores. Change scores between baseline and 12-month follow-up were computed for each outcome measure. Duration of symptoms was dichotomized into a "short" and "long" group at several cut-offs. An iterative mixed model analytic approach procedure was used to evaluate differences in change scores on the mJOA, Nurick, SF-36 MCS and PCS and NDI between duration groups in 1-month increments. Two models were constructed: 1) an unadjusted model between duration of symptoms and surgical outcome and 2) a model adjusting for significant independent covariates identified through stepwise regression analysis.

Thursday, December 3, 2015, 7:11–7:17 am CSRS–2015

Presentation #1

Results: Our cohort consisted of 201 (57.43%) men and 149 (42.57%) women, with a mean age of 57.49 ± 11.77 years (range: 29–87 years). The mean duration of symptoms was 25.71 ± 36.68 months (range: 1-240 months). In unadjusted analysis, patients with a duration of symptoms shorter than 4 months had significantly better functional outcomes based on the mJOA ($p = 0.04$) than patients with a longer duration of symptoms (> 4 months). On average, patients with < 4 months symptom duration improved by 3.71 on the mJOA, whereas those with a duration 4 months or longer only exhibited a 2.96 mean gain, difference of 0.75 (95%C.I. .03 to 1.47). Twelve months was identified as the next important cut-off beyond which patients had significantly worse outcomes on the mJOA. In adjusted model, patients with < 12 months symptom duration improved by 3.37 on the mJOA, whereas those with a duration 12 months or longer exhibited a 2.85 mean gain, difference of 0.52 (95%C.I. .01 to 1.03. Duration of symptoms was not associated with Nurick or SF-36 PCS or MCS in either the unadjusted or adjusted models (Figure 1).

Conclusions: Patients who are operated on within 4 months of symptom presentation have better mJOA outcomes. It is recommended that patients with DCM are diagnosed in a timely fashion and referred early for surgical consultation. Our study does not support the traditional conservative "watchful waiting" approach to symptomatic patients with DCM.

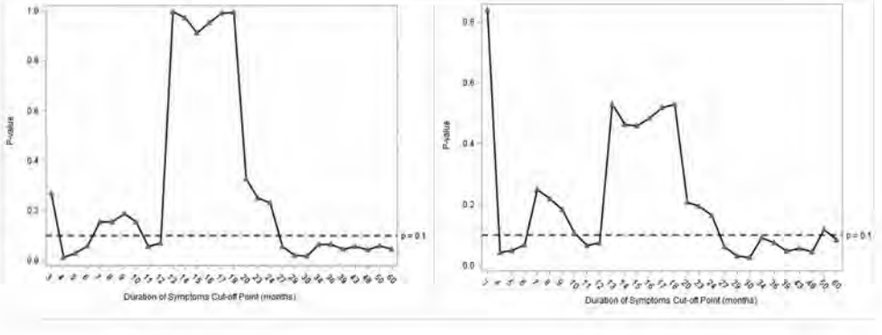


Figure 1. Unadjusted (left) and Adjusted (right) Analysis between Duration of Symptoms and Change in mJOA between Baseline and 1-year Follow-up

Each point on the x-axis reflects a different cut-off between "short" and "long" duration of symptoms. Points below the green dashed line have p-values <0.1. These graphs help to identify important cut-offs beyond which there is a negative impact on outcome.

See Disclosure Index pages 40–88.

Presentation #2

Laminoplasty vs. Laminectomy and Fusion to Treat Cervical Spondylotic Myelopathy: Outcomes of the Prospective Multicenter AOSpine North America and International CSM Studies

***Carlo Santaguida, MD**, Toronto, ON, Canada*
Michael G. Fehlings, MD, PhD, Toronto, ON, Canada
Branko Kopjar, MD, PhD, Seattle, WA
Paul M. Arnold, MD, Kansas City, KS
Helton Defino, MD, Ribeirao Preto, Sao Paulo, Brazil
Shashank Kale, MD, New Delhi, India
S. Tim Yoon, MD, PhD, Atlanta, GA
Giuseppe Barbagallo, MD, Catania, Italy
Ronald H.M.A. Bartels, MD, PhD, Nijmegen, Netherlands
Qiang Zhou, MD, Chongqing, China
Alexander R. Vaccaro, III, MD, PhD, Philadelphia, PA

Introduction: The posterior surgical options for the treatment of CSM include cervical laminoplasty (CLP) and laminectomy and fusion (CLF). Prior prospective and retrospective studies do not allow for inferences to be made regarding relative efficacy of each treatment. We present the results from the pooled analysis of the two largest prospective CSM studies to better elucidate whether CLP or CLF is the more efficacious surgical treatment.

Methods: A total of 757 patients with clinical and radiologic confirmed diagnosis of CSM were enrolled in the combined North America (CSM-NA, clinicaltrial.gov NCT00285337) and International (CSM-I, clinicaltrial.gov NCT00565734) prospective multicenter observational studies. The enrollment period for the CSM- NA study was from December 2005 to September 2007 and involved 12 sites. The CSM-I study enrolled from November 2007- January 2011 and involved 16 sites distributed through Asia Pacific, Europe, North America and Latin America. 166 participants underwent CLF and 100 participants underwent CLP. Primary outcomes included Nurick Score, modified Japanese Orthopedic Association Score (mJOA), Neck Disability Index (NDI) and secondary outcomes include the Short form-36 v2 physical (SF-36 PCS) and mental component (SF-36 MCS) scores at 1-year following treatment.

Presentation #2

The study has 90% power to detect a 8/100 change in NDI and 80% power to detect a 1 point change in mJOA. Chi-square tests and T-test were used to analyze baseline characteristics. The difference in outcome measures at 1 year after surgery were analyzed by 1-way ANOVA and ANCOVA adjusting for covariates: gender, age, smoking, # of operative level, baseline scores, and duration of symptoms. $P < 0.05$ were considered statistically significant. The analysis was performed on SAS 9.4 (SAS Institute, Inc., Cary, NC, USA).

Results: Baseline characteristics of the patient populations reveal comparable characteristics the exception of Asia Pacific region performing a disproportionate number of CLP cases (53% of population) compared to CLF (1.8% of population, $p < 0.0001$) (Table 1). The baseline mJOA scores were more severe in the CLP group (11.52 vs. 12.30, $p = 0.0297$). The -year improvement in outcomes for participants who underwent CLF were mJOA 2.45 (1.97, 2.93), Nurick score 1.23 (0.98, 1.47), NDI 10.08 (6.56, 13.60), SF-36 PCS 5.27 (3.50, 7.04), and SF-36 MCS 6.29 (3.95, 8.63). The 1-year improvement in outcomes for participants who underwent CLP were found to have a mean improvement in mJOA score 3.29 (2.67, 3.91), Nurick score 1.40 (1.09, 1.70), NDI improvement of 13.21 (8.37, 18.06), SF-36 PCS 5.68 (3.45, 7.91), SF-36 MCS 7.22 (4.43, 10.01). Key adverse events that include C5 palsies, instrumentation failure, and deep wound infections were comparable between groups. There were no statistically significant differences in outcome measures between groups once baseline characteristics were adjusted for (Table 2).

Conclusions: The pooled analysis of the AOSpine North America and International prospective multicenter CSM studies revealed no difference in outcome measures (mJOA, Nurick, NDI, SF-36 PCS and MCS) between patients treated with CLP vs. CLF. C5 palsy rates and NDI scores were comparable between surgical groups. When left to the surgeon's discretion, both surgical treatments were similarly effective in the treatment of CSM.

See Disclosure Index pages 40–88.

Presentation #2 (cont.)

Table 1. Baseline Characteristics of Study Participants Classified by Surgical Approach

	Laminoplasty (N = 100)	Laminectomy and Fusion (N = 166)	p value
Age (yr)	60.68 (11.32)	61.36 (10.59)	0.6208
Female sex	33.00%	31.93%	0.8563
Current smoker	19.00%	27.11%	0.134
Region AP/Eu/LA/NA	53.0%/1.0%/11.0%/35.0%	1.8%/10.2%/25.3%/62.7%	<0.0001
Symptom duration (Mo)	23.12 (33.36)	31.96 (39.86)	0.0662
Nurick score	3.57 (1.25)	3.39 (1.19)	0.2304
mJOA	11.52 (2.77)	12.30 (2.85)	0.0297
Neck Disability Index	41.84 (20.66)	39.20 (20.90)	0.3694
SF-36 version 2 MCS	38.93 (12.49)	41.03 (14.62)	0.2376
SF-36 version 2 PCS	35.08 (10.10)	33.12 (9.30)	0.1134
No. levels operated*	4.78 (0.85)	4.96 (0.88)	0.0955

Numbers in parentheses are standard deviations
AP, Asia Pacific; Eu, Europe; LA, Latin America, NA, North America; mJOA, modified Japanese Orthopedic Assessment; SF-36, Short-Form 36; MCS, Mental Component Score; PCS, Physical Component Score.

Table 2. Adjusted Improvement in Outcome Measures at 12 Months Classified by Surgical Approach

	Laminoplasty (N=99)	Laminectomy and Fusion (N=166)	p value
Nurick score	1.21 (0.87, 1.54)	1.22 (0.95, 1.48)	0.3170
mJOA	2.93 (2.34, 3.53)	2.65 (2.18, 3.12)	0.3965
Neck Disability Index	10.28 (5.57, 14.99)	9.32 (5.82, 12.82)	0.2442
SF-36 version 2 MCS	5.98 (3.24, 8.71)	6.48 (4.11, 8.85)	0.4976
SF-36 version 2 PCS	5.11 (2.77, 7.45)	4.72 (2.84, 6.61)	0.4646

Numbers in parentheses are 95% confidence intervals
mJOA, modified Japanese Orthopedic Assessment; SF-36, Short-Form 36; MCS, Mental Component Score; PCS, Physical Component Score.
Adjusted for baseline outcome values, age, gender, smoking, duration of symptoms, number of operated levels

Presentation #3

Clinical Outcome of Cervical Laminoplasty and Postoperative Radiological Change for Cervical Myelopathy with Degenerative Spondylolisthesis

***Akinobu Suzuki, MD, PhD**, Osaka City, Japan*
Koji Tamai, MD, Osaka City, Japan
Hidetomi Terai, MD, PhD, Osaka City, Japan
Masatoshi Hoshino, MD, PhD, Osaka City, Japan
Hiromitsu Toyoda, Osaka City, Japan
Sho Dohzono, MD, Osaka City, Japan
Shinji Takahashi, MD, Osaka City, Japan
Kazunori Hayashi, MD, Osaka City, Japan
Hiroaki Nakamura, MD, Osaka City, Japan

Introduction: The presence of spondylolisthesis often represents segmental instability in cervical spine as well as lumbar spine, and fusion surgery is sometimes performed for cervical lesion with spondylolisthesis. Cervical laminoplasty is a common decompression surgery for cervical myelopathy, but its clinical result for cervical spondylolisthesis has not been well studied. The purpose of this study was to investigate the clinical outcome of cervical laminoplasty for cervical myelopathy with degenerative spondylolisthesis and to examine the postoperative radiological change of spondylolisthesis.

Materials/Methods: One hundred and seventeen patients (76 men, and 41 women) who underwent cervical laminoplasty for cervical compressive myelopathy and followed for more than 2 years were included in this study. The patients with tumor, ossification of posterior longitudinal ligament, and a history of acute trauma were excluded. Average age at surgery was 64.9 years, and average follow up period was 3.2 years. For the clinical evaluation, Japanese orthopaedic association score for cervical myelopathy (JOA score) and visual analogue scale of neck pain, upper arm pain and numbness were evaluated before surgery, and at 3 months, 1 years and 2 years after surgery. Recovery rate of JOA score was calculated by the Hirabayashi method. In this study, spondylolisthesis was defined as more than 2mm slip to adjacent vertebrae on plain radiograph at neutral position. The clinical results were compared between the patients with spondylolisthesis (group S) and without spondylolisthesis (group C). In the patients with spondylolisthesis, the slip distance and translational motion between flexion and extension was examined on plain lateral radiograph before surgery and 2 years after surgery. Statistical analysis was performed using Mann–Whitney U test.

See Disclosure Index pages 40–88.

Presentation #3 (cont.)

Results: Degenerative cervical spondylolisthesis was found in 49 levels of 33 patients (28.2%), and the average age of group S was significantly higher than that of group C. JOA score was significantly improved in both groups, and the recovery rate was similar between the two groups. However, average JOA score of group S was significantly lower than that of group C preoperatively, and at every postoperative time points. Each VAS score also improved in both groups after surgery, and there was no significant difference between the two groups. In the level of spondylolisthesis, average slip distance was 3.3mm before surgery and 3.2mm at 2 years after surgery, and the difference was not significant between the two time periods. Average translational motion was 1.7mm preoperatively and 0.6mm at 2 years after surgery, and it was significantly decreased in 2years after surgery. There was no patient who required revision surgery due to instability.

Conclusion: Cervical spondylolisthesis was common in elderly patients, and it may relate to severe functional deficit. The recovery rate of JOA score in group S was comparable with that in group C, and the level with spondylolisthesis has been stabilized after surgery. Thus, cervical laminoplasty can be an effective treatment option even for cervical compressive myelopathy with degenerative spondylolisthesis.

Presentation #4

Cervical Anterolisthesis is a Significant Poor Predictor of Neurologic Outcomes in Patients with Cervical Spondylotic Myelopathy following Cervical Laminoplasty

***Takeshi Oichi, MD**, Tokyo, Japan*
Yasushi Oshima, MD, PhD, Tokyo, Japan
Yuki Taniguchi, MD, PhD, Tokyo, Japan
Yoshitaka Matsubayashi, MD, Tokyo, Japan
Hirotaka Chikuda, MD, PhD, Tokyo, Japan
Katsushi Takeshita, MD, PhD, Tochigi-ken, Japan
Sakae Tanaka, MD, PhD, Tokyo, Japan

Introduction: Several risk factors, including age, duration of myelopathic symptoms, diabetes, degree of cervical canal stenosis, and cervical alignment, have been identified for poor neurological outcomes in cervical spondylotic myelopathy (CSM) patients after cervical laminoplasty. However, few studies have focused on the surgical outcomes in CSM patients with cervical spondylolisthesis. Our objective was to clarify the influence of cervical spondylolisthesis on neurological outcomes in CSM patients after cervical laminoplasty.

Materials and Methods: We retrospectively reviewed 125 CSM patients (86 men and 39 women) following cervical laminoplasty at our institute from January 1991 to June 2012. Neurological outcomes were evaluated by calculating the Japanese Orthopedic Association (JOA) recovery rate two years after surgery. The patients were divided into the following two groups according to the JOA recovery rate: effective group (JOA recovery rate ≥ 50%) and non-effective group (JOA recovery rate < 50%). We defined anterolisthesis as >3 mm of anterior slip in a flexion radiograph and retrolisthesis as >3 mm of posterior slip in an extension radiograph. We further assessed potential risk factors for poor neurological outcomes after cervical laminoplasty, including local kyphosis, cervical kyphosis, degree of spinal cord compression calculated by maximum spinal cord compression, duration of myelopathic symptoms, diabetes mellitus, and preoperative JOA score. Differences in both radiological and clinical variables between the effective and non-effective groups were compared. Variables with p-value <0.20 in univariate analyses were entered into the multivariate logistic regression model to identify the risk factors for poor neurological outcomes after cervical laminoplasty.

Results: The average age was 64 years (range, 30−89 years), and the average follow-up period was 4 years (range, 2−12 years). The average JOA score was 9.9 points (range, 4−15 points) before surgery, 13.3 points (range, 8−17 points) two years after surgery, and 13.3 points (range, 8−17 points) at the final follow-up. The average JOA recovery rate two years after surgery was 47.2% (range, −68%−100%), with 63 patients in the effective group and 62 patients in the non-effective group.

See Disclosure Index pages 40–88.

Presentation #4 (cont.)

Table 1 shows the differences in each variable between the effective and non-effective groups. Patients in the non-effective group were significantly older than those in the effective group ($p < 0.001$). Anterolisthesis was observed significantly more often in the non-effective group ($p < 0.01$). From the results of the univariate analyses, age, duration of myelopathic symptoms (short or long duration), diabetes mellitus, degree of cervical spinal cord compression (severe or non-severe), and cervical spondylolisthesis (none, anterolisthesis, or retrolisthesis) were considered as dependent variables. Anterolisthesis was a significant risk factor for poor neurological outcomes even after adjusting for other risk factors (OR, 8.8; 95% CI, 1.4–173, $p < 0.05$) (Table 2). Retrolisthesis did not significantly affect neurological outcomes ($p = 0.4$).

Conclusion: Anterolisthesis, but not retrolisthesis, is a significant risk factor for poor surgical outcomes after cervical laminoplasty. We suggest that cervical laminoplasty should not be considered in CSM patients with anterolisthesis. On the other hand, laminoplasty alone can achieve favorable neurological outcomes in CSM patients with retrolisthesis.

Table 1. Differences in demographics and radiographic findings between the effective and non-effective groups

	Effective group (JOARR ≥ 50%) (n = 63)	Non-effective group (JOARR < 50%) (n = 62)	*p* value
Male sex [no. of patients (%)]	45 (71)	41 (66)	0.5
Age (mean ± SD)	60.7 ± 11.1	67.7 ± 9.7	0.0001
Preoperative JOA	10.1 ± 2.3	9.8 ± 2.7	0.8
Long duration of myelopathic symptoms [no. of patients (%)]	27 (43)	35 (56)	0.1
Diabetic mellitus	8 (13)	15 (24)	0.1
Severe compression	37 (59)	25 (40)	0.1
Local kyphosis	7 (11)	11 (18)	0.3
Cervical kyphosis	11 (18)	9 (15)	0.8
Cervical spondylolisthesis			
Anterolisthesis	1 (47)	12 (19)	0.001
Retrolisthesis	13 (21)	11 (18)	0.7

JOA: Japanese Orthopedic Association, JOARR: JOA recovery rate, Long duration of myelopathic symptom: duration > 12 months, Severe compression: maximum spinal cord compression exceeding the median. Continuous variables were compared using Student's t-test or the Wilcoxon rank-sum test; categorical data were analyzed using chi-square test or Fisher's exact probability test.

Presentation #4

Table 2. Multivariate logistic regression analysis for OR and 95% CI of the variables for poor outcomes (JOA recovery rate < 50%) following laminoplasty

	OR	CI	*p* value
Age	1.06	1.01–1.11	0.01
Sex			
Male	Reference		
Female	1.29	0.52–3.22	0.6
Duration of myelopathic symptoms			
Short duration	Reference		
Long duration	1.40	0.62–3.20	0.4
Diabetes mellitus	1.60	0.57–4.65	0.3
Degree of cervical spinal cord compression			
Severe compression	Reference		
Non-severe compression	0.39	0.17–0.89	0.02
Spondylolisthesis			
None	Reference		
Anterolisthesis	8.8	1.42–173	0.02
Retrolisthesis	1.5	0.57–4.15	0.4

CI: confidence interval, MSCC: maximum spinal cord compression, OR: odds ratio.

See Disclosure Index pages 40–88.

Presentation #5

Physical Signs and Clinical Features of Elderly Patients with Cervical Myelopathy: Comparison of Three Different Age Groups in 100 Consecutive Operative Cases

***Takahiko Hamasaki, MD**, Hiroshima, Japan*

Introduction: With the ever aging population, a greater number of elderly patients with cervical myelopathy (CM) are encountered. Although it is important to check for physical signs when diagnosing CM, previous studies have demonstrated that not all myelopathic patients exhibit physical findings. Little is known about the prevalence of physical findings in elderly patients with CM. The purpose of this study was to examine the rate of physical signs in elderly patients with CM, and to compare findings in three different age groups.

Methods: We evaluated 100 consecutive CM patients with (1) a history of myelopathic symptoms and (2) correlative spinal cord compression on imaging, who then (3) underwent surgery and (4) improved their symptoms after surgery. Patients were divided into 3 age groups; (A) 80 years or older (34 cases; 15 male and 19 female; mean age 83.9 years), (B) 70s (33 cases; 18 male and 15 female; mean age 73.9 years) and (C) 69 years or younger (33 cases; 25 male and 8 female; mean age 60.9 years). Physical signs were evaluated and recorded by a single spine surgeon (T.H.).

Results: Preoperative Japanese Orthopaedic Association score (JOA score; -2 to 17) was 8.0 in group A, 8.7 in group B, and 9.9 in group C. Post-operative JOA score and recovery rate was 10.9 and 30.8% in group A, 11.8 and 37.9% in group B, and 13.4 and 49.3% in group C. Though the recovery rate decreased significantly with increasing age, all groups improved significantly compared to preoperative. Hoffmann sign was present in 75% of group A, 65% of group B, and 69% in group C, with no significant difference among the 3 groups. In contrast, the rate of hyperreflexia of patellar tendon reflex (PTR) was 59% in group A, 85% in group B, and 91% in group C. The rate of hyperreflexia of the Achilles tendon reflex (ATR) was 32% in group A, 49% in group B, and 70% in group C. The patients without PTR or ATR hyperreflexia were significantly older. The pre-operative JOA scores of those without PTR hyperreflexia were significantly lower than those with PTR hyperreflexia. However, even those without PTR hyperreflexia improved significantly after surgery.

Conclusion: Thus the absence of hyperreflexia should not necessarily be a contra-indication to surgery in patients with suspected CM. Surgical decision making should take other physical signs and imaging findings into account, especially in elderly patients.

Presentation #6

Cost Effectiveness of Operative vs. Non-operative Treatment of Geriatric Type-II Odontoid Fracture

Daniel R. Barlow, MS, Lebanon, NH
***Brendan T. Higgins, MD, MS**, Lebanon, NH*
Elissa Ozanne, PhD, Lebanon, NH
Anna N. A. Tosteson, ScD, Lebanon, NH
Adam M. Pearson, MD, MS, Lebanon, NH

Funding Source: This study was supported in part by a grant from the National Institute of Arthritis and Musculoskeletal and Skin Diseases (P60AR062799).

Introduction: Significant controversy exists regarding the optimum treatment of geriatric patients with type-II odontoid fractures. Operative treatment leads to lower rates of non-union, but carries surgical risks. Non-operative treatment does not carry the risks of surgery, but has higher rates of non-union. The objective of this study is to examine the cost-effectiveness of operative vs. non-operative treatment of type-II odontoid fractures in patients over 64 years old.

Materials/Methods: A decision-analytic model as seen in Figure 1, was created to compare operative and non-operative treatment of type-II odontoid fractures among three different age cohorts (65–74, 75–84, over-84) based on expected costs, quality-adjusted life years (QALYs) and incremental cost-effectiveness ratios (cost per QALY gained). Age-specific mortality rates for both treatments, costs for treatment, and complication rates were taken from the literature, and data from 2010 US life tables was used for age-specific life expectancy. Costs of complications were estimated using data obtained at a Level-I trauma center using micro-costing. Sensitivity analyses of all model parameters were conducted.

Results: As seen in Table 1, among the 65–74 year old cohort, operative treatment was more costly ($53,407 vs. $30,553) and more effective (12.00 vs. 10.11 QALY), with an incremental cost-effectiveness ratio (ICER) of $12,078/QALY. Among the 75–84 year old cohort, operative treatment was more costly ($51,308 vs. $29,789) and more effective (6.85 vs. 6.31 QALY), with an ICER of $40,467/QALY. Among the over-84 cohort, operative treatment was dominated by non-operative treatment as it was both more costly ($45,978 vs. $28,872) and less effective (2.48 vs. 3.73 QALY). The model was robust to sensitivity analysis across reasonable ranges for utility of union, disutility of complications and delayed surgery, and probabilities of non-union and complications.

Conclusions: This is the first study to evaluate the cost-effectiveness of operative versus non-operative treatment of type-II odontoid fractures and is important because type-II odontoid fractures are common and devastating injuries in the elderly population.

See Disclosure Index pages 40–88.

Presentation #6 (cont.)

The recently published AO Spine prospective cohort study reported one-year mortality rates of 14% for the surgical group and 26% for the non-operative group. Our analysis suggests that the cost-effectiveness of operative treatment of type-II odontoid fractures in the elderly is highly dependent on patient age and the corresponding probability of one-year operative and non-operative mortality. Based on the results of this study, operative treatment is likely cost effective for patients aged 65-84, while for patients older than 84, operative treatment is both more costly and less effective.

Figure 1. Model showing decision choice and possible complications and outcomes following a geriatric type-II odontoid fracture.

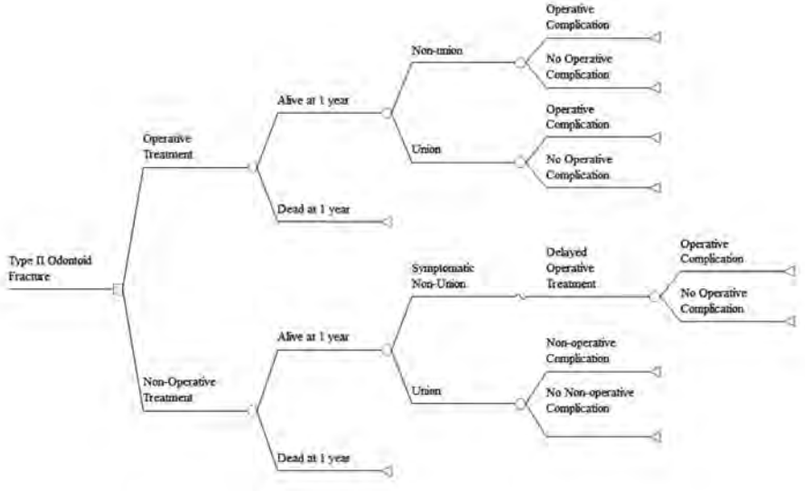


Table 1: Results of base case cost effectiveness analysis

Age Cohort	Cost (2013 USD)	Effectiveness (QALY)	ICER (cost per QALY gained)
65-74 yo			
Non-operative	$30,553	10.11	
Operative	$53,407	12.00	$12,078
75-84 yo			
Non-operative	$29,789	6.31	
Operative	$51,308	6.85	$40,467
>84 yo			
Non-operative	$28,872	3.73	
Operative	$45,978	2.48	Dominated

USD – United States Dollars, QALY – Quality Adjusted Life Years; C/E – Cost effectiveness ratio; ICER – incremental cost effectiveness ratio; yo – years old

Presentation #7

Cost Utility Analysis of Anterior Cervical Discectomy and Fusion for Degenerative Spine Disease in Elderly Population

Silky Chotai, MD, Nashville, TN
***Scott L. Parker MD**, Nashville, TN*
J. Alex Sielatycki, MD, Nashville, TN
Ahilan Sivaganesan, MD, Nashville, TN
Harrison F. Kay, BS, Nashville, TN
Joseph B. Wick, BA, Nashville, TN
Matthew J. McGirt, MD, Charlotte, NC
Clinton J. Devin, MD, Nashville, TN

Background: With growing elderly population and increasing rates of cervical spinal surgery it is vital to understand the value of cervical surgery in this population. We set forth to determine the cost-utility following anterior cervical decompression and fusion (ACDF) for degenerative disease in elderly patients.

Methods: 299 consecutive patients undergoing elective ACDF for degenerative diseases over a period of four-years were enrolled into prospective longitudinal registry. Patient-reported outcomes (NDI, NRS-neck and arm pain (NP, AP), EQ-5D, and SF-12) were recorded at baseline, 3-months, 12-months, and 24-months postoperatively. Two-year medical resource utilization, missed work, and health state values (quality-adjusted life years [QALYs]) were assessed. Two-year resource use was multiplied by unit costs based on Medicare national allowable payment amounts (direct cost). Patient and caregiver workday losses were multiplied by the self-reported gross-of-tax wage rate (indirect cost). Total cost (direct+indirect) was utilized to compute cost per QALY gained. Patients were dichotomized based on age: < 65 years (younger) and ≥ 65 years (older) to compare the cost-utility in these age groups.

Results: 263 (88%) younger patients and 36 (12%) older patients who underwent ACDF were analyzed. 155 (52%) patients underwent ACDF for myelopathy and 144 (48%) for radiculopathy (similar representation in younger and older cohorts). A significant improvement in pain (NP, AP), disability (NDI) and general health scores (EQ-5D and SF-12) was noted among all age groups 2-year after surgery ($p < 0.0001$). Mean total 24-month cost was $23503 for younger patients and $21681 for older patients, $p = 0.31$. Younger patients had higher mean cumulative 2-year gain in QALYs vs. older patients (0.47 vs. 0.28 QALYs, $p = 0.19$). Two-year cost-utility in younger vs. older patients was $50,006/QALY vs. $77,432/QALY, $p = 0.59$, Table 1).

See Disclosure Index pages 40–88.

Presentation #7 (cont.)

Conclusion: ACDF provided a significant gain in health state utility in elderly patients with degenerative cervical pathology, with a mean cumulative 2-year cost per QALY gained of $77,432/QALY, which can be considered moderately cost-effective. While elderly patients have a slightly higher cost-utility compared to their younger counterparts, surgery in the elderly cohort does provide a clinically meaningful improvement in pain, disability, and quality of life.

Table 1. Summarizing Cost, QALYs gained and cost-utility at 12m and 24m

	All patients (n=299)	Age < 65 (n=263)	Age ≥ 65 (n=36)	p-value
Total QALY gained 24m	0.45 ± 0.49	0.47 ± 0.50	0.28 ± 0.43	0.19
Total Cost 24m	23292	23503 ±11236	21681±10104	0.31
Total Direct cost 24m	18878	18737 ±7740	19705±9017	0.50
Total Indirect cost 24m	4414	4766 ±7212	1903 ±3167	0.0005*
Cost per QALY gained 24m (Direct + Indirect cost)	$51,760	$50,006	$77,432	0.59
Cost per QALY gained 24m (Direct cost)	$41,951	$39,865	$70,375	0.56

Presentation #8

Determining the Drivers of Cost for Elective Anterior Cervical Discectomy and Fusion for Cervical Degenerative Disease

***Silky Chotai, MD**, Nashville, TN*
Ahilan Sivaganesan, MD, Nashville, TN
Scott L. Parker, MD, Nashville, TN
Oran S. Aaronson, MD, Nashville, TN
Joseph S. Cheng, MD, Nashville, TN
Matthew J. McGirt, MD, Charlotte, NC
Clinton J. Devin, MD, Nashville, TN

Background: Bundle payments are being investigated as a value-based payment model for reimbursement. Variability in the cost of index surgery affects the payment bundling during the 90-day global period. We determined drivers of variability in total cost associated with elective anterior cervical discectomy and fusion (ACDF) for degenerative cervical disease.

Methods: 457 consecutive patients undergoing elective ACDF for degenerative cervical conditions were enrolled into prospective longitudinal registry. Hospital discharge and billing records were collected prospectively. Total direct cost during 90-day global period included: diagnosis-related group (DRG) code (hospital fee), CPT code (surgeon fee), pre and post-operative provider visits, emergency room visit, readmission within 90 days of discharge, diagnostic imaging, and medication cost. Cost data was adjusted based on Medicare national allowable payment amounts. Multivariable stepwise linear regression analyses were conducted to determine influence of baseline patient characteristics on total direct cost at 90-days.

Result: Median cost for ACDF was $15,837(range: $6580–$55550). Based on linear regression model, baseline 90-day direct cost of ACDF was $10,700, controlling for all variables. R2 of model was 26.8%. History of diabetes (n =105,23%; p = 0.009), length of hospital stay(mean = 1.2 days, p < 0.001), length of surgery(mean=156 minutes, p < 0.001), 23-hour observation status(n = 200,44%, p < 0.001), and readmission (n = 15, 3.3%; p < .001) were statistically significant drivers of direct cost.
Model constructed regression equation revealed: Total direct cost for ACDF =$10,700 +$30(Length of surgery per minute) +$1,172 (Length of hospital stay per day) +$2,261(history diabetes) +$3,071(readmission) -$2,696 (23-hour observation status).

Conclusion: There was considerable variation in total cost for ACDFs. Baseline direct cost for primary single-level ACDF in patients with no comorbidities was $10,700 based on Medicare allowable reimbursement. Payment bundling during 90-day global period following elective ACDF for degenerative cervical disease should account for a history of

See Disclosure Index pages 40–88.

Presentation #9

Where do True Cost Savings Exist following Elective Surgery for Degenerative Spine Disease?

Silky Chotai, MD, Nashville, TN
***Scott L. Parker, MD**, Nashville, TN*
Ahilan Sivaganesan, MD, Nashville, TN
David P. Stonko, BS, MS, Nashville, TN
Matthew J. McGirt, MD, Charlotte, NC
Clinton J. Devin, MD, Nashville, TN

Background: Value-base purchasing and pay-for-performance model are driving the development of the bundle payment systems for reimbursement. In an effort to have a sustainable bundling system, it is important to identify the contributions of each component of the total cost of index surgery and to determine the domain where the targeted savings should occur. We determine the percent contribution of health-care resource utilization, hospital fee, surgeons' fee and readmission to the total cost of index surgery following elective spine surgery.

Methods: A total of 1694 consecutive patients undergoing elective spine surgery for degenerative cervical and lumbar pathologies, that were enrolled in a prospective longitudinal registry were included in the study. The hospital discharge and billing records for the patients undergoing elective spine surgery were collected in a prospective longitudinal registry. Total direct cost during the 90-day global period included cost derived from diagnosis-related group (DRG) code (hospital fee), CPT code (surgeon fee), diagnostic imaging and medication cost, cost of visits to the providers (operative or non-operative visit, chiropractor, physical therapy, occupational therapy visits, and emergency room visit), and readmission within 90-days of discharge. All the cost data were adjusted based on the Medicare national allowable payment amounts. The percent contribution of each of this attribute to the total direct cost was analyzed.

Results: The median total direct 90-day cost for index anterior cervical discectomy and fusion (ACDF, n = 457), lumbar microdiscectomy (n = 232), laminectomy (n = 389) and laminectomy and fusion (n = 616) was $15837, $6075, $8810 and $26408 respectively. The mean (± SD) percent contribution of hospital fee to the total cost was 75% ± 10% (range 71%-82%), surgeons' fee was 15% ± 5% (range, 12% to 18%), and health care resource utilization including (diagnostic and imaging, medication and health-care visits costs) was 8.5% ± 7% (range, 5% to 11%). The rate of readmission was 6.2% (105); which accounted for 21% ± 15% (range, 16%-23%) of the total direct cost during 90-days after surgery.

Presentation #9

Conclusion: The hospital fee had the largest contribution to the total cost of index surgery, followed by readmissions. Surgeons' fee and health-care resource utilization had a much smaller contribution to the total cost. True cost savings can occur through engagement and partnering between the hospital and surgeon, decreasing costs and maintaining quality. Reducing the readmission episodes within 90-days after surgery, understanding and determining the modifiable drivers of hospital fee and total cost have the potential to decrease the total direct cost of the index elective spine surgery.

See Disclosure Index pages 40–88.

Presentation #10

Impact of Obesity on Cost per Quality Adjusted Life Years Gained following Anterior Cervical Discectomy and Fusion in Elective Degenerative Pathology

***Silky Chotai, MD**, Nashville, TN*
J. Alex Sielatycki, MD, Nashville, TN
Ahilan Sivaganesan, MD, Nashville, TN
Scott L. Parker, MD, Nashville, TN
Harrison F. Kay, BS, Nashville, TN
Kevin R. O'Neill, MD, Nashville, TN
Matthew J. McGirt, MD, Charlotte, NC
Clinton J. Devin, MD, Nashville, TN

Background: Obese patients are at increased risk of co-morbidities and complications after spine surgery, which might result in increased cost and lower quality of life compared to their non-obese counterparts. The aim of present study was to determine the cost-utility following anterior cervical discectomy and fusion (ACDF) in obese patients.

Methods: A total of 299 consecutive patients undergoing elective ACDF for degenerative cervical pathology over a period of four-years were included in the study. One and two-year medical resource utilization, missed work, and health state values (QALYs), calculated from the EQ-5D with US valuation using time weighted area under the curve approach) were assessed. Two-year resource use was multiplied by unit costs based on Medicare national allowable payment amounts (direct cost). Patient and caregiver workday losses were multiplied by the self-reported gross-of-tax wage rate (indirect cost). Total cost (direct + indirect) was used to compute cost per QALY gained. Patients were defined as obese for body mass index (BMI) ≥ 35 based on the WHO definition of class-II obesity. A subgroup analysis was conducted in morbidly obese patients (BMI ≥ 40).

Results: A significant improvement in pain (NP/AP), disability (NDI) and quality of life (EQ-5D and SF-12) was noted 2-year after surgery ($p < 0.0001$). Mean total 2-year cost was $24,524 for obese patients and $22,492 for non-obese patients ($P = 0.06$). Obese patients had lower mean cumulative 2-year gain in QALYs vs. non-obese patients (0.39 vs. 0.47 QALYs, $P = 0.19$, Figure 1). Two-year cost-utility in patients obese vs. non-obese patients was $65,805/QALY vs. $47,634/QALY. Morbidly obese patients had significantly lower (0.15) QALYs gained and significantly higher cost $168,915/QALY gained at 2-years ($P < 0.0001$) (Table 1).

Thursday, December 3, 2015, 8:28–8:34 am CSRS–2015

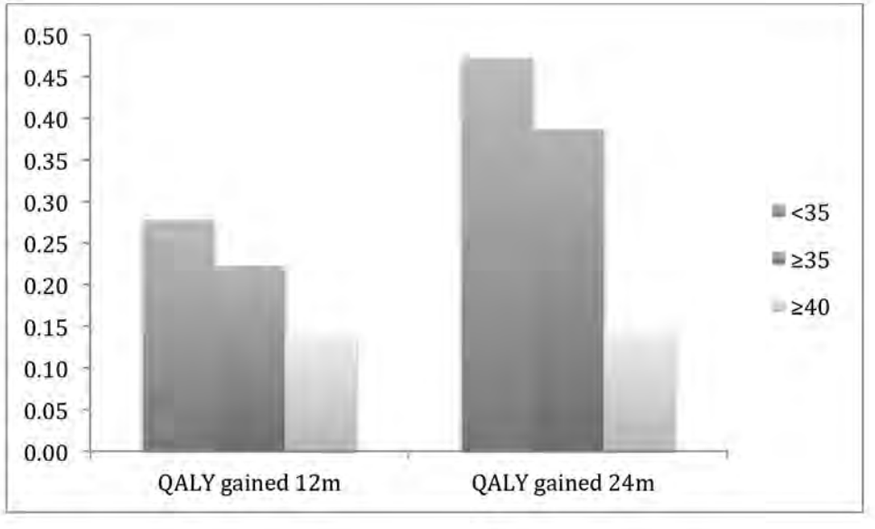
Presentation #10

Conclusion: ACDF provided a significant gain in health-state utility in obese patients, with a mean 2-year cost-utility of $65,805/QALY gained, which can be considered moderately cost-effective. Morbidly obese patients had lower cost-effectiveness; however, surgery does provide a significant improvement in outcomes. Obesity needs to be taken into consideration as physician and hospital reimbursements move toward a bundled model.

Table 1. QALYs gained and cost per QALY at 24months after ACDF

	<35 (219)	≥35 (80)	P-value	≥40 (30)	P-value
QALY gained 24m	0.47	0.39	0.19	0.15	0.036
Direct cost 24m	18232.94	20598.90	0.03	21323.96	0.03
Total cost 24m	22492.63	25428.18	0.06	24687.37	0.05
Cost utility 24 m total	$47,634	$65,805	0.13	$168,915	<0.0001

Figure 1. QALYs gained in obese and non-obese patients 2-years after ACDF surgery for degenerative cervical diseases



Presentation #11

Cost Utility Analysis of the Cervical Artificial Disc vs. Fusion for the Treatment of Two-Level Symptomatic Degenerative Disc Disease: Five-Year Follow-up

***Jared D. Ament, MD, MPH**, Sacramento, CA*
Zhuo Yang, MSc, Tucker, GA
Pierce D. Nunley, MD, Shreveport, LA
Marcus Stone, PhD, Indianapolis, IN
Kee D. Kim, MD, Sacramento, CA

Introduction: The cervical total disc replacement (cTDR) was developed to treat cervical degenerative disc disease (DDD), while preserving motion. While anterior cervical discectomy and fusion (ACDF) has been the standard of care for two-level symptomatic disease, a recent randomized controlled trial (RCT) suggested similar outcomes. Cost-effectiveness of this intervention was established looking at two-year follow-up data. This update reevaluates our prior conclusion by analyzing the same cohort over five years.

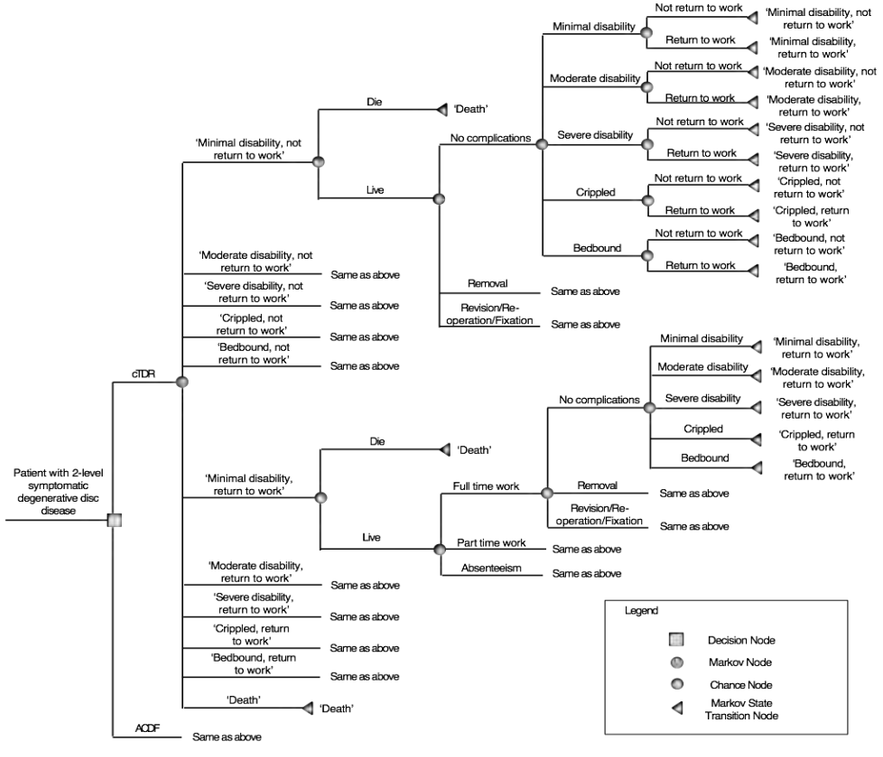
Methods: Data was derived from a recent RCT that followed 330 patients over 5-years. Using linear regression, health states were constructed by stratifying neck disability index (NDI) and visual analog scale (VAS). Data from SF-12 were transformed into utilities using the SF-6D mapping algorithm. Costs were calculated by extracting DRG codes from institutional billing data and then applying 2014 Medicare reimbursement rates. Costs of complications, return-to-work data (RTW), persistence of working status and unscheduled office visits were also included. A Markov model (Figure 1) was built to evaluate quality adjusted life years (QALYs) for both treatment groups. A comprehensive univariate and multivariate sensitivity analysis was conducted to test the stability of the model. The model adopted both societal and health system perspectives and applied a 3% annual discount rate.

Results: cTDR was found to have a higher initial surgical cost ($20,488) than ACDF ($16,945) but lower costs associated with adverse events. Taken together, cTDR costs $1,687 more than ACDF over 5 year. In contrast, cTDR had substantially less productivity loss compared to ACDF, $57,447 versus $91,824, respectively. This was likely secondary to significant differences in RTW rates between the two surgical cohorts, 81.6% compared to 65.4% for cTDR and ACDF, respectively (p-value = 0.0295).
The model projected that a patient undergoing cTDR enjoyed 35.5 out of 60 months in the 'mild disability' health state, 10.4 months greater than the ACDF cohort. The ACDF group spent longer in all worse health states. Consequently, cTDR patients had 3.574 QALYs compared to the ACDF patient with 3.376 QALYs at 5 years.
Therefore, at 5 years, from a societal perspective, the ICER for cTDR was -$165,103 per QALY. From a health system perspective the ICER for cTDR was $8,518 per QALY. In the sensitivity analysis, the ICER for cTDR remained below the U.S. willingness-to-pay threshold of $50,000 per QALY in all scenarios (-$225,816 per QALY to $22,071 per QALY). When assessing thresholds, ACDF only became cost-effective when cTDR cost 44-250% more than the current DRG reimbursement rate (Table 1).

Presentation #11

Conclusions: This study is the first to report the comparative cost-effectiveness of cTDR versus ACDF for 2-level DDD at 5 years. It is also the first surgical analysis to include 'work persistence' for measuring societal impact. The authors conclude that because of the negative ICER, for patients with 2-level DDD, cTDR is the dominant modality. In a rapidly changing medical climate surgeons and payers will naturally gravitate towards these analyses. And, as healthcare becomes more informed in an established setting of scarce resources, sustainable surgical technologies that improve quality of life while saving costs require serious attention.

Figure 1. Markov Model Schematic



Presentation #11 (cont.)

Table 1. Threshold Analysis

Parameter	Base case value	cTDR cost-ineffective *, societal perspective	cTDR cost-ineffective*, health system perspective
cTDR DRG (518)	$17,965	>$62,637	>$26,217
ACDF DRG (473)	$13,025	Nonexistent†	<$5,079
QALY for mild disability	0.849	Nonexistent†	<0.635
QALY for moderate disability	0.689	Nonexistent†	Nonexistent†
cTDR adverse events	0.5% (0-6mo), 0.5% (6-12mo), 0.6% (1-2yr), 0.6% (>2yr)	>14.2% per 6-months	>4.6% per 6-months
ACDF adverse events	0.0% (0-6mo), 5.7% (6-12mo), 5.2% (1-2yr), 0.1%(>2yr)	Nonexistent†	Nonexistent†

* cTDR is no longer considered as cost-effective when the ICER for cTDR > $50,000 per QALY.
** Complication rates are time-specific. For the purpose of threshold analysis, we varied all complication rates at the same time.
† Nonexistent = the value beyond which cTDR is no longer effective does not exist within any possible range. For probability parameters, the possible range is 0% to 100%; for cost parameters, the possible range is $0 to positive infinite; for multiplier, the possible range is 0 to positive infinite.

Presentation #12

Seven-Year Cost-Effectiveness of Cervical Disc Replacement vs. Anterior Cervical Discectomy and Fusion – Results from Investigational Device Exemption and Post-Approval Studies of ProDisc®-C Total Disc Replacement

Kristen E. Radcliff, MD, Egg Harbor Township, NJ
Jason H. Lerner, PT, MBA, MSc, Raynham, MA
Thierry Bernard, MS, Raynham, MA
Chao Yang, MD, Raynham, MA
***Jack E. Zigler, MD**, Plano, TX*

Introduction: Cervical total disc replacement (CTDR) is an increasingly accepted option for the treatment of cervical radiculopathy. Previous evaluations using large administrative datasets have demonstrated CTDR to be cost-effective relative to anterior cervical discectomy and fusion (ACDF). However, to our knowledge, there have been no long-term, patient-level evaluations of the incremental cost-effectiveness of CTDR vs. ACDF. The purpose of this study was to calculate the seven-year cost-effectiveness of CTDR vs. ACDF from a commercial payer perspective. The results of this study are intended to support value-based treatment decision making.

Materials/Methods: This study takes a United States commercial payer perspective to evaluate the cost-utility and net monetary benefit (NMB) of CTDR vs. ACDF over a seven-year time horizon. Prospectively collected healthcare resource utilization and treatment effects (quality adjusted life years (QALYs)) were estimated from individual patient-level adverse event reports and Short-Form 36 (SF-36) data, respectively, from the randomized, multicenter ProDisc C Investigational Device Exemption (IDE) study and post-approval study (NCT00291018). Statistical distributions for all unit costs were obtained from commercial claims data and applied using Monte Carlo simulation. Patient-level costs and effects were modeled via multivariate probabilistic analysis. Confidence intervals for seven-year costs, effects, and NMB were obtained using the nonparametric percentile method from the results of 10,000 bootstrap simulations. The robustness of base-case results was assessed through scenario analysis and within a parametric regression model controlling for baseline demographic and clinical variables.

See Disclosure Index pages 40–88.

Presentation #12 (cont.)

Results: Overall, 209 patients were randomized and treated: 103 to CTDR and 106 to ACDF. In the base-case analysis, CTDR was a dominant treatment option resulting in mean (95% CI) per-patient cost savings of $12,789 ($5,362-$20,856) and per-patient QALY gains of 0.16 (-0.073-0.39) relative to ACDF over seven years (Table 1). CTDR was the dominant treatment option (more effective and less costly) in 90.8% of simulations run in probabilistic sensitivity analyses (Figure 1). CTDR was a cost-effective option in 99.8% of sensitivity analysis simulations and generated mean (95% CI) incremental NMB of $20,679 ($6,053-$35,377) per patient at a willingness-to-pay threshold of $50,000/QALY (Figure 1). Results were robust across a range of scenarios and perspectives (Table 1).

Conclusions: CTDR was found to be more effective and less costly than ACDF over a seven-year time horizon for patients with single-level symptomatic degenerative disc disease. These findings are relevant for treatment decision-making in a climate of greater accountability for costs and population health.

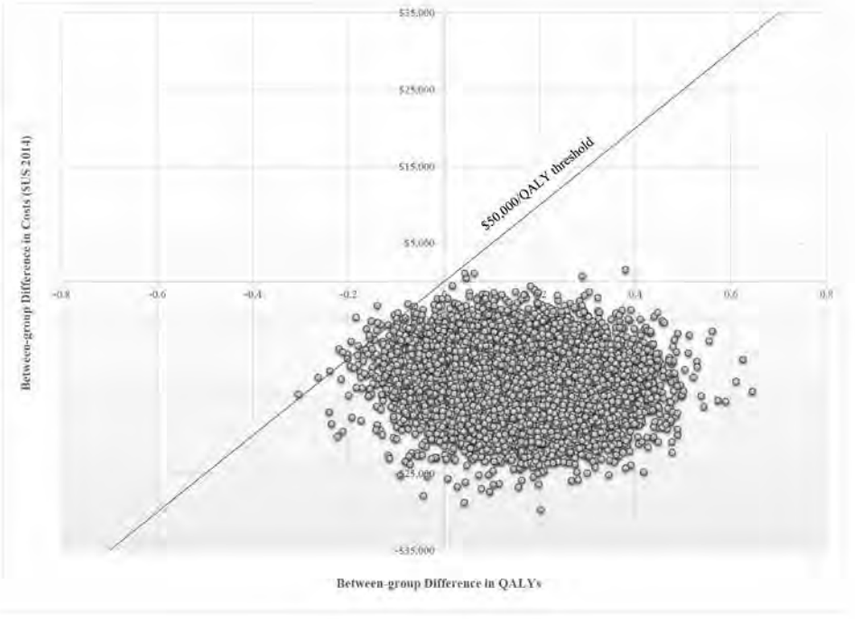
Table 1. Scenario Analysis – Cumulative costs, QALYs, and Incremental Net Monetary Benefit over 7 years

	ACDF	CTDR	Difference
Base Case, mean (95% CI)			
Seven-year Costs	$42,486 ($36,100-$49,790)	$29,697 ($26,137-$33,721)	$12,789
Seven-year QALYs	4.36 (4.19-4.53)	4.52 (4.36-4.68)	-.16
Incremental Net Monetary Benefit at $50,000/QALY		$20,679 ($6,053-$35,377)	
Medicare Surgical Costs, mean (95% CI)			
Seven-year Costs	$21,772 ($19,407-$24,574)	$14,317 ($13,426-$15,407)	$7,455
Seven-year QALYs	4.36 (4.19-4.53)	4.52 (4.37-4.67)	-.16
Incremental Net Monetary Benefit at $50,000/QALY		$15,406 ($3,204-$27,804)	
Equal Risk of Secondary Surgery for Patients Lost to Follow-up, mean (95% CI)			
Seven-year Costs	$41,864 ($35,612-$49,154)	$30,085 ($26,371-$34,239)	$11,779
Seven-year QALYs	4.36 (4.19-4.53)	4.52 (4.36-4.68)	-.16
Incremental Net Monetary Benefit at $50,000/QALY		$19,740 ($5,049-$34,439)	
Inclusion of Productivity Costs, mean (95% CI)			
Seven-year Costs	$45,596 ($38,161-$54,137)	$30,471 ($26,589-$34,865)	$15,125
Seven-year QALYs	4.36 (4.19-4.53)	4.52 (4.36-4.68)	-.16
Incremental Net Monetary Benefit at $50,000/QALY		$23,015 ($7,691-$38,494)	
Net Monetary Benefit Regression, mean (95% CI)			
Incremental Net Monetary Benefit at $50,000/QALY*		$19,157 ($2,225-$36,089)	

* NMB regression model controlled for sex, race, baseline SF-6D index, and age for 73 PDC patients and 68 ACDF patients with complete SF-6D data at baseline, 24-months, and 84 months

Presentation #12

Figure 1. Cost-effectiveness Plane (10,000 Bootstrap Samples) – Mean Difference in Cost-QALY pairs (CTDR minus ACDF)



Presentation #13

Comparison of One- and Two-Level Treatment with Cervical Disc Arthroplasty or Anterior Cervical Discectomy and Fusion through Five-Year Follow-up

Scott L. Blumenthal, MD, Plano, TX
***Michael S. Hisey, MD**, Flower Mound, TX*
Hyun W. Bae, MD, Los Angeles, CA
Jack E. Zigler, MD, Plano, TX

Introduction: Anterior cervical discectomy and fusion (ACDF) has been a widely accepted procedure for years. There has been variation in reported results for two-level ACF. Cervical disc arthroplasty (CDA) has been gaining acceptance for single-level treatment and more data is becoming available for two-level. The purpose of this analysis was to compare the safety and effectiveness of one and two level treatment with CDA or anterior cervical discectomy and fusion (ACDF).

Materials/Methods: A prospective, randomized, controlled trial in the U.S. compared CDA using Mobi-C© Cervical Disc Prosthesis and the ACDF control with allograft and anterior plate at one or two contiguous levels. The one-level arm consisted of 164 CDA and 81 ACDF patients. The two-level arm consisted of 225 CDA and 105 ACDF patients. Outcome assessments including the Neck Disability Index (NDI), visual analog scale (VAS) assessing neck and arm pain, range of motion (ROM), patient satisfaction, SF-12 mental and physical composite scores (MCS/PCS), and subsequent surgery rates were recorded through 60 month follow-up.

Results: Combined five-year follow-up rate was 88.5% for CDA and 83.1% for ACDF. No significant differences were found between one and two-level treatment in VAS neck and arm pain, SF-12 MCS, subsequent surgery rates, or patient satisfaction for TDR and ACDF, respectively. Two-level ACDF patients demonstrated less improvement in NDI (Figure 1) and SF-12 PCS (1-level: 14.0, 2-level: 8.8, $p = 0.0141$) scores compared to one-level ACDF. Additionally, the NDI success rate was significantly lower for two-level ACDF (1-level: 80.7%, 2-level: 56.6%, $p = 0.0049$). However, no significant differences were found between one and two-level CDA in NDI success, mean improvement in NDI or SF-12 PCS scores. When considering index level re-operations through five-year follow-up, the highest rate was in the 2-level ACDF group (16.2%), followed by 11.1% in the 1-level ACDF group compared with 3.0% and 4.0% in the 1- and 2-level CDA groups.

Discussion: At five-years, one- and two-level CDA patients showed no significant differences in clinical outcomes. In contrast, two-level ACDF patients demonstrated less NDI improvement, less SF-12 PCS improvement and lower NDI success than their one-level ACDF counterparts. These results suggest that CDA has potential benefits over ACDF, particularly for 2-level procedures.

Presentation #13

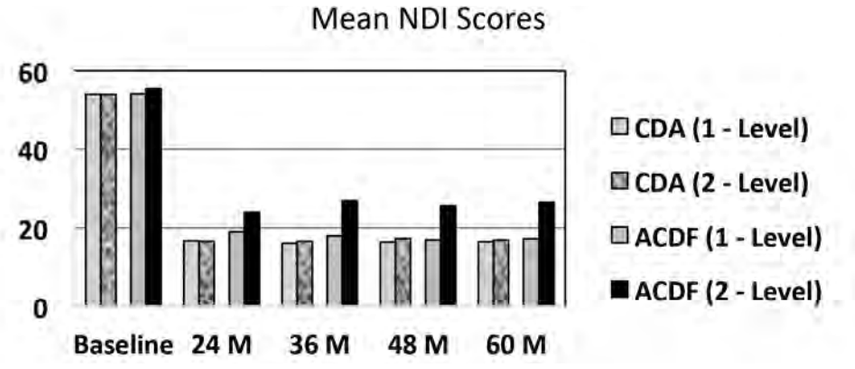


Figure 1. Mean NDI scores were similar for 1 and 2-level CDA. Scores were significantly less for 2-level ACDF ($p<0.01$) than for 1-level procedures.

See Disclosure Index pages 40–88.

Presentation #14

The Positive Effect of Continued Motion of a Cervical Artificial Disc Replacement on Radiographic Adjacent Level Degeneration at Seven-Year Follow-up

***Jeffrey M. Spivak, MD**, New York, NY*
Jack E. Zigler, MD, Plano, TX
Michael E. Janssen, DO, Denver, CO
Bruce V. Darden, II, MD, Charlotte, NC
Kristen E. Radcliff, MD, Philadelphia, PA

Introduction: Development of symptomatic adjacent level degeneration (ALD) following anterior cervical discectomy and fusion (ACDF) remains a clinical concern. Cervical artificial disc replacement (C-ADR) maintains motion at the surgical level, and has been demonstrated to lower the incidence of developing radiographic ALD (R-ALD) than following ACDF. The purpose of this study is to compare the rates of progressive R-ALD 7 years post-surgery in patients treated with ProDisc-C, C-ADR or ACDF for one-level symptomatic cervical disc disease, and to examine the effect of final flexion-extension range of motion (ROM) of the C-ADR with the progression of R-ALD.

Methods: A prospective randomized FDA approved IDE study was conducted at 13 sites to assess the safety and effectiveness of single-level C-ADR compared to ACDF. The study included annual patient follow-up through 7 years. 209 patients were randomized and treated (106 ACDF; 103 C-ADR). All study radiographs were assessed by independent radiologists utilizing a qualitative assessment of disc degeneration at the levels adjacent to the index surgery based on the Kellgren-Lawrence system (0-4 scale). Range of motion at the index and adjacent levels were measured. Radiographic results are presented for patients at final 7 year follow-up using the last observation carried forward with a minimum 5 year follow-up. Progression in R-ALD, and ROM at the C-ADR, at the latest follow-up was assessed.

Presentation #14

Results: Final follow-up data was available for 160 patients (87 C-ADR, 73 ACDF) Basic demographics were similar between the two patient groups. The rate of progressive R-ALD at either adjacent level was statistically significantly lower in the C-ADR cohort compared to ACDF patients (rates: 53% vs. 77% respectively (p=0.0028). The rate of R-ALD was significantly lower only in the superior adjacent level for the C-ADR vs. ACDF patients (36% vs. 59%, p = 0.0061), although R-ALD trended lower in C-ADR patients for the inferior adjacent level (C-ADR 34% vs. ACDF 43% (p=0.24)). The index level ROM of the C-ADR at final follow up was found to significantly correlate (inversely) with the degree of progressive R-ALD (p = 0.0113). Discs moving 0-3 degrees had a 68% rate of progressive R-ALD, while the rate was only 53% in discs moving 4–6 degrees, and only 43% in discs moving 7 or more degrees (p = 0.0704). Severe progression of R-ALD (grade 0-1 initially, 3-4 at follow-up) in C-ADR patients was found in 47% of patients with discs moving 0-3 degrees, in no patients with discs moving 4-6 degrees, and in 9.5% of patients with discs moving 7+ degrees (p = 0.0013).

Conclusions: Long-term results demonstrated that the rate of progressive radiographic adjacent level disc degeneration was significantly lower in C-ADR patients as compared to ACDF patients. The rate of radiographic ALD in the C-ADR patients was found to correlate inversely with the final ROM of the C-ADR.

FDA Device Status: ProDisc-C approved.

See Disclosure Index pages 40–88.

Presentation #15

Cervical Total Disc Replacement and Anterior Cervical Discectomy and Fusion have Similar Short-Term Complication Rates

Bryce A. Basques, MD, Chicago, IL
Nathaniel T. Ondeck, BS, New Haven, CT
Adam M. Lukasiewicz, MSc, New Haven, CT
Matthew L. Webb, AB, New Haven, CT
Andre M. Samuel, BBA, New Haven, CT
Daniel D. Bohl, MD, MPH, Chicago, IL
Junyoung Ahn, BS, Chicago, IL
Jason O. Toy, MD, New Haven, CT
Kern Singh, MD, Chicago, IL
***Jonathan N. Grauer, MD**, New Haven, CT*

Introduction: Anterior cervical discectomy and fusion (ACDF) is currently the standard of care for treating many cervical spine pathologies, and has had high clinical success. Cervical total disc replacement (CTDR) is a newer technology that is considered for similar indications as ACDF, with the potential benefit of maintaining motion while allowing decompression. While several studies have compared outcomes between these two interventions, this research has generally been limited by sample sizes. There is a need to compare short-term outcomes between these two procedures using a national cohort of patients in order to evaluate the safety of CTDR. The purpose of this study was therefore to compare 30-day postoperative outcomes between CTDR and ACDF using a national surgical registry.

Materials/Methods: This study was a retrospective review of the prospectively-collected American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database. The ACS-NSQIP was used to identify patients that underwent CTDR or ACDF from 2010 to 2013. A total of 7,685 patients were identified. Demographics and comorbidities were compared between the two procedure groups using logistic regression. The occurrence of aggregated postoperative complications (any adverse event, severe adverse events, and minor adverse events) and readmission within 30 days was compared between CTDR and ACDF using propensity-adjusted multivariate logistic regression. Operative time and postoperative length of stay were compared between procedures using propensity-adjusted multivariate linear regression. Propensity-adjusted multivariate analysis was used to control for differences in baseline patient characteristics between the two treatment groups.

Presentation #15

Results: Of the 7,685 patients included in this study, 7,231 (94.1%) underwent ACDF and 454 (5.9%) underwent CTDR (Table 1). CTDR patients were younger ($p < 0.001$), had decreased body mass index ($p < 0.001$), decreased American Society of Anesthesiologists class ($p < 0.001$), and decreased rates of diabetes ($p < 0.001$), COPD ($p < 0.001$), and hypertension ($p < 0.001$). Propensity-adjustment successfully controlled for differences in preoperative patient characteristics ($p > 0.05$ for all). Table 2 reports the rates of adverse events. Propensity-adjusted multivariate analysis revealed no differences in the rates of any adverse event (2.46% vs. 1.76%, $p = 0.999$), severe adverse events (1.84% vs. 1.54%, $p = 0.601$), minor adverse events (0.68% vs. 0.22%, $p = 0.475$), surgical site infection (0.44% vs. 0.44%, $p = 0.968$), postoperative length of stay (1.4 vs. 1.1 days, $p = 0.150$), or readmission (2.31% vs. 1.23%, $p=0.593$) between ACDF and CTDR, respectively. On average, operative time was found to be 10 minutes longer for CTDR compared to ACDF ($p < 0.001$).

Conclusion: Using 7,685 patients from a prospectively-collected national surgical registry, this study suggests that CTDR does not carry significantly increased risk of complications, readmission, or increased length of stay compared to ACDF. We did find that on average, operative time was ten minutes longer for CTDR compared to ACDF. This information suggests that patients may expect a similar perioperative course for both CTDR and ACDF and makes the decision between these procedures dependent on longer-term disease-specific outcomes.

Table 1. Comparison of patient and operative characteristics between anterior cervical discectomy and fusion (ACDF) and cervical total disc replacement (CTDR)

	All Patients	ACDF	CTDR	Unadjusted *p*	Propensity-adjusted *p*
Overall	7,685 (100%)	7,231 (94.1%)	454 (5.9%)		
Age				<0.001	0.185
18-39	12.7%	11.9%	25.3%		
40-49	29.8%	29.3%	37.0%		
50-59	32.3%	32.5%	29.3%		
≥60	25.2%	26.3%	8.4%		
Male sex	48.5%	48.3%	48.9%	0.846	0.884
Body mass index				<0.001	0.982
<25	21.8%	21.3%	28.2%		
25-30	34.5%	34.1%	39.7%		
30-35	25.0%	25.3%	20.4%		
≥35	18.8%	20.4%	11.8%		
ASA 3-4	34.4%	35.4%	19.6%	<0.001	0.322
Diabetes	13.0%	13.5%	5.3%	<0.001	0.195
Smoking	30.1%	30.3%	26.4%	0.082	0.538
COPD	3.5%	3.6%	0.9%	0.002	0.257
Hypertension	40.3%	41.4%	23.6%	<0.001	0.331

See Disclosure Index pages 40–88.

Presentation #15 (cont.)

Table 2. Rates of adverse outcomes after ACDF and CTDR

	ACDF	CTDR
	%	%
Any adverse event	2.46%	1.76%
Any severe adverse event	1.84%	1.54%
Death	0.10%	0.22%
Coma > 24 hours	0.00%	0.00%
Ventilator > 48 hours	0.22%	0.00%
Unplanned intubation	0.36%	0.22%
Stroke/cerebrovascular accident	0.03%	0.00%
Thromboembolic event (DVT/PE)	0.19%	0.00%
Surgical site infection	0.44%	0.44%
Sepsis	0.17%	0.00%
Cardiac arrest requiring CPR	0.08%	0.00%
Myocardial Infarction	0.12%	0.00%
Acute renal failure	0.00%	0.00%
Return to the operating room	0.97%	0.66%
Graft/implant failure	0.00%	0.00%
Wound dehiscence	0.04%	0.00%
Any minor adverse event	0.68%	0.22%
Urinary tract infection	0.32%	0.22%
Pneumonia	0.25%	0.00%
Blood transfusion	0.19%	0.00%
Peripheral nerve injury	0.01%	0.00%
Readmission	2.31%	1.23%

Presentation #16

Total Disc Replacement using Tissue-Engineered Intervertebral Discs: In Vivo Outcome in a Canine Model

Yu Moriguchi, MD, PhD, *New York, NY*
Jorge Mojica-Santiago, BS, Ithaca, NY
Peter Grunert, MD, New York, NY
Rodrigo Navarro-Ramirez, MD MSc, New York, NY
Thamina Khair, BA, New York, NY
Connor Berlin, BS, New York, NY
Lawrence J. Bonassar, PhD, Ithaca, NY
Roger Härtl, MD, New York, NY

Introduction: Despite the efficacy of the most commonly performed treatments for degenerative disc disease, anterior cervical decompression and fusion and prosthetic total disc replacement devices (TDR), they still pose risks of pseudoarthrosis, implant dislodgement, and adjacent segment disease. Tissue engineered intervertebral disc (TE-IVD), an alternative treatment option, has been previously developed by our group as a biological TDR device and tested in a rat tail model. In order to bring closer to clinical application, we developed a TDR model using our TE-IVD in the canine cervical spine. In the presented study, we evaluate implant stability at different levels and its ability to maintain disc height, size and hydration, and tissue viability.

Materials/Methods: Canine-sized TE-IVDs were constructed as previously described [Bowles 2011]. Cervical IVDs from skeletally mature beagles were separated into AF and NP tissues by macroscopic appearance; component cells were isolated and cultured in vitro. The cultured NP cells were seeded with alginate, injected into a predesigned mold, and encircled with two layers of an AF cell-laden collagen gel. The combined construct was kept in media for 2 weeks as surrounding annulus fibrous aligned and contracted until required diameter of TE-IVD was reached. 13 skeletally mature beagles underwent discectomy with whole IVD resection at different levels and were divided into two groups: solely discectomized control and TE-IVD implanted group. Adjacent proximal segments served as internal healthy control. Dogs were imaged post-operatively at 4, 8, and 16 weeks. Quantitative analysis using T2 intensity measured NP size and hydration of implanted TE-IVD, while X-rays measured disc height indices of treated segments. Qualitative histological analysis evaluated implant engraftment and ingrowth over time plus secondary degeneration post discectomy.

See Disclosure Index pages 40–88.

Presentation #16 (cont.)

Results: Discectomy and TE-IVD implantation were performed anteriorly under segmental distraction sans major complications. Upon distraction release, 30% in volume of 5 TE-IVDs were anteriorly displaced from the surgical site (unstable group), whereas the remaining 6 implants had no displacement (stable group). There was a correlation between surgical level and implant stability, with implants at C3/4 having greatest stability. The stable group outperformed unstable group in the following postoperative assessment (Figure 1, 2). Quantitative analysis showed stable group had significant retention of disc height at 4 weeks compared to discectomy group. There was a trend of higher NP size in the stable group compared to that of discectomy group. Conversely, unstable group showed a downward trend over time. 4-week histology reveals chondrocytic cells surrounded by proteoglycan-rich matrices in NP portion and by fibrocartilaginous matrices in AF. These NP-like and AF-like tissues were sustained at 16 weeks. Integration of TE-IVDs to the host tissues was observed both at 4 and 16 weeks.

Conclusions: Biological total disc replacement demonstrated level-dependent implant stability in a canine model. Despite significant biomechanical demands of the beagle cervical milieu, securely implanted TE-IVDs, remained in the disc segment and yielded disc-like tissues over 16 weeks. Discs displayed dynamic adaptation to the host environment, with extracellular matrix production and cell proliferation. Further long-term experiments will elucidate the clinical applicability and efficacy of the presented innovation.

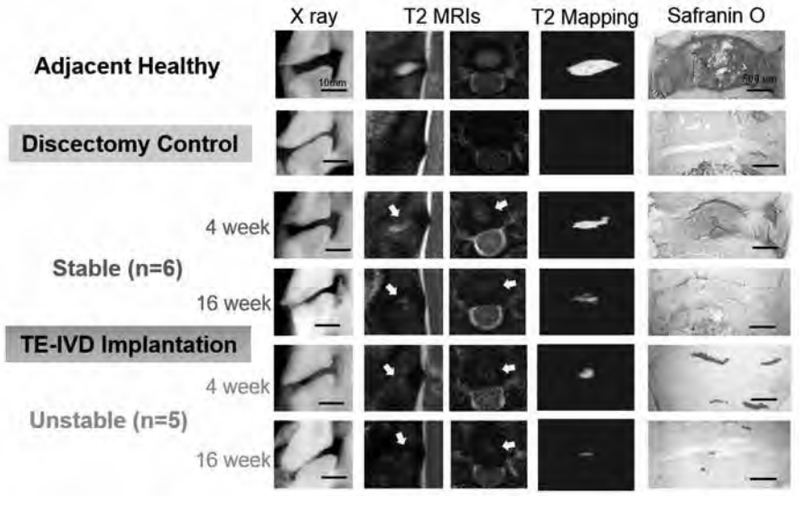


Figure 1. Postoperative outcome examples at 4 and 16 weeks. Adjacent segment served as healthy control. Discectomy group demonstrated collapsed, black disc. In the TE-IVD implanted group, location of the implant was confirmed by sagittal and axial MRIs (yellow arrows). Stable group outperformed unstable one, maintaining disc height on X-rays as well as signal intensity on T2 MRI mapping, which was corroborated by abundant proteoglycan rich matrices on histology.

Presentation #16

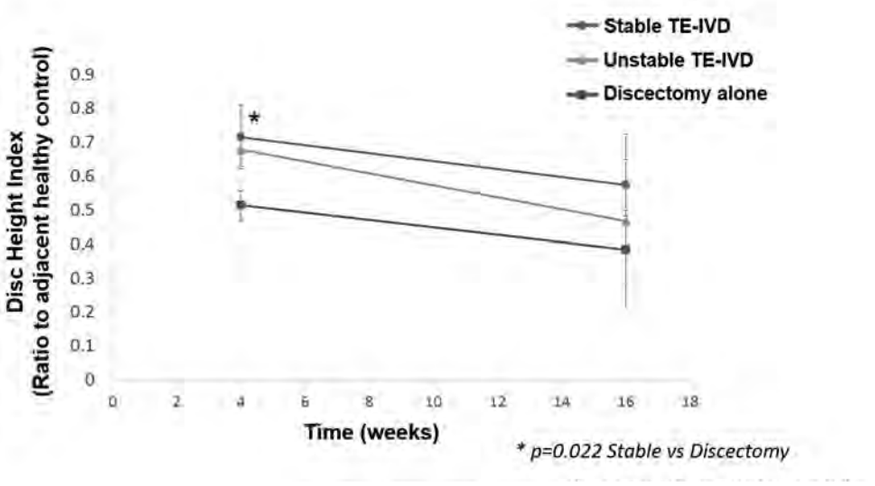


Figure 2. Quantitative assessment demonstrated the stable TE-IVD group had significant retention of disc height at 4 weeks compared to discectomy group.

See Disclosure Index pages 40 – 88.

Presentation #17

Cervical Intervertebral Disc and Paraspinal Muscle Deconditioning following Long-Duration Spaceflight and 30-Day Recovery

***Jacquelyn A. Holt**, San Diego, CA*
Robert M. Healey, BS, MBA, San Diego, CA
Brandon R. Macias, PhD, San Diego, CA
Alan R. Hargens, PhD, San Diego, CA
Jeffrey C. Lotz, PhD, San Francisco, CA
Douglas G. Chang, MD, PhD, San Diego, CA

Introduction: Exposure to microgravity during long-duration spaceflights lengthens the spine. Additionally, there is a 4-fold greater incidence of herniated nucleus pulposus particularly in the cervical region, compared with age-matched ground military flight controls. Concurrent muscle atrophy or deconditioning may also contribute to increased HNP risk. There is a paucity of spaceflight induced cervical spine deconditioning data. We hypothesize cervical intervertebral disk (IVD) heights will increase following a 6-month International Space Station (ISS) mission and decrease after 30 days return to Earth. In addition, we hypothesize that spaceflight will result in paraspinal muscle atrophy but recover 30 days after flight.

Methods/Materials: Cervical spine MRI images were obtained pre-flight, immediate post-flight and 30-to-63 days post-flight on five ISS astronauts (5 male). IVD heights were measured at each level, from upper C2-C3 to lower C7-T1 disc levels, at the anterior, middle and posterior sections of the IVD. The mean cervical height at each level was the mean of the anterior, middle, and posterior heights of the IVD. Mean cervical height was calculated from the mean IVD heights of all measured levels. Fraction cross sectional area (FCSA) was measured using a threshold to isolate lean muscle tissue from the total cross sectional area of the muscle. FCSA of cervical paraspinal muscles at the C5-C6 level were measured. The fractional portion of lean muscle area was measured from a standardized region of interest within the posterior cervical extensors. FCSA is reported as percent lean muscle tissue. Student-T tests were used to determine significant changes at $p<0.05$. Data presented as means ± SD.

Presentation #17

Results: Cervical IVD mean heights increased significantly from 4.5 ± 0.7mm to 4.5 ± 0.7mm during the 6-month exposure to microgravity ($p = 0.01$). During recovery cervical IVD disk heights decreased to preflight heights from 4.5 ± 0.7mm to 4.3 ± 0.6 mm ($p = 0.003$) (Figure 1). Spaceflight decreased cervical lean muscle area by 9.9 ± 17.8% compared to preflight. However, 30–63 days after return to Earth, values were similar to preflight (2.2 ± 3.8%). The posterior IVD heights were significantly increased by spaceflight (0.36 ± 0.18mm $p = 0.02$) and recovered to preflight heights (-0.33 ± 0.19 mm, $p = 0.03$), as compared to the non-significant IVD height changes observed at the anterior and middle segments (Table 1).

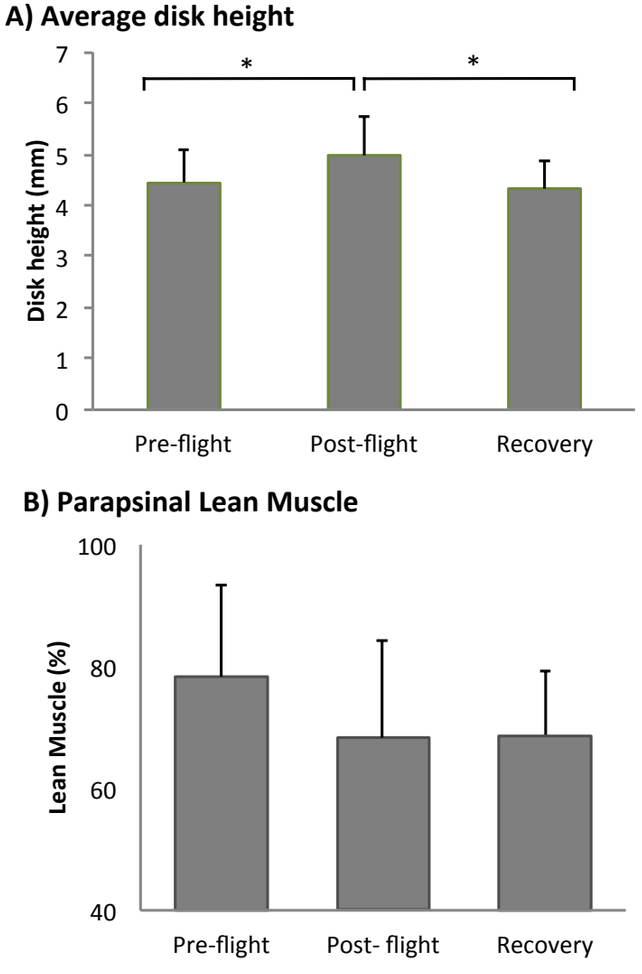
Conclusions: Cervical IVD heights increased 12% during 6 months ISS space flight. These swollen cervical IVDs early post-flight were associated with decreased lean muscle mass of posterior extensors. However, this lean muscle loss was not recovered during the recovery period. In the 30–63 days following ISS missions, cervical IVD heights decreased to preflight values. These results are limited by a small sample size, but these spaceflight data are unique and very difficult to obtain. The increase in cervical IVD heights and atrophy of cervical muscles may contribute to the reported neck pain and high incidence of cervical herniated nucleus pulposus in astronauts. This research is important in understanding spinal deconditioning during spaceflight and unloading, inactivity or aging on earth.

Supported by NASA grants NNX10AM18G and NNX13AM89G

See Disclosure Index pages 40–88.

Presentation #17 (cont.)

Figure 1. Average disk heights (A) and paraspinal lean muscle (B) before spaceflight, after spaceflight, and after recovery period.



*Significantly different from post flight $p<0.05$

Presentation #17

Table 1. Anterior, middle, and posterior disk heights before spaceflight, after spaceflight, and after recovery period.

	Anterior	Middle	Posterior
Pre-flight	4.1 (0.4)	5.6 (0.8)+	3.7 (0.7)
Post-flight	4.6 (0.6)	5.9 (1.1)+	4.4 (0.7)*
Recovery	4.2 (0.5)	5.7 (1.0)+	4.0 (0.7)*#

*significantly different from pre-flight
significantly different from post-flight
+significantly different from anterior and posterior disk height

See Disclosure Index pages 40–88.

Presentation #18

Transplantation of Human IPS Cell-Derived Oligodendrocyte Precursor Cells Enriched Neural Stem/Progenitor Cells in Chronic and Subacute Spinal Cord Injury

***Soya Kawabata, MD**, Tokyo, Japan*
Akio Iwanami, MD, PhD, Tokyo, Japan
Morito Takano, MD, PhD, Tokyo, Japan
Go Itakura, MD, PhD, Tokyo, Japan
Yoshiomi Kobayashi, MD, PhD, Tokyo, Japan
Hideyuki Okano, Tokyo, Japan
Morio Matsumoto, MD, PhD, Tokyo, Japan
Masaya Nakamura, MD, PhD, Tokyo, Japan

Background: Previously we have reported the efficacies of human iPS cell-derived oligodendrocyte precursor cells enriched neural stem/progenitor cells (hiPSC-OPCs enriched NS/PCs) transplantation for subacute spinal cord injury (SCI) in adult mice. On the other hand, we have reported that there are limits to functional recovery by transplantation of NS/PCs for chronic SCI. It was partly because of inadequate remyelination of surviving axons by transplanted cells. It is well known that remyelination of demyelinated axons could be a viable target in transplantation therapy for chronic SCI. Since hiPSC-OPCs enriched NS/PCs have potentials to differentiate into mature oligodendrocytes, these cells might be effective for the chronic SCI by remyelinating demyelinated axons in the injured spinal cord. In this study, we verified the effectiveness of transplanted hiPS-OPC enriched NS/PCs for mouse chronic SCI, then compared with the subacute transplantation.

Methods: hiPSC-OPCs enriched NS/PCs were induced from pre-evaluated safe iPS cell line (201B7), and cytokine antibody array experiments were performed in vitro. Contusive SCI was induced in immunodeficiency mice and hiPSC-OPCs enriched NS/PCs were transplanted into the injured spinal cord 9 or 45 days after SCI (subacute and chronic transplantation group). Instead of cells, phosphate buffered saline was injected in each vehicle control group. For histological analyses, mice were intracardially perfused 12 weeks after transplantation. Locomotive motor functions were periodically assessed and electrophysiological examinations using Motor-evoked potential (MEP) were also performed 12 weeks after transplantation.

Presentation #18

Results: Cytokine antibody array analysis revealed that much more vascular endothelial growth factor (VEGF) and platelet-derived growth factor (PDGF)-AA were secreted from hiPSC-OPCs enriched NS/PCs than hiPSC-NS/PCs. Grafted cells well survived and differentiated into MBP-positive mature oligodendrocytes in both transplantation groups. Transplanted hiPSC-OPCs derived oligodendrocytes were capable of forming mature sheathes on the spared axons.
Additionally, nodes of Ranvier were observed in the transplanted cells derived myelin sheathes. Furthermore grafted cells promoted axonal growth and contributed to the synapse formation between grafted cells derived neurons and host mouse neurons. Therefore there were many NF-H+ neuronal fibers in the both transplanted groups whereas a few NF-H+ axons were observed in the control group. The subacute transplantation group demonstrated significantly larger myelinated areas compared to the subacute control group, whereas myelinated areas did not significantly differ between the chronic transplantation and chronic control groups. Moreover, The subacute transplantation group showed a better functional recovery, compared to the control group. However, no significant motor function recovery was observed in the chronic transplantation group, compared to the control group. Although MEP waves were detected in all the mice of the subacute transplantation group, there were no waves in 50% of the mice in the chronic transplantation group and the both control groups. The latency was significantly longer in the subacute control group than the subacute transplantation group.

Conclusion: The effectiveness of hiPSC-OPC enriched NS/PCs transplantation for chronic SCI was restricted compared to the transplantation for subacute SCI. Combination therapy of hiPSC-OPCs enriched NS/PCs transplantation with debridement of glial scar formation or rehabilitation may be critical to achieve functional recovery for chronic SCI.

See Disclosure Index pages 40–88.

Presentation #19

Altered Forelimb Neural Circuitry Associated with Impaired Manual Dexterity in Cervical Spondylotic Myelopathy (CSM)

Kajan Satkunendrarajah, PhD, *Toronto, ON, Canada*
Spyridon K. Karadimas, MD, PhD, Toronto, ON, Canada
Michael G. Fehlings, MD, PhD, Toronto, ON, Canada

Introduction: CSM causes devastating neurological deficits, including significant impairment of hand function to varying degrees depending on the level and severity of compression. Although surgical treatment prevents further damage to the spinal cord and may reverse some of the neurological deficits, many patients still experience significant impairment of manual dexterity. Skilled motor function involves the descending commands to motor neurons as well as the cervical spinal circuits for rapid refinement of motor output for precise movements. We hypothesize that essential neuronal elements of the forepaw circuitry is lost in CSM resulting in impaired manual dexterity. Moreover, we hypothesize that significant rewiring of the remaining neuronal elements within the compressed cord can be exploited to prevent further decline in manual dexterity and promote recovery of skilled movements. As such, this study provides novel insights into the altered forelimb neural network of the CSM.

Methods: In this study, we examined the above hypothesis of anatomical plasticity of the forelimb neural circuitry and associated changes in manual dexterity under CSM using cutting edge viral tracing techniques paired with detail analysis of manual dexterity, and in vivo longitudinal electrophysiological recordings during reaching and grasping tasks in a novel CSM mouse model. First, changes in the numbers of forelimb specific motoneurons and interneurons and their connectivity were examined by injecting modified rabies virus expressing GFP into the forelimb musculature of vGluT2-Cre::tdTomato and vGAT-Cre::tdTomato transgenic mice. Subsequently, the associated loss of skilled forelimb function was assessed prior to CSM and at 2, 4 and 8 weeks post-CSM using kinematic analysis of forelimb reaching and grasping movements and horizontal ladder task. A second cohort of animals with implanted EMG electrodes into forelimb and forepaw muscles were evaluated for absolute timing, correlation in time of activity and the force generated in relation to extension and grasping movements.

Presentation #19

Results: Anatomically, we observed a significant loss of motoneurons (GFP + neurons), inhibitory (GFP+/Tdtomato+) and excitatory (GFP+/Tdtomato+) interneurons of the forelimb neural circuitry in vGAT-Cre::tdTomato and vGluT2-Cre::tdTomato mice, respectively. Mice displayed significantly more errors while reaching resulting in increased number of failures in reaching the target objects and grasping with the progression of CSM. Also, grasping became significantly more impaired in the horizontal ladder task with disease progression. In addition, CSM led to mice making significantly more adjustments while completing all of the neurobehavioural tasks, increasing the time required for task completion. Although, the force generated during reaching grasping behaviour was decreased, there was no detectable disruption in muscle activity correlated to time of activity.

Conclusions: Here, for the first time we demonstrate the alterations of the hand function network associated with the loss of manual dexterity in CSM. Moreover, we provide the anatomical and physiological substrate explaining the residual dysfunctions in manual dexterity following decompression. Our work provides the impetus for the development of novel therapeutic interventions that can further enhance the connectivity within the hand function network synergistically with decompression to improve quality of life in CSM patients.

See Disclosure Index pages 40–88.

Presentation #20

- **Evaluation of Vancomycin Powder on Bone Healing in a Rat Spinal Arthrodesis Model**

Marco C. Mendoza, MD, Chicago, IL
Kevin A. Sonn, MD, Chicago, IL
Abhishek S. Kannan, BS, Chicago, IL
Sharath Bellary, MD, Chicago, IL
Sean M. Mitchell, BS, Chicago, IL
Gurmit Singh, BS, Chicago, IL
Christian Park, BS, Chicago, IL
Chawon Yun, PhD, Chicago, IL
Anjan Ghosh, Chicago, IL
Stuart R. Stock, PhD, Chicago, IL
Erin L. Hsu, PhD, Chicago, IL
***Wellington K. Hsu, MD**, Chicago, IL*

**Vancomycin*

Introduction: Surgical site infections (SSIs) after cervical spinal surgery occur in 0.9% to 15.0% of patients. Such complications are devastating to patients and the healthcare system. As *Staphylococcus aureus* is the most common organism responsible for SSIs, vancomycin powder has the potential to serve as a simple, cost-effective solution to the problem. It is poorly absorbed from the wound avoiding potential systemic side effects while maintaining high local wound concentrations. Although *in vitro* studies suggest that vancomycin is cytotoxic to differentiating osteoblasts, the effect of vancomycin powder application on the rates of spinal arthrodesis has not been properly evaluated. This study aims to quantify the impact of vancomycin powder application on new bone formation and spine fusion rates in a rat posterolateral arthrodesis model.

Methods: Thirty-six female Sprague-Dawley rats underwent a posterolateral lumbar spinal fusion at the L4 and L5 vertebrae. Fusion was elicited *via* implantation of an absorbable collagen sponge containing 3µg rhBMP-2. Rats were divided into three groups: no vancomycin (control), standard dose vancomycin, and high dose vancomycin. Clinical studies typically describe the application of 1g vancomycin into the surgical wound. Presuming an average individual weight of 70 kg, a weight-based equivalent dose of vancomycin powder was applied subfascially in the PLF model constituting a “standard-dose” treatment group (14.3 mg/kg; n = 12). To determine whether there is a critical threshold beyond which vancomycin increases the risk of pseudarthrosis, a ten-fold higher dose was administered to a “high dose” treatment group (143 mg/kg; n = 12). No vancomycin powder was applied to the surgical site in the control group (n = 12).

Presentation #20

Spines were harvested and evaluated at 8 weeks post-operatively using radiographs, fusion scoring, microCT, and histologic analysis.

Results: Qualitative radiographs demonstrated equivalent bridging bone formation in all groups (Figure 1). No significant differences in fusion scores were seen in the standard-dose (2.25) or high-dose (2.13) treatment groups relative to untreated control animals (1.78; Figure 2A). Similarly, fusion rates were not significantly different between vancomycin-treated animals (100% for both groups) and control animals (92%; Figure 2B). Quantification of new bone formation *via* microCT imaging revealed no significant differences in the volume of newly regenerated bone among groups (Figure 2C).

Conclusion: This is the first *in vivo* study to specifically address pseudarthrosis with topically-applied vancomycin. Our results demonstrate that vancomycin powder does not inhibit fusion rates at an equivalent wt% dose to what is routinely used by surgeons. Moreover, bone formation and fusion rates were not reduced even after administration of a vancomycin dose that is ten-fold higher than that which is typically administered clinically. Our findings suggest that if there is a critical threshold above which vancomycin inhibits bone healing, such a dose is out of the range which might be considered reasonable for clinical use.

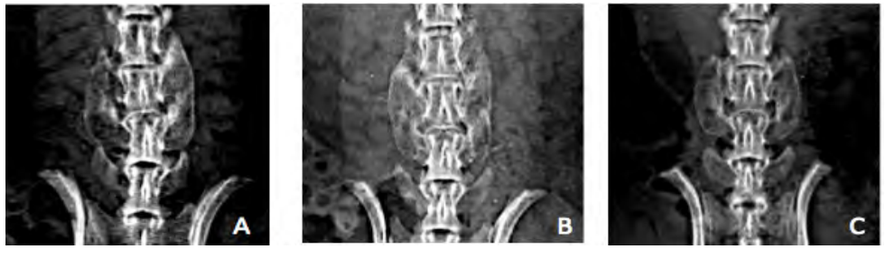


Figure 1. (A) No vancomycin (B) Standard Dose Vancomycin (C) High Dose Vancomycin

See Disclosure Index pages 40–88.

Presentation #20 (cont.)

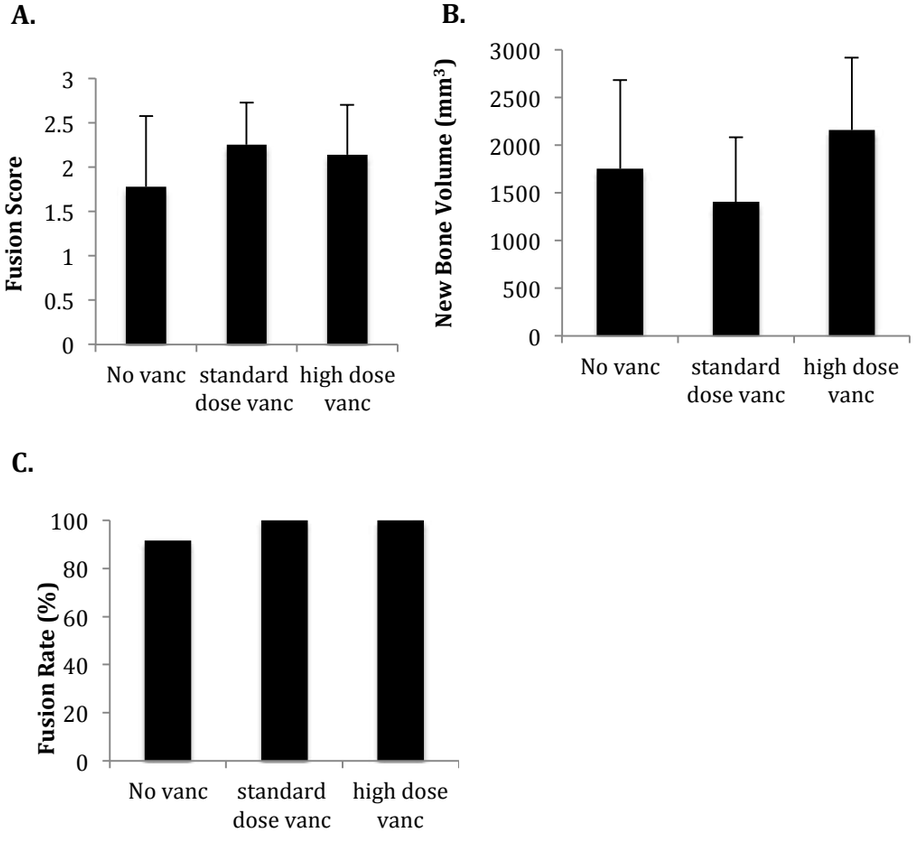


Figure 2. (A) Fusion scores (B) Fusion Rate (C) New Bone Volume

Presentation #21 P

Return to Work Rates after Single-Level Cervical Fusion Surgery for Degenerative Disc Disease Compared to Fusion for Radiculopathy in Workers' Compensation Setting

***Mhamad Faour, MD**, Cleveland, OH*
Joshua T. Anderson, BS, Cleveland, OH
Nicholas U. Ahn, MD, Cleveland, OH

Introduction: Studies have shown that workers' compensation subjects have poorer functional outcomes compared to the general population. Cervical decompression and fusion have provided great results with relieving radicular symptoms. However, decompression and fusion for degenerative disc disease (Axial neck pain without radiculopathy) remains controversial. Our purpose was to compare RTW rates after single level cervical fusion between subjects diagnosed with radiculopathy and subjects diagnosed with degenerative disc disease (DDD) before fusion.

Methods: ICD-9 and CPT codes were used to collect administrative data from Ohio Bureau of Workers' Compensation (BWC) between 1993 and 2011. Patients included in the study were subjects qualified for WC benefits for injuries they sustained at work. A population of 2208 subjects that underwent single-level cervical fusion was identified. Two groups were constructed using ICD-9 codes. The first group included 1927 subjects with documented cervical radiculopathy before undergoing fusion. The second group included 281 subjects diagnosed with degenerative disc disease (DDD) only (Axial neck pain without radicular symptoms) before fusion. The primary outcome was whether subjects met RTW criteria within 3 years follow-up after index fusion. The secondary outcome measures and presurgical characteristics of each cohort were also reported.

Results: Subjects underwent fusion for radiculopathy had significantly better return to work rates compared to subjects with DDD only before fusion (OR: 1.32, 95%CI: 1.02–1.73, p-value: 0.03). RTW criteria were met in 1212 subjects (62.9%) with radiculopathy compared to 143 subjects (50.9%) with DDD within 3 years follow-up period (p-value: 0.0001). Also, higher rates of RTW within the first year after fusion was observed in radiculopathy subjects (53.1%) compared to DDD subjects (39.8%, p-value: 0.0001). RTW Status was negatively affected by: fusion for DDD, age over 50 at the time of surgery, absence from work for more than 6 months before surgery, receiving psychological care, preoperative opioid use, legal representation within 3 years before surgery, and awarded permanent disability benefits before surgery.

Presentation #21 P (cont.)

Conclusion: Subjects with DDD without radicular symptoms have worse RTW rates after single-level cervical fusion compared to subjects with radicular symptoms. In many cases, the goal may be a return to functionality rather than achieving a completely asymptomatic state. Further studies should investigate further treatment options of DDD and optimize patient selection for undergoing cervical spine surgeries.

Presentation #22 P

Does Depression or Anxiety affect Patient-Reported Outcomes and Satisfaction following Operative Treatment for Cervical Myelopathy or Radiculopathy?

***Harrison F. Kay, BS**, Nashville, TN*
Silky Chotai, MD, Nashville, TN
Joseph B. Wick, BA, Nashville, TN
David P. Stonko, MS, Nashville, TN
Matthew J. McGirt, MD, Charlotte, NC
Clinton J. Devin, MD, Nashville, TN

Introduction: Preoperative depression and anxiety have been reported to lead to worse surgical outcomes. Better understanding of these factors as predictors for patient-reported outcomes (PROs) could improve selection of patients with the greatest opportunity for a successful outcome. This study evaluates the differences in PROs and patient satisfaction following surgery for cervical radiculopathy and myelopathy in patients with depression or anxiety.

Methods: Patients undergoing surgery for cervical radiculopathy or myelopathy over a four-year period were enrolled into a prospective registry. Baseline and 12-month PROs included: NDI, SF-6D, VAS-NP, VAS-AP, Zung depression scale (ZDS), and Modified Somatic Perception Questionnaire (MSPQ). Patients with ZDS > 33 were characterized as depressed, and patients with MSPQ > 12 as anxious. Mean absolute and change-score between groups were compared using Student's t-test. Chi-square test was used to compare proportions between groups for patients who achieved MCID and patients who were satisfied. Multivariable linear regression was used to determine the effect of depression and anxiety on NDI% change score controlling for 13 independent variables.

Results: In total, 170 patients with radiculopathy and 262 with myelopathy met inclusion criteria. In radiculopathy patients, 12-month absolute scores were significantly worse in depressed patients for all measures except VAS-AP. No difference in mean change scores was observed in depressed patients: NDI% (21.79 vs. 18.03, P = 0.201), SF-6D (0.109 vs. 0.102, P = 0.791), VAS-NP (3.11 vs. 2.53, P = 0.260), VAS-AP (3.94 vs. 3.03, P = 0.134). Myelopathy patients demonstrated similar results for both absolute and change scores. No difference in proportion of patients achieving MCID was observed except for NDI%, in which depressed patients achieved MCID significantly more (P = 0.016). Multivariable linear regression demonstrated neither depression nor anxiety is significantly associated with NDI% change score

See Disclosure Index pages 40–88.

Presentation #22 P (cont.)

Conclusions: Despite having worse absolute pain and disability one year following surgery, patients with depression and anxiety have statistically similar 12-month change scores, achievement of MCID for patient-reported outcomes, and satisfaction with surgery compared to those without. These patients should not be dismissed as potential candidates for surgery as they stand to gain measurable clinical benefit.

Presentation #23 P

The Profile of a Smoker and its Impact on Outcomes after Cervical Spine Surgery

***Raul A. Vasquez-Castellanos, MD**, Nashville, TN*
Silky Chotai, MD, Nashville, TN
Joseph B. Wick, BA, Nashville, TN
David P. Stonko, BS, MS, Nashville, TN
Joseph S. Cheng, MD, MS, Nashville, TN
Clinton J. Devin, MD, Nashville, TN
Anthony L. Asher, MD, Charlotte, NC
Matthew J. McGirt, MD, Nashville, TN

Objective: Smoking has been associated with worse self-reported outcomes in patients undergoing degenerative lumbar spine surgery. Current focus is on decreasing cost and complications while improving outcomes. This potentially can be accomplished by acting on modifiable preoperative patient characteristics such as smoking. However, the impact of smoking on outcomes following degenerative cervical spine surgery is poorly understood. The aim of the study is to understand impact of smoking on patient reported outcomes after degenerative cervical spine surgery.

Methods: A total of 473 patients enrolled in a prospective longitudinal registry undergoing degenerative cervical degenerative surgery over a period of one year were included in the study. Smoking status, patient demographics, and patient reported outcomes were obtained. The patient reported outcomes were obtained preoperatively, at 3 months, and 1 year following surgery. The instruments utilized include: numeric neck and arm pain, NDI, SF-12, mJOA (in those with myeolopathy), and EQ-5D. The patients were divided into smokers and non-smokers to compare patient reported outcomes.

Results: A total of 123 (26%) patients reported to be current smokers at the moment of the initial evaluation and 350 (74%) patients were not smoking. The smoking population was younger (51 vs. 56 year-old, $p < 0.001$), and had at higher pre-operative use of narcotics than non-smokers (56% vs. 50%, $p = 0.046$). At baseline and 12 months follow-up, smokers had significantly higher arm and neck pain scores, NDI percentages, and lower EQ-5D scores. The smoking population had less improvement in neck pain, NDI percentages, mJOAS, and SF-12 PCS at 12 months follow-up. The smoking population reported lower satisfaction scores, with 24% of smokers having unfulfilled expectations at 12 months after surgery, versus 14% in the non-smokers group ($p < 0.013$).

See Disclosure Index pages 40–88.

Presentation #23 P (cont.)

Conclusions: The smoking population was younger and had a higher preoperative narcotic utilization. Smoking results in lower absolute scores and these patients have less benefit following surgical intervention as compared to the non-smokers, after controlling for confounding variables. Smoking cessation should be strongly considered prior to surgical intervention so as to optimize outcome.

Table 1. Patient Characteristics

	Non-Smoker (350)	Smoker (123)	p-Value
Age (years)	57	52	<0.001
Gender			0.31
Female	156 (45%)	50 (41%)	
Male	194 (55%)	73 (59%)	
BMI	30.41±7.43	29.22 ±6.14	0.082
Ambulatory preoperative			0.261
Yes, with assistance	64 (18%)	31 (25%)	
Yes, without assistance	278 (80%)	90(73%)	
No	7 (2%)	2 (2%)	
Narcotic Use	162 (47%)	69 (56%)	0.046
Unemployed	176 (50%)	48 (39%)	<0.001
ASA grade			0.727
1	3 (1%)	0 (0%)	
2	111 (32%)	42 (34%)	
3	229 (65%)	79 (64%)	
4	7 (2%)	2 (2%)	
History of Arthritis	218 (62%)	75 (61%)	0.829
Afib	7 (36%)	1 (1%)	0.05
Back/Neck Pain Dominant	31 (9%)	10 (8%)	0.486
Equal Back/Neck Pain-Leg/ Arm Pain	200 (57%)	71 (58%)	0.499
Leg/Arm Pain Dominant	38 (11%)	10 (8%)	0.25
Chronic Obstructive Pulmonary Disease (COPD)	13 (4%)	8 (7%)	0.15
Congestive Heart Failure (CHF)	13 (4%)	4 (3%)	0.535
Coronary Artery Disease (CAD)	64 (18%)	22 (18%)	0.515
Diabetes	94 (27%)	25 (20%)	0.093
Osteoporosis	5 (1%)	1 (1%)	0.508
Duration of symptoms			0.9
1 months	60 (18%)	20 (16%)	
2 months	149 (43%)	55 (45%)	
3 months	140 (40%)	47 (39%)	
Diagnoses			0.964
Disc Herniation	128 (36%)	46 (37%)	
Spondylosis	34 (10%)	11 (9%)	
Stenosis	188 (54%)	66 (54%)	

Presentation #23 P

Table 2. Patient Self-Reported Outcomes

	Non-Smoker	Smoker	p-value
Arm Pain Score			
Baseline	1.9 ±2.9	3.2 ±3.6	<0.001
Change at 12 months	3.1 ±4.0	2.8 ±4.2	0.413
NDI Percentage			
Baseline	40.4 ±18.5	47.0 ±17.3	<0.001
Change at 12 months	18.1 ±18.6	13.1 ±17.3	0.007
EQ-5D			
Baseline	0.6 ±0.2	0.5 ±0.2	<0.001
Change at 12 months	0.2 ±0.2	0.1 ±0.2	0.223
Neck pain score			
Baseline	5.6 ±2.9	6.3 ±2.8	0.015
Change at 12 months	2.7 ±3.3	2.0 ±3.2	0.043
SF-12 Mental Component Score			
Baseline	47.5 ±11.2	43.6 ±13.2	0.005
Change at 12 months	3.3 ±12.1	1.4 ±13.3	0.159
SF-12 Physical Component Score			
Baseline	31.0 ±10.6	27.6 ±10.2	0.002
Change at 12 months	10.2 ±12.3	6.7 ±11.6	0.005
mJOAS Score			
Baseline	11.6 ±3.1	10.1 ±3.2	0.102
Change at 12 months	5.6 ±6.1	3.6 ±6.1	0.017
NASS Patient Satisfaction			0.013
Fulfilled expectations	293 (86%)	94 (76%)	
Unfulfilled expectations	48 (14%)	29 (24%)	

See Disclosure Index pages 40–88.

Presentation #24 P

Patient-Specific Factors Predicting Dissatisfaction after Elective Surgery for Degenerative Spine Diseases

***Sheyan J. Armaghani, MD**, Nashville, TN*
Silky Chotai, MD, Nashville, TN
Ahilan Sivaganesan, MD, Nashville, TN
Scott L. Parker, MD, Nashville, TN
J. Alex Sielatycki, MD, Nashville, TN
David P. Stonko, BS, MS, Nashville, TN
Matthew J. McGirt, MD, Charlotte, NC
Clinton J. Devin MD, Nashville, TN

Background: Patient satisfaction metrics are emerging as determinants of quality of care and reimbursement following spine surgery. Identifying modifiable factors that improve satisfaction is of utmost importance. We evaluate if preoperative factors or patient reported outcomes (PROs) could predict dissatisfaction following spine surgery.

Methods: Patients undergoing elective surgery for degenerative lumbar and cervical disease over a period of two-years were enrolled into a prospective longitudinal registry. PRO instruments: ODI/NDI, numeric rating scale (NRS)-Back/Neck and leg/arm pain (BP/NP, LP/AP), Zung depression scale (ZDS), Modified Somatic Perception Questionnaire (MSPQ) were recorded at baseline and 12-month follow-up. Previously published values of minimal clinically important difference (MCID) for ODI-14.9, NDI-17.3%, BP/NP-2.1/2.6 and LP/AP-2.8/4.1 were used. Patients were dichotomized as satisfied or not based on the NASS four-item questionnaire; “patient satisfaction” was defined as a level of improvement after surgery that met patient’s expectations (Question 1 and 2 of the NASS satisfaction questionnaire). Univariate analyses were conducted to determine the association of the clinical parameters to patient dissatisfaction. Multivariable logistic regression analyses were performed with dissatisfaction as the outcome variable.

Results: A total of 1645 patients underwent elective spine surgery (811 male, 57 ± 13 years old). Eighty-three percent (1362) of patients reported satisfaction with outcome 12-months after surgery. In a multivariate analyses, after controlling for age, gender, predominant LP/AP, BP/NP, insurance type, history of diabetes, preoperative narcotic use, preoperative anxiety and depression, ASA grade, readmission, and complications; the inability to achieve MCID for ODI/NDI (OR = 4.215, P < 0.0001, CI-2.7-6.5), back/neck pain (OR = 3.1,P < 0.0001, CI -2.188-4.43), and leg/arm pain (OR = 2.6, P < 0.0001, CI-1.8-3.6), Medicaid/uninsured payer status (P = 0.044,OR = 1.39, CI-1.01-1.93) higher baseline ODI/NDI scores (P = 0.002, OR=1.11,CI-1.04-1.19), and higher baseline BP/NP scores (P = 0.002,OR=1.03,CI-1.01-1.06) were the independent predictors of patient dissatisfaction at 12-months after surgery.

Presentation #24 P

Conclusion: Patient satisfaction with outcome may accurately represent effectiveness of surgical spine care in terms of one-year improvement in pain and disability. However, healthcare stakeholders relying on satisfaction as a proxy of overall quality or effectiveness of care need to account for Medicaid or uninsured payer status and lower baseline pain and disability scores as confounders.

See Disclosure Index pages 40–88.

Presentation #25 P

Clinical Obesity in Total Disc Replacement and Anterior Cervical Discectomy and Fusion Patients through Five Years Follow-up

Todd J. Albert, MD, New York, NY
Domagoj Coric, MD, Charlotte, NC
Han Jo Kim, MD, New York, NY
Elizabeth Roensch, BS, Austin, TX
Kyle Marshall, BS, Austin, TX
***Kristen E. Radcliff, MD**, Philadelphia, PA*

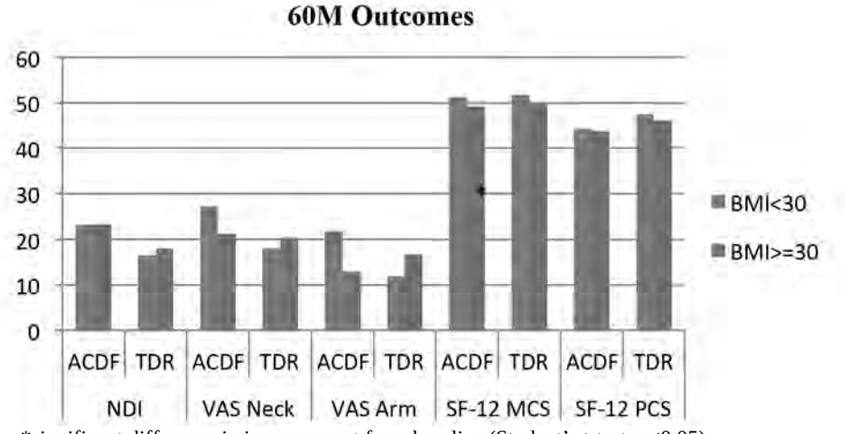
Introduction: According to National Institute of Health, clinical obesity may lead to certain health risks and physical inactivity. Here we assess whether obesity affects clinical outcomes after treatment total disc replacement (TDR) or anterior cervical discectomy and fusion through five years.

Methods: Data from an FDA IDE, clinical trial comparing TDR with Mobi C cervical disc prosthesis to ACDF with allograft and anterior plate. A total of 575 patients were randomized to receive TDR (389 patients) or ACDF (186 patients) at one or two contiguous levels. A pre-operative BMI ≥ 30 was considered clinical obesity according to the NIH Clinical Guidelines. Patients with extreme clinical obesity (BMI≥ 40) were excluded from enrollment in the IDE study. BMI data was not gathered after the study surgery, introducing a limitation in this analysis. Outcomes included NDI, VAS neck/arm pain, SF-12 MCS/PCS, ROM, and patient satisfaction. Student's t-test was used to test for significance between groups in outcomes. Subsequent surgeries included all index and adjacent level secondary surgeries. Grade III and IV heterotopic ossification (HO) were considered clinically relevant. Adjacent segment degeneration (ASD) was considered any increase in grade from baseline. Fisher's Exact test were used to determine significant difference in patient satisfaction, subsequent surgeries, HO, and ASD. Sagittal balance was measured by the C2-C7 angle. Spearman's rho was used to determine significant correlation with BMI.

Results: Clinical obesity was presented in 52 (28.0%) ACDF and 112 (28.8%) TDR patients. For the TDR group, BMI was not significantly correlated to NDI, VAS neck/arm, or SF-12 scores at baseline or 60 months. No significant correlation was found between BMI and 60 month improvement scores for TDR. For the ACDF group, BMI was significantly correlated to baseline SF-12 PCS ($r = -0.1808$, $p = 0.0154$), VAS arm score ($r = -0.2771$, $p = 0.0014$) at 60 months and VAS arm improvement ($r = 0.2232$, $p = 0.0104$) at 60 months. Satisfaction and recommendation rates were similar between BMI groups for ACDF and TDR.

Presentation #25 P

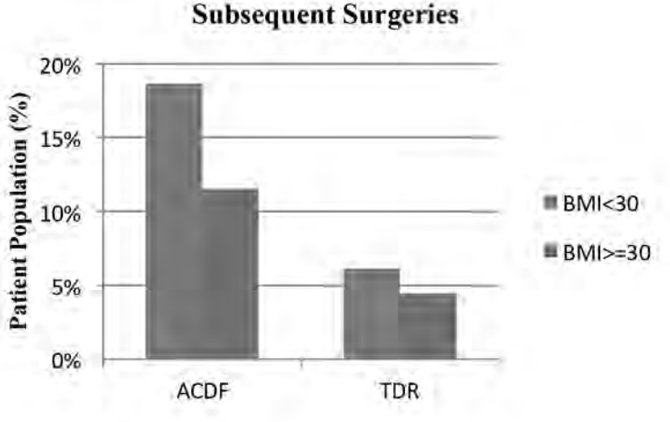
Figure 1.



*significant difference in improvement from baseline (Student's t-test, $p<0.05$)

No significant difference was seen in subsequent surgeries for ACDF (11.5% vs. 18.7%) or TDR (4.5% vs. 6.1%) patients with clinical obesity compared to the non-obese population.

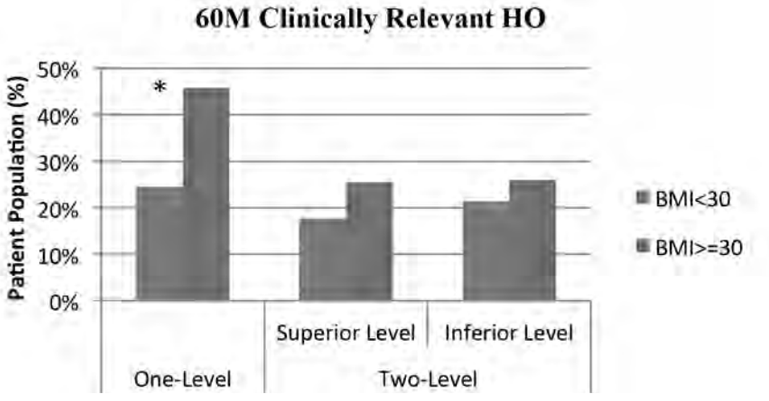
Figure 2.



Clinically relevant HO was significantly higher in one-level obese TDR patients (45.7% vs. 24.4%, $p = 0.02883$). No significant difference in HO was seen among the two-level TDR patients at either level.

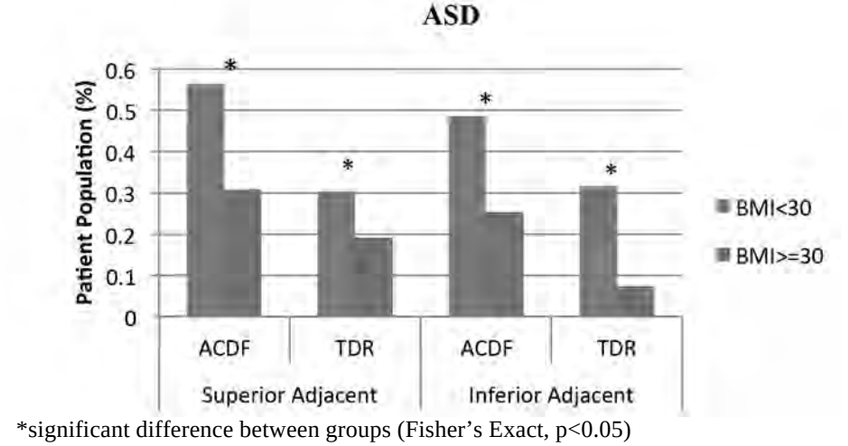
See Disclosure Index pages 40–88.

Presentation #25 P (cont.)



*significant difference between groups (Fisher's Exact, p<0.05)

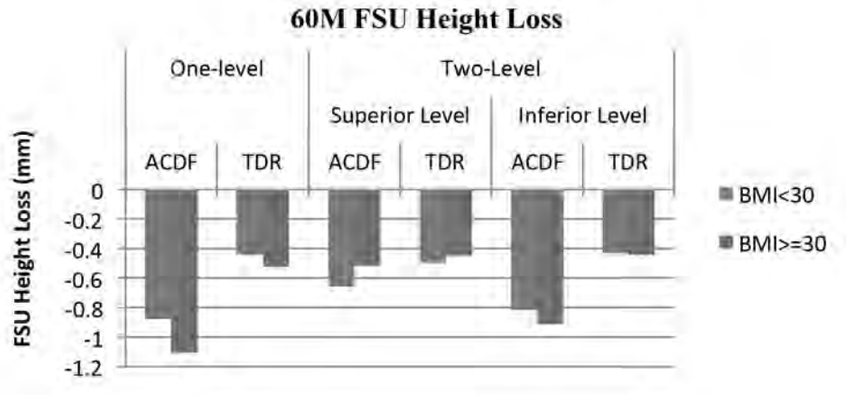
ASD was significantly lower at the superior (30.9% vs. 56.4%, p = 0.02669) and inferior (25.3% vs. 48.6%, p = 0.02064) adjacent levels for obese ACDF patients. ASD was significantly lower at the superior (19.2% vs. 30.4%, p = 0.0273) and inferior (7.4% vs. 31.6%, p < 0.0001) adjacent levels for obese TDR patients.



*significant difference between groups (Fisher's Exact, p<0.05)

No significant difference between groups was found in post-operative functional spine unit (FSU) height loss or sagittal balance. One-level FSU height at 60 months was significantly correlated to BMI (r = 0.1720, p = 0.0183).

Presentation #25 P



Regarding range of motion for TDR patients, BMI was negatively correlated to one-level lateral bending (r = -0.1787, p = 0.0471) and two-level flexion/extension at the superior index level (r = -0.1915, p = 0.0092). Flexion/extension (8.25 degrees vs. 10.79 degrees, p = 0.0630) and lateral bending (4.66 degrees vs. 5.65 degrees, p = 0.1518) was lower for one-level obese TDR patients. Flexion/extension was significantly lower for two-level obese patients (8.57 degrees vs. 10.70 degrees, p = 0.0262) at the superior index level; no difference was seen in inferior flexion/extension (8.27 degrees vs. 8.21 degrees) or lateral bending at the superior (5.26 degrees vs. 5.57 degrees) or inferior (4.99 degrees vs. 4.94 degrees) level.

Conclusion: At five years, clinical obesity had no observable effect on subsequent surgery rate, sagittal balance, FSU height loss, NDI, VAS neck pain, SF-12 scores or patient satisfaction. Obese patients presented higher rates of clinically relevant HO and significantly lower rates of adjacent segment degeneration. Certain range of motion measures were significantly lower for patients with high BMI. Further analysis is necessary to understand the influence of obesity on clinical outcomes following treatment with TDR and ACDF.

See Disclosure Index pages 40 – 88.

Presentation #26 P

Classifying Injury Severity and Predicting Neurologic Outcome after Acute Human Spinal Cord Injury with Cerebrospinal Fluid Biomarkers

Brian K. Kwon*, *MD, PhD, *Vancouver, BC, Canada*
Femke Streijger, PhD, Vancouver, BC, Canada
Nader Fallah, PhD, Vancouver, BC, Canada
Scott Paquette, MD, MEd, Vancouver, BC, Canada
John Street, MD, PhD, Vancouver, BC, Canada
Charles G. Fisher, MD, MPH, Vancouver, BC, Canada
Marcel F. Dvorak, MD, Vancouver, BC, Canada

Introduction: Neurologic impairment after spinal cord injury (SCI) is currently measured and classified by functional examination (i.e. the ASIA Impairment Scale (AIS) and ISNCSCI exam). These are gross measures of spinal cord pathology and imprecise predictors of neurologic outcome. Furthermore, such a detailed examination is often impossible to perform in the acute trauma setting. Biological markers that could objectively classify injury severity and precisely predict outcome would greatly facilitate clinical efforts to evaluate desperately needed therapies for acute SCI. Due to its proximity, cerebrospinal fluid (CSF) offers the most direct opportunity to evaluate the biological responses within the injured spinal cord. *The purpose of this study was to determine how well inflammatory and structural proteins within the CSF of acute SCI patients predicted their AIS grade conversion and motor score improvement.*

Methods: Fifty individuals with acute SCI (29 AIS A, 9 AIS B, 12 AIS C) were prospectively enrolled at our level one trauma institution (32 cervical, 18 thoracic). Lumbar intrathecal catheters were inserted at the time of surgery to obtain CSF samples over 3 to 5 days. A bead multiplex array and ELISAs were performed for inflammatory cytokines and structural proteins: IL-6, IL-8, MCP-1, IL-16, IP-10, IL-16, TNF-R1, Tau, S100β, and GFAP. The 24-hour post-injury CSF concentrations were analyzed in relation to baseline AIS grade, AIS grade improvement ("conversion") over 6 months, and motor score improvement over 6 months.

Results: The 24-hour post-injury CSF levels of IL-6, tau, S100b, and GFAP were each strongly correlated with baseline AIS grade of A, B, or C ($p<0.001$, Kruskal Wallis Test). For cervical SCI (n = 32), the IL-6, IL-8, MCP1, Tau, S100β, and GFAP concentrations strongly predicted AIS conversion at 6 months post-injury ($p < 0.01$ for all proteins). The levels of these proteins were clearly different between those who achieved AIS grade improvement (YES) vs. those who did not (NO) (Figure 1). For thoracic SCI (n = 18), AIS conversion was strongly correlated with IL-6 ($p = 0.034$) and S100b ($p = 0.003$). For cervical SCI, total motor score improvement at 6 months was significantly correlated with IL-6, IL-8, IP-10, TNF-R1, MCP-1, Tau, S100b, and GFAP.

Presentation #26 P

For thoracic SCI, only IL-6, S100b, and GFAP were correlated with total motor score improvement. Using locally weighted linear regression (Lowess) modeling, the combination of IL-6 and S100b clearly identifies cervical and thoracic SCI patients who will not spontaneously recover motor function (Figure 2).

Conclusions: The analysis of CSF can provide valuable biological information about injury severity after acute SCI. Such biological markers may be valuable tools for stratifying individuals in acute clinical trials where variability in spontaneous recovery requires large recruitment cohorts for sufficient power. We demonstrate in this study that patients who will not spontaneously recovery motor function or who will not improve on their AIS grade can be identified using the 24-hour concentration of CSF biomarkers. In a clinical trial of a novel therapeutic agent, being able to identify these populations of patients will help to distinguish naturally-occurring spontaneous recovery from that which may be induced by the treatment.

Figure 1. CSF concentrations between cervical SCI patients who experienced AIS grade improvement (YES) versus those who did not improve (NO) reveal that higher levels are associated with the failure to spontaneously improve.

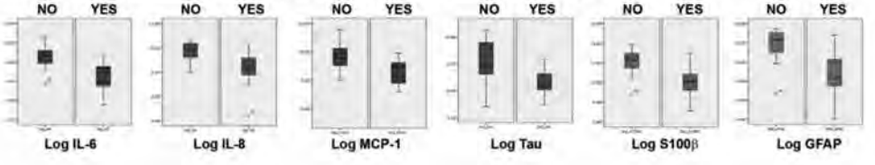
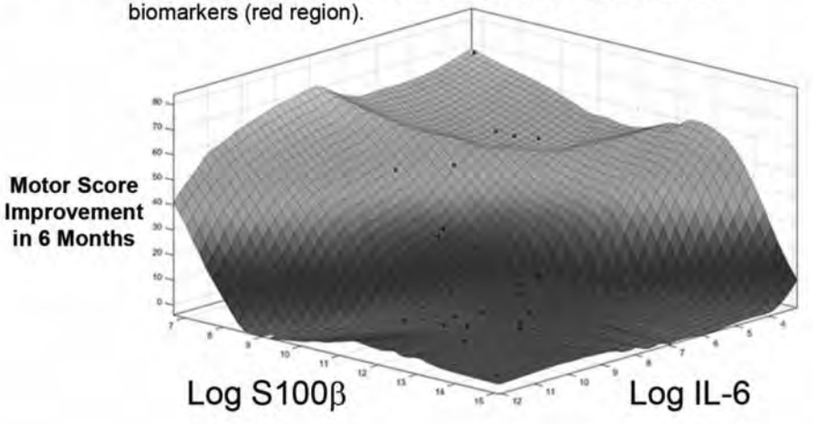


Figure 2. Lowess modeling with S100β and IL-6 concentrations demonstrates poor motor recovery in those with high concentrations of both biomarkers (red region).



See Disclosure Index pages 40–88.

Presentation #27 P

- **Functional Assessment of Local vs. Distal Transplantation of Human Neural Stem Cells following Chronic Spinal Cord Injury**

***Ivan Cheng, MD**, Stanford, CA*
Michael Githens, MD, Stanford, CA
Tyler Johnston, MD, Stanford, CA
R. Lane Smith, PhD, Stanford, CA

**Neural stem cells*

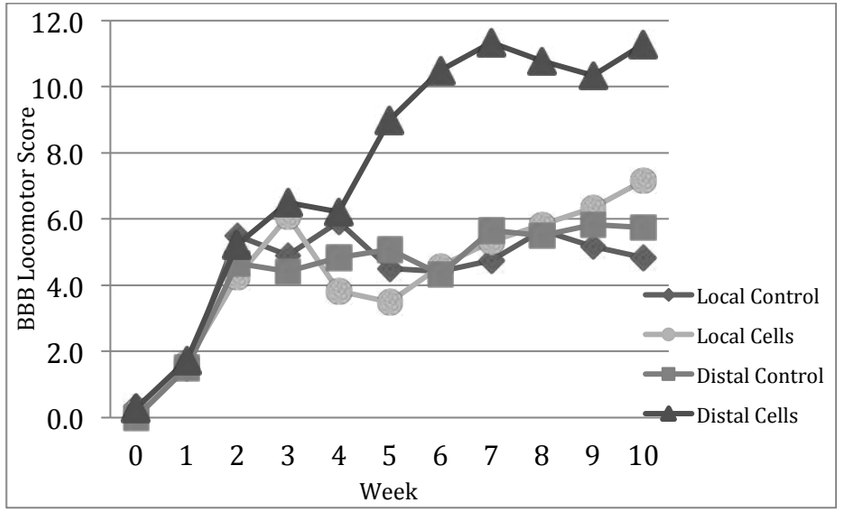
Introduction: Previous studies have demonstrated functional recovery of rats with spinal cord contusions after transplantation of neural stem cells adjacent to the site of acute injury. No known studies up to this point, however, have analyzed the effects of distal intrathecal injection of stem cells in chronic spinal cord injury.

Materials/Methods: 4 groups of Long-Evans hooded rats were identified: 2 experimental and 2 control. A moderate spinal cord contusion at the T10 level was created by use of the Multicenter Animal Spinal Cord Injury Study Impactor. Experimental subjects received a subdural injection of human neural stem cells (hNSCs) adjacent to the site of injury or an intrathecal injection of hNSCs through a separate laminotomy made in the mid-lumbar spine distal to the injury site 4 weeks after injury. Control subjects received an injection of control media alone. Subjects were assessed following injury and then weekly for 10 weeks using the BBB Locomotor Rating Score. Stem cells were pre-labeled with GFP and ex vivo histologic analysis of the spinal cords was performed.

Results: 24 subjects underwent spinal cord injury and injection, 6 in each group (local cells, local media, distal cells, distal media). A statistically significant functional improvement in subjects that received hNSCs injected distally to the site of injury was observed when compared to controls ($p = 0.030$, see figure). There was no significant difference between subjects that received hNSCs locally compared to controls ($p = 0.350$) and the improvement in distally injected animals was significantly greater than locally injected animals ($p = 0.048$). Histological analysis of the spinal cords revealed migration of labeled stem cells from the site of intrathecal injection and survival at the site of injury.

Conclusion: The transplantation of hNSCs into the contused spinal cord of a rat led to significant functional recovery of the spinal cord when injected distally but not locally at the site of chronic spinal cord injury. The stem cells were shown to migrate and survive at the site of injury.

Presentation #27 P



See Disclosure Index pages 40–88.

Presentation #28 P

Intrathecal Administration of Recombinant Human Hepatocyte Growth Factor for Acute Spinal Cord Injury: Road from Bench to Clinical Trial and Future Perspective

Kazuya Kitamura, MD, PhD, *Tokyo, Japan*
Akio Iwanami, MD, PhD, Tokyo, Japan
Hiroki Iwai, MD, PhD, Tokyo, Japan
Jun-ichi Yamane, MD, PhD, Tokyo, Japan
Kanehiro Fujiyoshi, MD, Tokyo, Japan
Yoshiaki Toyama, MD, Tokyo, Japan
Morio Matsumoto, MD, PhD, Tokyo, Japan
Hideyuki Okano, Tokyo, Japan
Masaya Nakamura, MD, Tokyo, Japan

Introduction: Hepatocyte growth factor (HGF) has been highlighted as a potent organotrophic and angiogenic factor in the central nervous system, as well as in other solid organs. We first revealed that endogenous up-regulation of HGF in injured spinal cord was insufficient, compared with sharp increase of c-Met (HGF receptor) expression during acute phase of spinal cord injury (SCI) and introduction of exogenous HGF into spinal cord by HSV injection significantly promoted the survival of neurons and oligodendrocytes, angiogenesis and axonal regeneration, thereby reducing the damaged area and promoting functional recovery after SCI. We have also reported efficacy of intrathecal infusion of recombinant human HGF (rhHGF) in thoracic SCI model of rats and cervical SCI model of non-human primate (common marmoset). The purpose of this study is to investigate its therapeutic time window, confirm its efficacy in clinically-relevant severe cervical SCI model of marmosets and establish novel treatment by conducting clinical trial.

Methods: 1) To investigate therapeutic time window of intrathecal rhHGF, contusive SCI was induced at Th10 level in adult rats and 200 mg of rhHGF or PBS was infused intrathecally from Th12 level for 4 weeks from right after, 4 days, 2 or 6 weeks after SCI (n = 6 for each group). 2) Contusive SCI was induced at C5 level and rhHGF or PBS was infused intrathecally from C7 level from right after SCI for 4 weeks in adult marmosets. To examine efficacy of intrathecal rhHGF in clinically-relevant severe cervical SCI model as preclinical trial, marmosets without any recovery of forelimbs until 3 days after SCI were included (n = 5 in HGF group, n = 3 in PBS group). Motor function was evaluated by our original scoring scale which focuses on primate-specific upper limb function (flexion and extension of fingers, wrists, elbows and shoulders and pronation of forearms) in walking and grasp performance.

Presentation #28 P

Results: 1) Significant motor recovery of hindlimbs was observed when intrathecal rhHGF started from right after or 4 days after SCI, whereas no effects were observed when intrathecal rhHGF started from 2 or 6 weeks after SCI.
2) Original scoring scale revealed that more than one key muscle of forelimbs became useful in marmosets with intrathecal rhHGF infusion, whereas all key muscles remained useless thereafter in control marmosets.

Conclusions: Since we reported dynamism of endogenous HGF expression before and after SCI and therapeutic efficacy of introduction of HGF into spinal cord during acute phase of SCI, we have developed the current therapeutic strategy for people with SCI using rhHGF based on experiments using viral vector and rhHGF in rodent SCI models. Present study suggests evidence of therapeutic time window of intrathecal rhHGF and its efficacy in clinically-relevant severe cervical SCI in primates. Based on results of these consecutive studies, we have recently launched phase I/II clinical trial (randomized, double-blinded, placebo-controlled) for people with cervical SCI who show modified-Frankel A/B1/B2 at 72 hours after onset. rhHGF is injected intrathecally at lumbar level once a week for 5 weeks, with primary injection within 6 hours after final registration at 72 hours after onset.

See Disclosure Index pages 40–88.

Presentation #29 P

Preexisting Severe Cervical Spinal Cord Compression is a Significant Risk Factor for Developing Severe Paralysis in Patients with Traumatic Cervical Spinal Cord Injury without Bone Injury: A Retrospective Cohort Study

***Takeshi Oichi, MD**, Tokyo, Japan*
Yasushi Oshima, MD, PhD, Tokyo, Japan
Rentaro Okazaki, MD, PhD, Saitama, Japan
Seiichi Azuma, MD, Saitama, Japan

Introduction: Cervical spinal cord injury (CSCI) without bone injury occurs as a result of various factors, including dynamic factor (i.e., traumatic external force) and static factor (i.e., preexisting cervical spinal cord compression). As for dynamic factor, high energy trauma is a well-known predictor of neurologic outcomes in patients with CSCI. As for static factor, the influence of preexisting canal stenosis on the severity of paralysis remains controversial. Several studies have reported that the degree of preexisting canal stenosis is not associated with the severity of the paralysis. Studies focusing on the impact of preexisting severe cervical canal stenosis in patients with CSCI without bone injury are limited. Therefore, the objective of this study was to investigate whether the presence of preexisting severe cervical canal stenosis affects the neurological outcomes in patients with traumatic CSCI without bone injury.

Methods: We retrospectively investigated 122 consecutive patients with traumatic CSCI without bone injury. The severity of paralysis on admission was assessed by the American Spinal Injury Association impairment scale (AIS). We divided the patients into 2 groups according to the AIS grade on admission: severe group (AIS A–C); and the less-severe group (AIS D). The differences in each variable between the severe group and the less-severe group were compared. The degree of preexisting cervical spinal cord compression was evaluated by the maximum spinal cord compression (MSCC) and was divided into three categories: minor compression (MSCC ≤ 20%), moderate compression (20% < MSCC ≤ 40%), and severe compression (40% < MSCC). We investigated soft-tissue damage on magnetic resonance imaging to estimate the external force applied. Other potential risk factors, including age, sex, fused vertebra adjacent to the injury level, and ossification of longitudinal ligament, were also reviewed. Then, a multiple logistic regression model was used to identify predictors of severe paralysis (AIS A-C) on admission.

Presentation #29 P

Results: Our study included 103 males and 19 females with mean age of 65 years. Sixty-one patients showed severe paralysis (AIS A–C) on admission. The average MSCC was 22%. Moderate compression was observed in 41, and severe in 20. Soft-tissue damage was observed in 91. Table a shows the differences in each variable between the severe group and the less-severe group. Patients in the severe group were significantly older than those in the less severe group ($p < 0.05$). Patients with severe compression developed severe paralysis significantly more often compared with those with minor or moderate compression ($p < 0.05$). A multivariate logistic regression analysis showed that severe cervical spinal cord compression significantly affected the severity of paralysis at the time of injury ($p < 0.05$) whereas both mild and moderate compression did not affect it (Table 2). Soft-tissue damage was also significantly associated with severe paralysis on admission ($p < 0.05$).

Conclusions: Preexisting severe cervical cord compression is an independent risk factor for severe paralysis once patients develop traumatic CSCI without bone injury. Furthermore, soft-tissue damage found on MRI scan is associated with severe paralysis. Identifying these factors will help provide appropriate information for patients and aid in patients' stratification in future clinical trials or clinical therapeutic protocol.

Table 1. Characteristics and radiographic findings on admission between severe group and less-severe group

	Severe group (AIS A–C) (n = 61)	Less-severe group (AIS D) (n = 61)	p-value
Age (mean ± SD)	68 ± 13	61 ± 13	0.01
Sex (Male/Female)	53/8	50/11	0.62
MSCC (%)	26 ± 22	19 ± 14	0.13
Degree of spinal cord compression (no. of patients [%])			
Minor compression	27 (44)	34 (56)	
Moderate compression	18 (30)	23 (38)	
Severe compression	16 (26)	4 (7)	0.01
Ossification of longitudinal ligament	16 (26)	12 (20)	0.52
Fused vertebrae adjacent to the injury level	8 (13)	8 (13)	1.00
Soft tissue damage	50 (82)	41 (67)	0.09

AIS: American Spinal Injury Association impairment scale, MSCC: maximum spinal cord compression, minor compression: MSCC of less than 20%, moderate compression: MSCC exceeding 20% and less than 40%, and severe compression: MSCC exceeding 40%. Continuous variables were compared using Wilcoxon rank-sum test; categorical data were analyzed using chi-square test.

See Disclosure Index pages 40–88.

Presentation #29 P (cont.)

Table 2. Multivariate logistic regression analysis of severe paralysis (AIS A–C) on admission

	OR	95% CI	p-value
Age	1.04	1.00–1.07	0.03
Sex			
Male	Reference		
Female	0.54	0.18–1.58	0.26
Soft tissue damage	2.81	1.08–8.06	0.03
Degree of spinal cord compression			
Minor compression	Reference		
Moderate compression	1.06	0.44–2.55	0.90
Severe compression	5.3	1.5–24.1	0.01

AIS: American Spinal Injury Association impairment scale, CI: confidence interval, MSCC: maximum spinal cord compression, OR: odds ratio, minor compression: MSCC of less than 20%, moderate compression: MSCC exceeding 20% and less than 40%, and severe compression: MSCC exceeding 40%

Presentation #30 P

Defining Central Cord Syndrome: Does Neurology or Injury Morphology Provide Better Discrimination of Neurological Outcomes?

Jérôme Paquet, MD, Quebec City, QC, Canada
***Jin W. Tee, MD**, Vancouver, BC, Canada*
Vanessa K. Noonan, Vancouver, BC, Canada
Brian K. Kwon, MD, PhD, Vancouver, BC, Canada
Eve C. Tsai, MD, PhD, Ottawa, ON, Canada
Sean Christie, MD, Halifax, NS, Canada
Carly S. Rivers, PhD, Vancouver, BC, Canada
Henry Ahn, MD, Toronto, ON, Canada
Najmedden Attabib, MD, Halifax, NS, Canada
Christopher S. Bailey, MD, London, ON, Canada
Brian Drew, MD, Hamilton, ON, Canada
Michael G. Fehlings, MD, PhD, Toronto, ON, Canada
Joel A. Finkelstein, MD, Toronto, ON, Canada
Daryl R. Fourney, MD, Saskatoon, SK, Canada
R. John Hurlbert, MD, PhD, Calgary, AB, Canada
Stefan Parent, MD, Montreal, QC, Canada
Marcel F. Dvorak, MD, Vancouver, BC, Canada

Introduction: Central cord syndrome (CCS) is an incomplete spinal cord injury (SCI) pattern characterized by an ASIA Impairment Scale (AIS) C/D grade and a lower motor score in the upper extremities than lower extremities (UEMS < LEMS). CCS has been defined neurologically when UEMS is 5 to 10 points lower than LEMS. The morphology of CCS spans the spectrum from unstable injuries to more stable hyper-extension injuries in a spondylotic spine. While neurologic recovery is generally favourable, there is a wide spectrum of outcomes following CSS. We analyzed how neurologic outcome in patients with incomplete cervical SCI was influenced by the injury morphology (stable vs. unstable) and the difference in baseline motor score between upper and lower extremities.

Methods: Participants from the Rick Hansen Spinal Cord Injury Registry (RHSCIR) with cervical (C1-T1) injuries with baseline severity AIS C/D (ISNCSCI) were analyzed (n = 473). Injury morphology was defined by the treating spine surgeon and grouped into those with a fracture, dislocation or subluxation (unstable spine) and those with spondylosis and hyperextension (stable spine). The patients' injuries were neurologically defined by the difference in baseline motor score between upper and lower extremities (< 5, 5–10, > 10 UEMS < LEMS). A multivariate linear regression model was performed to determine the relationship between total motor score change (TMSΔ; discharge-admission) with baseline AIS grade; injury level (C1-C4 vs. C5-T1); injury morphology (stable vs. unstable); and UEMS < LEMS differences of < 5, 5–10, or >10.

See Disclosure Index pages 40–88.

Presentation #30 P (cont.)

Results: TMSΔ was not associated with any of the UEMS < LEMS difference groups ($p = 0.2267$) nor with high vs low cervical level ($p = 0.1256$). Patients with a stable spine had a higher mean change in motor score than those with unstable spine (25.9 vs. 21.1, $p = 0.0233$). Multivariate linear regression modelling showed AIS (C vs. D, $p < 0.0001$), spine stability ($p = 0.0084$), and the interaction of AIS with stability ($p = 0.0030$) were significantly associated with TMSΔ, whereas UEMS < LEMS differences had no significant association with TMSΔ. In patients with AIS C/D cervical injuries, those with a stable spine were more likely: older (58.4 vs 44.1y, $p < 0.0001$), male (88.1 vs. 75.5%, $p < 0.0025$), injured by fall (66.4 vs. 35.2%, $p < 0.0001$), and have 1+ comorbidities (41.7 vs. 19.3%, $p < 0.0001$). Stable patients had a longer delay from injury to arrival at specialized acute care, were less likely to receive acute surgery (65.4 vs. 93.1%; $p < 0.0001$) and had longer mean injury-surgery interval if operated on than those with unstable spines (77.2 vs 40.9h, $p < 0.0001$). TMSΔ was not different between stable and unstable spines for AIS C (38.6 vs. 38.3, $p = 0.8699$), but was significantly greater for AIS D patients with stable spines (16.3 vs. 10.2, $p = 0.009$).

Conclusion: The recovery of motor function (TMSΔ) after CCS is influenced by the stability of the spinal column; conversely, TMSΔ was not related to the magnitude of the difference in baseline motor score between upper and lower extremities. Hence, injury morphology was a more robust and meaningful predictive criteria for motor recovery than the neurologic definition of injury. The stable CCS population seems to be uniquely related to demographics and neurology and influences surgical management.

Presentation #31 P

Vertebral Artery Course for Occipital Condyle Screw Fixation

***Ho Jin Lee, MD**, Incheon, Republic of Korea*
Jae Taek Hong, MD, PhD, Suwon, Republic of Korea

Introduction: Fixation at the craniovertebral junction (CVJ) is necessary in a variety of clinical situations, and many surgical approaches have been developed to achieve it. Although the occipital squama (OS) is a general cephalad fixation point to connect the cranium to the cervical spine, there are several limitations to traditional OS fixation. The occipital condyle (OC) may be a good alternative fixation point in occipito-cervical fusion. However, the risk of vertebral artery (VA) injury during OC fixation has not been adequately assessed. The purpose of this study was to establish the course of the VA (V3) and its relationship to nearby osseous structures to estimate the feasibility of OC fixation.

Methods: A total of 387 three-dimensional computed tomographic angiograms (3D-CTA) were used and compared between two age groups. The vertebral artery diameter (VAD) and two kinds of bony space were measured. The occipito-C1 arch space (O-C1S) and VA-occipital bone distance (VOD, six entry points) were measured on both sides. O-C1S: The distance from the lower margin of the occipital bone to the upper margin of the C1 arch groove and VOD: The distance from the lower margin of the occipital bone to the superior surface of the VA. The feasibility of OC fixation can be represented by the VOD value; the minimum feasible value was determined to be 4 mm. Angular measurements (O-C1A and O-C2A) were also taken to assess their relationship to the bony space.

Results: The mean value of the O-C1S ranged from 9.0 to 9.9 mm. The mean value of the VOD ranged from 3.2 to 3.5 mm, and the proportion of individuals for which OC fixation was considered feasible ranged from 32 to 42% in both age groups. OC fixation was considered feasible in 102 (35.5%, right) patients and 111 (38.7%, left) patients in the young age group. OC fixation was considered feasible for 42 (42%, right) patients and 32 (32%, left) patients in the older age group. The VOD value was not affected by laterality or by gender ($P > 0.05$). The mean and standard deviation (SD) for the O-C1A was $-5 \pm 5.2°$ (range, -22–8°) in the young age group and $-7.6 \pm 5.3°$ (range, -26–2°) in the older age group. The mean and SD for the O-C2A was $12.4 \pm 6.4°$ (range, 3–33°) in the young age group and $10.4 \pm 6.4°$ (range, 0–36°) in the older age group. A greater number of older patients showed a floating or rising course of the VA than did the younger patients (older, 56%; younger, 47%) in the present study ($P < 0.05$).

Conclusion: The feasible space for OC fixation, as assessed by the VOD value, was limited, regardless of age. Fixation was not possible in a considerable number of cases due to the position and direction of the VA. Only about one quarter (21–24%) of all patients can undergo OC fixation of both sides simultaneously.

See Disclosure Index pages 40–88.

Presentation #31 P (cont.)

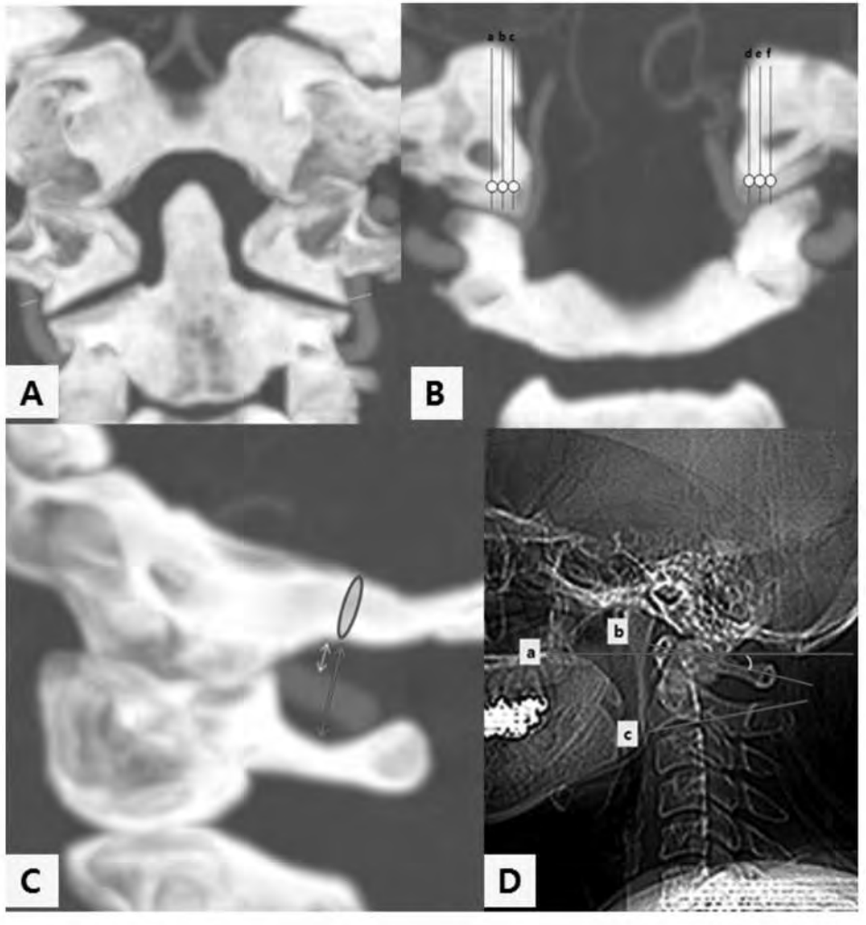


Figure 1.
A. vertebral artery diameter (VAD)
B. Three possible, adjacent fixation points (lateral, middle and medial) were identified around 5 mm lateral to the medial margin of the occipital condyle
C. vertebral artery-occipital bone distance (VOD) - yellow arrow, occipito-C1 arch space (O-C1S) - red arrow, occipital bone depth (OBD) - green ellipse
D. O-C1A (between a and b), O-C2A (between a and c)

Presentation #31 P

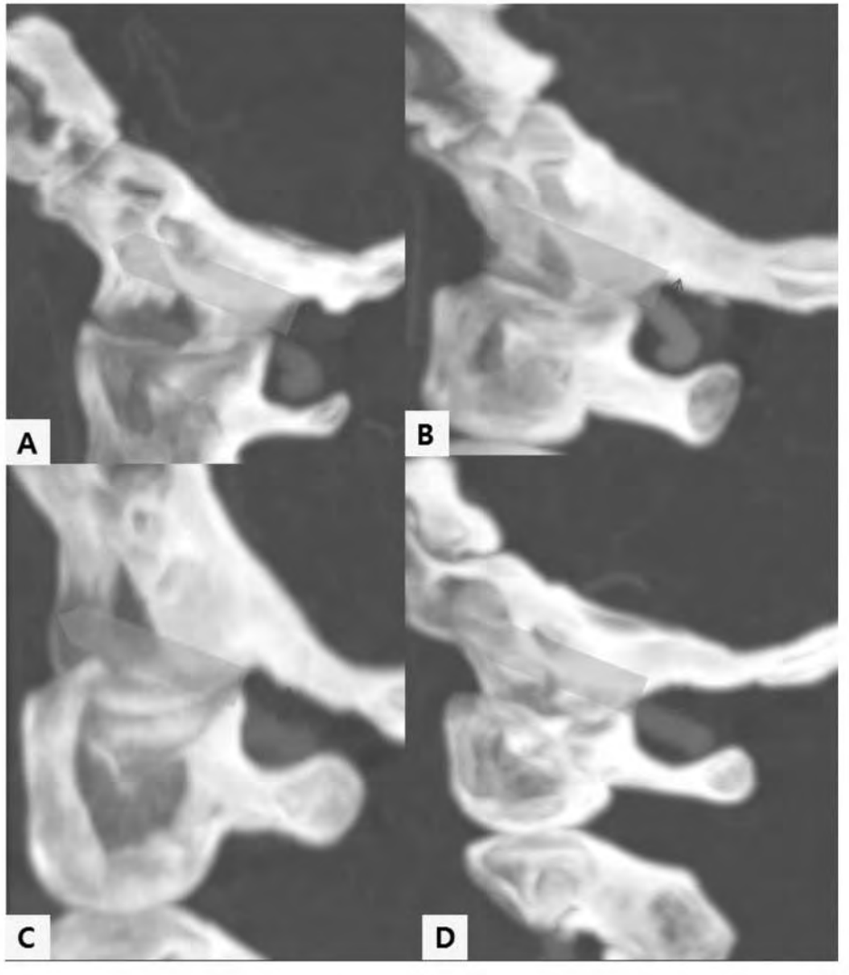


Figure 2.
A, B. Although two cases showed a riding course of the VA, OC fixation may be feasible only in case A considering the status of the O-C1S
C. This case show a absolutely impracticable status for OC fixation due to the narrow O-C1S value
D. Floating course of the VA disturbed the OC fixation

See Disclosure Index pages 40–88.

Presentation #32 P

Minimum Five-Year Follow-up Results for Occipitocervical Fusion Using the Screw-Rod System in Craniocervical Instability

***Kei Ando, MD**, Nagoya, Japan*
Shiro Imagama, MD, PhD, Nagoya, Japan
Naoki Ishiguro, MD, PhD, Nagoya, Japan

Introduction: Occipitocervical fusion surgery effectively treats severe neck pain and myelopathy from craniocervical instability and spinal cord compression. There has been no long term study with a consecutive series of patients treated by occipitocervical (OC) fusion using pedicle screws and rods. The purpose of this study was to evaluate the clinical outcome of patients who had undergone OC fusion using pedicle screws and rods over a minimum 5-year follow-up.

Materials and Methods: Twenty-seven consecutive patients with OC disorders treated underwent posterior OC fusion using pedicle screws and rods over a minimum 5-year follow-up. The Modified McCormick scale to grade a patient's functional status, and the Japanese Orthopaedic Association (JOA) scoring system were used to evaluate preoperative and postoperative neurological function. We assessed fusion by both direct and indirect evidence; bony trabeculae at the graft-recipient interface on lateral cervical radiographs and sagittal CT reconstruction was considered direct evidence of union. The implant-related complications included pullout of screws, rod breakage, plate breakage, screw breakage, screw loosening, and problems from sublaminar wiring.

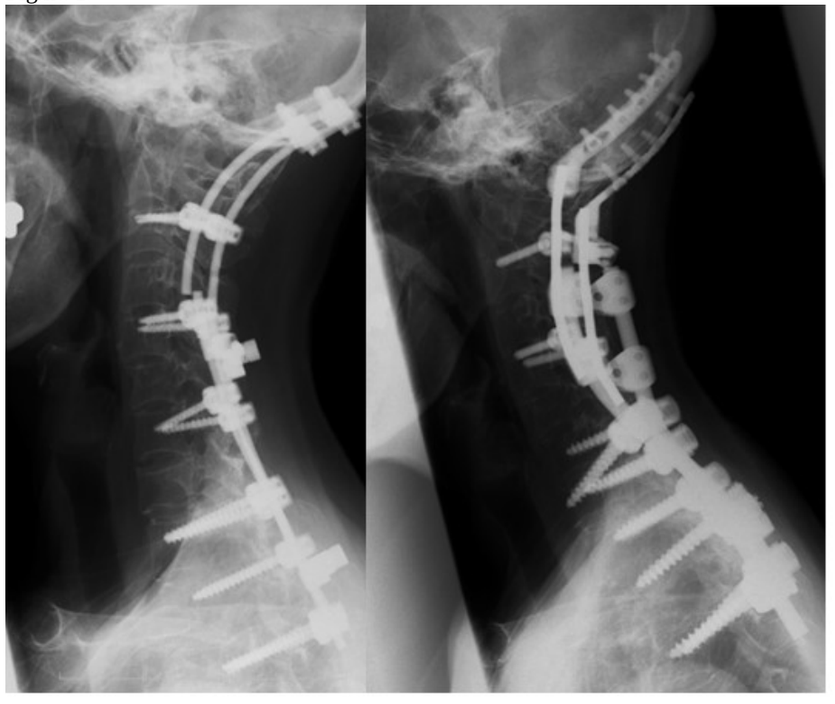
Results: The mean follow-up period was 7.2 years (5-14 years). There were 10 men and 17 women with an average age of 52.2 years (3–78 years). JOA scores were 8.1 ± 3.8 before surgery and 11.7 ± 3.7 at the final follow-up. The recovery rate calculated from the JOA scores was 42.0 ± 30.0%. Functional status did improve at least 1 grade according to the modified McCormick scale in 18 patients (66.7%). There was no deterioration at the final follow-up.

Conclusions: Complications such as pseudoarthrosis still occur following occipitocervical fusion surgery in spite of advances and refinements of spinal implants. In the present study, 6 of 8 cases with implant failure occurred 12 or more months after surgery. Furthermore, 4 implant failures occurred 24 or more months after surgery, and one case did not have rod breakage until 5 years after surgery. This is the first report showing the mean rate of delayed failure. Sufficient bone grafting, proper decortication of the bone bed, using thicker and high stiffness rods, and ultra-high molecular weight polyethylene tape as a fixation or reinforcement of implant may help prevent implant failure.

Thursday, December 3, 2015, 11:53 – 11:55 am CSRS – 2015

Presentation #32 P

Figure 1.



See Disclosure Index pages 40–88.

Presentation #33 P

Accurate and Simple Screw Insertion Procedure with Patient-Specific Screw Guide Templates for Posterior C1-C2 Fixation

***Taku Sugawara, MD, PhD**, Akita, Japan*
Shuichi Kaneyama, MD, PhD, Kobe, Japan
Masatoshi Sumi, MD, PhD, Kobe, Japan

Background: Posterior C1 lateral mass screw (LMS) and C2 pedicle screw (PS) fixation, also known as the Goel-Harms method can provide immediate rigid fixation, but the screw insertion carries a potential risk for injury to neuronal and vascular structures. It is also sometimes problematic to dissect venous plexus and C2 nerve root to confirm the insertion point of C1 LMS. To solve these problems, we developed an intraoperative screw guiding method using patient-specific laminar templates.

Methods: Preoperative bone images of the computed tomography (CT) scans were analyzed using three-dimensional (3D)/multiplanar imaging software and the trajectories of the screws were planned (Figure 1, upper left panel). Plastic templates with screw guiding structures were created for each lamina by 3D design and printing technology (Figure 1, upper right panel). Three types of templates were made for precise multi-step guidance, and all templates were specially designed to fit and lock on the lamina during the procedure. Plastic vertebra models were also generated and preoperative screw insertion simulation was performed (Figure 1, lower panels). Surgery was performed using this patient-specific screw guide template system, and the placement of screws was postoperatively evaluated using CT scanning.

Results: Twenty patients with C1-C2 instability were included in the study. This method was used to insert a total of 80 screws (40 C1 LMS, 34 PS, 6 C2 laminar screws). Intraoperatively, each template was found to exactly fit and lock on the lamina and screw insertion was completed successfully without seeing venous plexus and C2 nerve root. Postoperative CT scans showed no cortical violation of the screws (Figure 2), and mean deviation of the screws from the planned trajectories was 0.40 plus/minus 0.31 mm at mid coronal section of the spinal canal.

Conclusions: The multi-step, patient-specific screw guide template system is useful for intraoperative screw navigation in the posterior C1-C2 fixation. This simple and economical method can improve the accuracy of screw insertion, and reduce the operating time and radiation exposure of posterior C1-C2 fixation surgery.

Presentation #33 P

Figure 1.

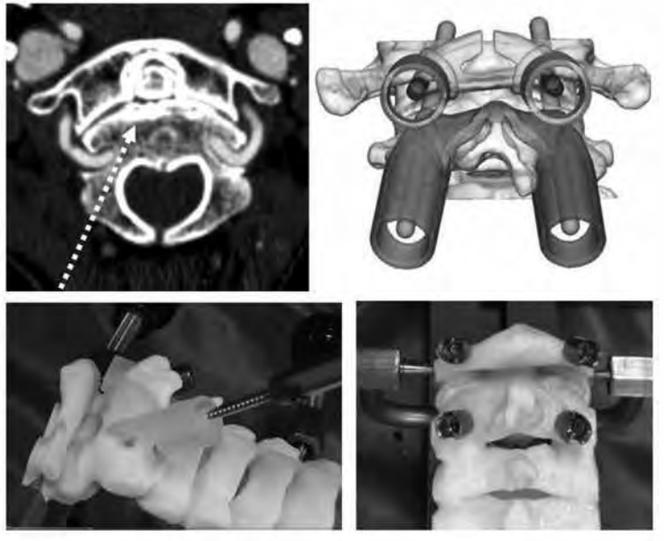
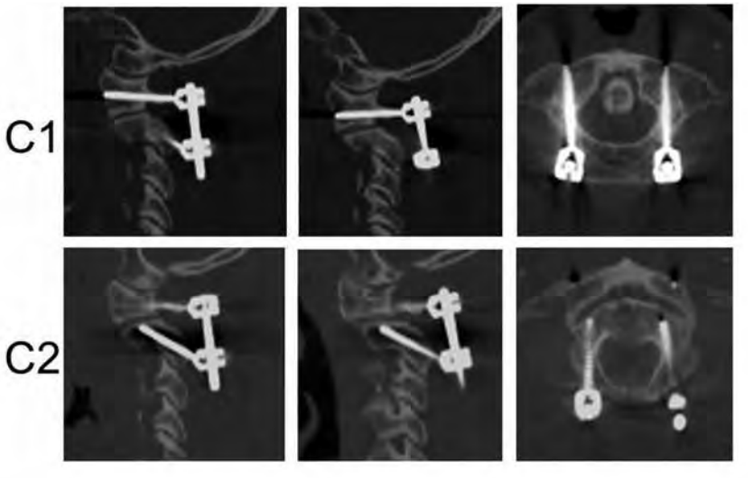


Figure 2.



See Disclosure Index pages 40–88.

Presentation #34 P

Subaxial Cervical Sagittal Alignment following C1-C2 Fusion for Atlanto-Axial Osteoarthritis

Daniel G. Kang, MD, St. Louis, MO
***Ronald A. Lehman, Jr., MD**, New York, NY*
Scott C. Wagner, MD, Bethesda, MD
K. Daniel Riew, MD, New York, NY

Introduction: Few studies have evaluated the outcomes following C1-C2 fusion for atlanto-axial osteoarthritis (AAOA). Previous studies in rheumatoid arthritis (RA) patients with atlanto-axial instability have demonstrated unexpected development of subaxial kyphosis following C1-C2 fusion, however this complication in patients with AAOA remains unknown. Therefore, we set out to evaluate subaxial cervical sagittal alignment following C1-C2 fusion for AAOA.

Methods: We performed a retrospective review of all patients following C1-C2 fusion from a single center, single-surgeon from 2002-2012. All charts, records and imaging studies were reviewed for each case, and pre-operative, immediate post-operative and final follow-up plain films were evaluated. Patients were divided into 3 diagnostic categories for further comparison: AAOA, rheumatoid, and trauma.

Results: A total of 29 patients were included in the review, with an average radiographic follow-up of 38 months. There were 14 patients with AAOA, 4 patients with RA/gout (1 gout patient with C1-C2 pannus causing spinal cord compression), and 11 patients treated for a traumatic etiology. Overall we found patients with AAOA did not have a significant change in subaxial sagittal alignment from pre-op to final follow-up (-11.7 to -13.8 deg, $p = 0.23$, (- deg) = lordosis, (+deg) = kyphosis), which was similar in the trauma group (-9.7 to -8.4 deg, $p = 0.47$). This was comparable to the RA/gout group that demonstrated a significant change in sagittal alignment from -20.5 to -0.2 deg ($p = 0.04$).

Conclusion: Our study demonstrates patients with non-rheumatologic conditions, (AAOA and trauma), undergoing C1-C2 fusion, do not develop post-operative subaxial cervical kyphosis. We postulate the loss of subaxial lordosis in the rheumatologic patients may be a function of their underlying systemic disease.

Presentation #35 P

The Pathomecahnisms of Dysphagia after Occipitospinal Fusion – Kinematic Analysis by Videofluoroscopic Swallowing Study

Shuichi Kaneyama, MD, PhD, Kobe, Japan
Masatoshi Sumi, MD, PhD, Kobe, Japan
Koichi Kasahara, MD, PhD, Kobe, Japan
Aritetsu Kanemura, MD, PhD, Kobe, Japan
Masato Takabatake, MD, Kobe, Japan
Akihiro Koh, MD, Kobe, Japan
Hiroaki Hirata. MD, PhD, Kobe, Japan

Introduction: Dysphagia is one of serious complications of occipitospinal fusion (OSF). It has been suggested that posterior shift of mandible and tongue root caused by the reduction of the occipito-C2 angle (O-C2A) makes the oropharyngeal space narrow and resulted in postoperative dysphagia. In fact, there has been little tangible evidence to support this hypothesis. The aim of this study is to elucidate the mechanism of dysphagia after OSF by analyzing swallowing process using the videofluoroscopic swallowing study (VFSS).

Materials and Methods: A total of 42 patients underwent OSF between 2005 and 2014 and six patients experienced postoperative dysphagia. Four patients with postoperative dysphagia (group D: all were female, averaged 76.0 y.o.) and four patients without postoperative dysphagia (group N: all were female, averaged 67.3 y.o.) participated in this study. For VFSS, all patients were monitored to swallow 5 ml diluted barium solution under fluoroscopic condition in the lateral view, and then dynamic passing pattern of the barium solution were analyzed. In addition, O-C2A was measured in each patient for the assessment of craniocervical alignment.

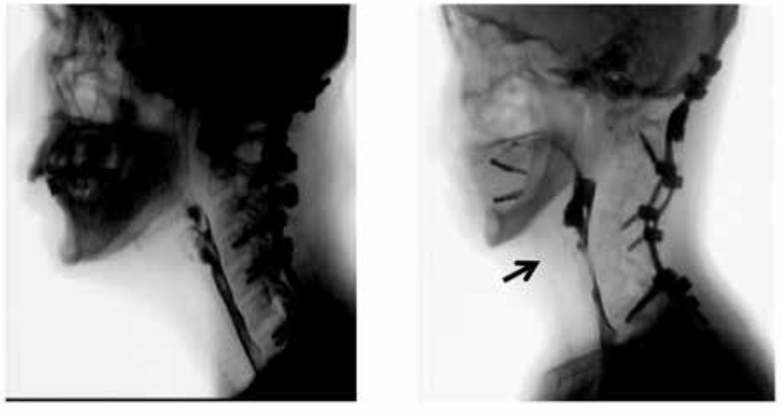
Results: O-C2A in group D was -8.0 degrees, which was relatively smaller than 7.8 degrees in group N ($P = 0.07$). It took an average of 7.3 seconds (4.0–11.0 seconds) to swallow the medium in group D, whereas it took only 1.5 seconds on average (1.4–1.6 seconds) in group N ($P < 0.05$). In group D, all cases presented smooth medium passing without any obstruction at the upper cervical level regardless of the posterior shift of the mandible and tongue root. However, the obstruction to the passage of medium by the pharyngeal stenosis was detected at the level of the apex of mid-lower cervical curvature below piriform sinus, where the anterior protrusion of mid-lower cervical spine compressed directly the pharyngeal space (Figure 1). In addition, three cases of group D showed that the medium was stuck at the mid-lower cervical apex and needed two or three times of swallowing motion to swallow 5 ml medium. In group N, all cases showed smooth passing of medium through the process of swallowing and they can swallow the medium in one swallowing motion.

See Disclosure Index pages 40–88.

Presentation #35 P (cont.)

Conclusion: This study presented postoperative dysphagia did not occur at the upper cervical level even though there was smaller angle of O-C2A and demonstrated the narrowing of the oropharyngeal space due to direct compression by the anterior protrusion of the mid-lower cervical spine was the etiology of dysphagia after OSF. Therefore, surgeon should pay attention not only to the alignment of craniocervical junction but also to the alignment from cranium to mid-cervical spine during OSF.

Figure 1. Characteristics of VFSS findings



Group N: Normal swallowing

Smooth passing of medium through the process of swallowing

Group D: Dysphagia

Entrapment at epiglottis level due to a bump made by anteriorly protruded mid-cervical spine (arrow)

Presentation #36

Does the Timing of Pre-operative Epidural Steroid Injection affect Infection Risk after ACDF or Posterior Cervical Fusion?

***Jourdan M. Cancienne, MD**, Charlottesville, VA*
Brian C. Werner, MD, Charlottesville, VA
Anuj Singla, MD, Charlottesville, VA
Hamid Hassanzadeh, MD, Baltimore, MD
Frank H. Shen, MD, Charlottesville, VA
Adam L. Shimer, MD, Charlottesville, VA

Introduction: Cervical epidural steroid injections (ESI) are commonly performed for both diagnostic and therapeutic purposes for patients with cervical spine disease prior to surgical intervention. Data regarding any association between preoperative cervical ESI and risk of postoperative infection following anterior cervical discectomy and fusion (ACDF) or posterior cervical fusion is limited. The goal of the present study is to employ a national database to evaluate the association of preoperative cervical ESI at various time intervals prior to ACDF or posterior cervical fusion with the incidence of postoperative infection.

Methods: A national insurance database was utilized to compare rates of infection within 90 days postoperatively in patients who received a cervical ESI at various time intervals prior to ACDF and posterior cervical fusion. Three cohorts were created for each procedure: posterior cervical fusion within 3 months following a cervical ESI (n = 402), posterior cervical fusion within 3–6 months after ESI (n = 586), and posterior cervical fusion within 6–12 months after ESI (n = 629); ACDF within 3 months of ESI (n = 4,354), ACDF within 3–6 months of ESI (5,183), and ACDF within 6–12 months of ESI (n = 3,648). These cohorts were compared to control cohorts who underwent posterior cervical fusion (n = 61,253) and ACDF (241,678) without documented prior ESI. Infection rates within 90 days postoperatively were assessed using ICD-9 and CPT codes.

Results: The incidence of postoperative infection after posterior cervical fusion within 90 days was significantly higher in patients who underwent cervical ESI within 3 months preoperatively (4.0%) compared to controls (2.1%, OR 1.9, p = 0.017) (Table 1A). There was no significant difference in infection rates in patients who underwent posterior cervical fusion 3–6 months or 6–12 months after ESI compared to controls (Table 1A). There were no statistically significant differences in infection rates in patients who underwent ACDF following ESI at any time point compared to controls (Table 1B).

See Disclosure Index pages 40–88.

Presentation #36 (cont.)

Conclusions: The present study demonstrates a significant increase in postoperative infection in patients who underwent posterior cervical fusion within 3 months following cervical ESI. This association was not noted when posterior cervical fusion was performed more than three months after cervical ESI. There was no observed association with preoperative cervical ESI and postoperative infection following ACDF.

Table 1-A. Posterior Cervical Fusion after Cervical ESI. 3 Month Infection Rates Stratified by Timing of ESI

Time between ESI and Posterior Cervical Fusion	# of Patients	3 Month Infection Rate		Statistical Comparison to Control	
	N	*n*	*%*	*O.R. [95% CI]*	*P*
0-3 Months	402	16	4.0%	1.9 [1.2 - 3.1]	0.017
3-6 Months	586	19	3.2%	1.5 [1.0 - 2.4]	0.088
6-12 Months	629	14	2.2%	1.0 [0.6 - 1.8]	0.979
Control (no prior ESI)	*61,253*	*1305*	*2.1%*	-	-

Table 1-B. Anterior Cervical Fusion after Cervical ESI. 3 Month Infection Rates Stratified by Timing of ESI

Time between ESI and Anterior Cervical Fusion	# of Patients	3 Month Infection Rate		Statistical Comparison to Control	
	N	*n*	*%*	*O.R. [95% CI]*	*P*
0-3 Months	4,354	34	0.8%	1.4 [0.9 - 1.9]	0.062
3-6 Months	5,183	22	0.4%	0.7 [0.5 - 1.1]	0.182
6-12 Months	3,648	17	0.5%	0.8 [0.5 - 1.3]	0.427
Control (no prior ESI)	*241,678*	*1366*	*0.6%*	-	-

Presentation #37

Is Obesity Correlated with Increased Complications following Cervical Surgery for Degenerative Conditions?

***J. Alex Sielatycki, MD**, Nashville, TN*
Silky Chotai, MD, Nashville, TN
David P. Stonko, BS, MS, Nashville, TN
Joseph B. Wick, BS, Nashville, TN
Harrison F. Kay, BS, Nashville, TN
Kevin R. O'Neill, MD, MS, Nashville, TN
Clinton J. Devin, MD, Nashville, TN

Introduction: Obesity is a common comorbidity among spine patients. Previous studies have investigated correlations between obesity and complications in thoracolumbar spine surgery. To our knowledge no prospective studies have analyzed the direct effect of obesity on complications in patients undergoing elective cervical surgery. The impact of obesity on complications, operative time, and length of hospitalization remains uncertain in this population. The purpose of this study was to investigate the correlation between obesity, complications, length of stay, and operative time following elective anterior cervical discectomy and fusion (ACDF) for degenerative cervical conditions at a high-volume center.

Methods: Consecutive patients undergoing elective ACDF for stenosis, disc herniation, and cervical spondylotic myelopathy (CSM) at a single academic institution were evaluated from 2010 to 2013. Follow-up of at least 12 months was required. Patients were excluded in cases of trauma, tumor, infection, urgent/emergent surgery, deformity, and pseudarthrosis. Complications assessed included wound infection, hematoma, urinary tract infection (UTI), deep venous thrombosis (DVT), pulmonary embolism (PE), pneumonia, myocardial infarction, death, recurrent symptoms or new neurologic deficit. Patients were defined as "obese" for BMI greater than or equal to 35 based on the World Health Organization (WHO) definition of class II obesity. Chi-square and student-t tests were used to analyze demographic and surgical characteristic. Complications were tracked by electronic medical record, as well as by telephone interview in order to capture complications seen at outside hospitals. A sub-group analysis separated patients into the WHO obesity categories for BMI of ≤ 25, 25–30, 30–40, and ≥ 40. Complication rates in each group were compared using Chi-Square analysis.

See Disclosure Index pages 40–88.

Presentation #37 (cont.)

Results: A total of 299 patients were included with 219 (73%) BMI ≤ 35, and 80 (27%) with BMI > 35. The overall 90-day complication rate was 6%. There was no difference in complications between groups: BMI ≤ 35 had 15 (6.8%) complications, compared with 5 (6.2%) in the BMI > 35 group (p = 0.78). UTI and surgical site infection were the most common complications (3 incidents each); others included hematoma, new neurologic deficits, and hardware failure. Length of stay was slightly lower in the BMI ≤ 35 group (1.3 vs 1.7 days, p = 0.056). There was a small difference in operative time in non-obese vs. obese that did not reach statistical significance (158 vs. 173 minutes, p = 0.11). Subgroup analysis showed that there were no differences in complication rates for BMI ≥ 40 (6.6%) compared with other BMI categories (p = 0.76).

Conclusions: In this analysis of prospective data from patients undergoing elective cervical surgery at a high-volume academic center, BMI greater than 35 was not associated with increased 90-day complications. Length of stay was found to be slightly longer in the obese group. These findings suggest that when the added complexities of obesity are frequently seen and managed, obesity may not contribute to increased surgery-related complications in cervical procedures.

Presentation #38

Complications of Iliac Crest Bone Graft in Cervical Spine Surgery

***M. Leslie Golden, MD**, Atlanta, GA*
Steven K. Leckie, MD, Atlanta, GA
John G. Heller, MD, Atlanta, GA

Background: There is wide variation in the reported prevalence and severity of morbidity associated with iliac crest bone grafts (ICBG) for spine fusions. As these data have often been derived from lumbar fusion patients, the possibility that residual symptoms from the low back and donor site may have co-mingled casts doubt on the accuracy of such assessments.

Methods: Patients who had a posterior cervical fusion with ICBG from 2002-2012 were evaluated with an ICBG specific questionnaire and the Oswestry Disability Index. A matched group of cervical laminoplasty patients were given the ODI. The results of the ICBG patients' ODI and ICBG questionnaire were compared using an independent group t-test and a Fisher's exact test. The ICBG and laminoplasty groups ODI scores were compared using a t-test.

Results: The study cohort comprised 68 patients who had an ICBG for posterior cervical fusion and 61 patients who had a cervical laminoplasty. The mean follow-up time was 6.8 vs. 6.2 years (p = 0.276), with a range of 1.9 to 12.7 years. The mean age was 59.6 vs. 61.2 years old (p = 0.478). The average ODI score between the groups differed by 3.3% disabled (p =.316). The number of patients with no residual harvest site symptoms was 48/76 (63.2%). The number of patients taking medication for harvest site symptoms was 7/76 (9.2%).

Conclusions: Long-term follow-up of patients who had a posterior iliac crest bone graft for posterior cervical fusion showed no significant difference in low back pain or disability group as compared to a similar group of laminoplasty patients using the Oswestry Disability Index self-reported questionnaire, which places the functional impact of the residual donor site symptoms in perspective. The prevalence of ICBG-harvest site residual symptoms was within the range that is commonly reported. The data suggest that the functional impact of ICBG harvest may be over-stated, especially as increasing numbers of alternatives have entered the market, and more nuanced conversations about ICBG morbidity are needed.

See Disclosure Index pages 40–88.

Presentation #39

Does the use of Intrawound Vancomycin Decreases the Risk of Surgical Site Infection after Elective Spine Surgery? – A Multicenter Analysis

***Clinton J. Devin, MD**, Nashville, TN*
Alexander R. Vaccaro, III, MD, PhD, Philadelphia, PA
Matthew J. McGirt, MD, Charlotte, NC
Silky Chotai, MD, Nashville, TN
Jim A. Youssef, MD, Durango, CO
Douglas G. Orndorff, MD, Durango, CO
Paul M. Arnold, MD, Kansas City, KS
Anthony K. Frempong-Boadu, MD, New York, NY
Isador H. Lieberman, MD, MBA, Plano, TX
Hirad Hedayat, MD, Winston Salem, NC
Charles L. Branch, Jr., MD, Winston Salem, NC
Jeffrey C. Wang, MD, Los Angeles, CA
Robert E. Isaacs, MD, Durham, NC
Kristen E. Radcliff, MD, Philadelphia, PA
Joshua C. Patt, MD, Charlotte, NC
Kristen R. Archer, MD, Nashville, TN

Background: Surgical site infection (SSI) is an expensive complication associated with spine surgery. The application of intrawound vancomycin is rapidly emerging as a solution to reduce SSI. The impact of intrawound vancomycin has not been systematically studied in a well-designed multicenter study. We determine whether intrawound vancomycin application was associated with reduced risk of SSI in patients after spine surgery.

Methods: Patients undergoing elective spine surgery over the period of four-years at seven different sites across the US were included in the study. Patients were given standard IV antibiotics perioperatively and dichotomized based on whether intrawound vancomycin was applied. Multivariable random effect log-binomial regression analyses were conducted to determine the relative-risk of having a SSI and a SSI with return to OR within postoperative 30-days. Random effect was included *a priori* to account for clustering of patients within each site. Fraction of variance attributable to differences between sites was calculated by dividing the variance of site random effect by the total variance in the model (site + participants).

Presentation #39

Results: Total 2311 patients were included: degenerative spine pathologies 89% (2056), trauma 10% (233), and tumor 1% (22). Table1 summarizes patient characteristics. Intrawound vancomycin was used in 45% of patients. Prevalence of SSI was 5.1% in absence of vancomycin use vs. 2.4% with intrawound vancomycin. Site-to-site variation in SSI ranged from 1.5%–5.7% (Table 2). In multivariable regression model, patients in whom intra-wound vancomycin was not used (RR-2.3, CI-1.5–3.6), those with higher number of levels exposed (RR-1.1, CI-1.0–1.1), postoperative ICU admission (RR-2.1, CI-1.3–3.3) and obesity (RR-1.8, CI-1.0–3.0) had higher risk of developing SSI. Risk factors for SSI with return to OR included not applying intra-wound vancomycin (RR-5.2, CI-2.6-10.4), higher number of levels exposed (RR-1.1, CI-1.0–1.2), and postoperative ICU admission (RR-2.5, CI-1.5–4.3). Geographical site variation accounted for 3% of variance in SSI and 20% in SSI with return to the OR.

Conclusion: Intrawound application of vancomycin after elective spine surgery was associated with reduced risk of SSI and return to OR associated with SSI, even after controlling for confounding variables.

See Disclosure Index pages 40–88.

Presentation #39 (cont.)

Table 1. Demographic and Clinical Characteristics of Study Participants (N = 2311)

Characteristic	*Total*	*Vancomycin (N=1051)*	*No Vancomycin (N=1260)*	*p-Value*
Demographic Characteristics				
Age in years, Mean ± SD	58.8 ± 14.8	59.6 ± 14.3	58.1 ± 15.1	.01
Sex, N (%)				
Female	1132 (49.0)	513 (48.8)	619 (49.1)	.88
Male	1179 (51.0)	538 (51.2)	641 (50.9)	
Race, N (%)				
White	2017 (87.3)	925 (88.0)	1092 (86.7)	.33
Non White	294 (12.7)	126 (12.0)	168 (13.3)	
BMI Category, N (%)				
Normal	566 (24.5)	257 (24.4)	309 (24.5)	.16
Overweight	960 (41.5)	417 (39.7)	543 (43.1)	
Obese	785 (34.0)	377 (35.9)	408 (32.4)	
Current Smoker, N (%)				
No	1725 (74.6)	796 (75.7)	929 (73.7)	.27
Yes	586 (25.4)	255 (24.3)	331 (26.3)	
Diabetes, N (%)				
No	1872 (81.0)	831 (79.1)	1041 (82.6)	.03
Yes	439 (19.0)	220 (20.9)	219 (17.4)	
Steroid Use, N (%)				
No	2186 (94.6)	984 (93.6)	1202 (95.4)	.06
Yes	125 (5.4)	67 (6.4)	58 (4.6)	
Chronic Renal Insufficiency				
No	2222 (96.1)	1005 (95.6)	1217 (96.6)	.23
Yes	89 (3.9)	46 (4.4)	43 (3.4)	
Clinical Characteristics				
Primary Diagnosis, N (%)				
Degenerative	2056 (89.0)	966 (91.9)	1090 (86.5)	< .001
Trauma	233 (10.0)	80 (7.6)	153 (12.1)	
Tumor	22 (1.0)	5 (0.5)	17 (1.4)	
Location, N (%)				
Lumbar-Sacral	1502 (65)	715 (68.0)	787 (62.5)	< .001
Cervical	636 (27.5)	243 (23.1)	393 (31.2)	
Thoracic	173 (7.5)	93 (8.9)	80 (6.3)	
Revision Surgery, N (%)				

Presentation #39

No	1642 (71.1)	729 (69.4)	913 (72.5)	0.10
Yes	669 (28.9)	322 (30.6)	347 (27.5)	
Instrumentation, N (%)				
No	455 (19.7)	220 (20.9)	235 (18.7)	0.17
Yes	1856 (80.3)	831 (79.1)	1025 (81.3)	
Arthrodesis, N (%)				
No	391 (16.9)	160 (15.2)	231 (18.3)	0.05
Yes	1920 (83.1)	891 (84.8)	1029 (81.7)	
ICU Stay, N (%)				
No	1792 (77.5)	804 (76.5)	988 (78.4)	0.27
Yes	519 (22.5)	247 (23.5)	271 (21.6)	
Number of spine levels exposed	3.7 (2.8)	3.7 (2.9)	3.7 (2.7)	0.76
Length of Stay in days, Mean ± SD	5.6 ± 6.3	5.7 ± 5.6	5.6 ± 6.8	0.71

Table 2. Distribution of SSI and SSI resulting in return to OR by site and use of Vancomycin (N = 2 311). Site-to-site variation in SSI ranged from 1.5%–5.7%

Site	*Total SSI*	*Vancomycin*	*No Vancomycin*	*Total SSI return to OR*	*Vancomycin*	*No Vancomycin*
A.	8 (3.6%)	4 (1.8%)	4 (1.8%)	0 (0%)	0 (0%)	0 (0%)
B.	15 (4.5%)	5 (1.5%)	10 (3.0%)	2 (0.6%)	1 (0.3%)	1 (0.3%)
C.	21 (3.8%)	6 (1.1%)	15 (2.7%)	16 (2.9%)	2 (0.3%)	14 (2.6%)
D.	20 (5.1%)	1 (.3%)	19 (4.8%)	20 (5.1%)	1 (.3%)	19 (4.8%)
E.	14 (5.7%)	4 (1.6%)	10 (4.1%)	13 (5.3%)	3 (1.2%)	10 (4.1%)
F.	6 (1.5%)	4 (1%)	2 (0.5%)	3 (0.7%)	2 (0.5%)	1 (0.2%)
G.	5 (3.0%)	1 (0.6%)	4 (2.4%)	3 (1.8%)	0 (0%)	3 (1.8%)

See Disclosure Index pages 40–88.

Presentation #40

Recurrent Laryngeal Nerve Palsy after Cervical Spine Surgery – A Multicenter Study

Ziya L. Gokaslan, MD, Baltimore, MD
***Mohamad Bydon, MD**, Baltimore, MD*
Jay Won Rhee, MD, Baltimore, MD
Rafael D. De la Garza-Ramos, MD, Baltimore, MD
Zachary A. Smith, MD, Chicago, IL
Wellington K. Hsu, MD, Chicago, IL
Sheeraz A. Qureshi, MD, MBA, New York, NY
Samuel K. Cho, MD, New York, NY
Evan O. Baird, MD, New York, NY
Thomas E. Mroz, MD, Cleveland, OH
Michael G. Fehlings, MD, PhD, Toronto, ON, Canada
Paul M. Arnold, MD, Kansas City, KS
K. Daniel Riew, MD, New York, NY

Introduction: Recurrent laryngeal nerve (RLN) palsy is a known potential complication following anterior cervical spine surgery.

Methods: A multicenter retrospective study was performed to determine the incidence of RLN palsy following anterior cervical spine surgery. A total of 1,345 patients were screened. Demographic variables, modified Japanese Orthopedic Association (mJOA) score, Nurick score, and symptom resolution were recorded from clinical notes.

Results: Nineteen patients (1.4%) with a diagnosis of RLN palsy were identified. The range across centers was 0.6% to 2.9% and the rate of RLN palsy at the primary center was 2.9%. The mean age of patients was 59 ± 13 years, and 42% were female; the mean height was 1.71 + 0.13 m and mean weight was 71.7 ± 17.5 kg. Two patients had a history of smoking (10.5%). The baseline mJOA score was 17.4 ± 1.5, and Nurick score was 1.3 ± 0.9. Eighteen patients (94.7%) underwent an anterior approach, and 1 (5.3%) a circumferential approach. The mean hospital stay for all patients was 4.2 ± 2.6 days. Ten patients (52.6%) required treatment – 6 required medical therapy (steroids), 1 surgical treatment (injection laryngoplasty), and 3 conservative therapy. When examining outcomes, 73.7% (14/19) of cases resolved completely, 15.8% (3/19) resolved with residual effects, and in 10.5% (2/19) of cases this could not be determined. At last follow-up, the mJOA score was 17.4 ± 1.6 and Nurick score 0.4 ± 1. The Nurick score decreased significantly from baseline to last follow-up (p = 0.002).

Conclusion: In this multicenter study, the rate of recurrent laryngeal nerve palsy following cervical spine surgery was 2.9% at the primary center. When examining outcomes, 74% of cases were found to resolve completely. However, 16% of patients may experience resolution with residual effects.

Presentation #41

Predictive Risk Factors of Cervical Spine Instabilities in Rheumatoid Arthritis: A Prospective Minimum 10-Year Multicenter Cohort Study

***Yoshiki Terashima, MD**, Kobe, Japan*
Takashi Yurube, MD, PhD, Kobe, Japan
Hiroaki Hirata, MD, PhD, Kobe, Japan
Daisuke Sugiyama, MD, PhD, Kobe, Japan
Masatoshi Sumi, MD, PhD, Kobe, Japan

Introduction: Rheumatoid arthritis (RA) is a chronic inflammatory disease. RA often causes cervical spine instabilities such as atlantoaxial subluxation (AAS), vertical subluxation (VS) of the atlas, and subaxial subluxation (SAS), which can induce serious compression myelopathy. Identification of predictors for the development of instabilities is essential for the clinical follow-up of patients with RA. Our objective was to elucidate predictive risk factors of cervical spine instabilities in RA.

Methods: According to lateral cervical spine radiographs, cervical spine instability was defined as AAS with the anterior atlantodental interval (ADI) > 3 mm, VS with the Ranawat value <13 mm, and SAS with irreducible vertebral translation ≥ 2 mm. "Severe" category of instabilities with impending neurological deficit was defined as AAS with ADI ≥10 mm, VS with Ranawat value ≤ 10 mm, and SAS with translation ≥ 4 mm or at multiple levels. Between 2001 and 2002, in 21 facilities, 634 outpatients who fulfilled the criteria for "definite" or "classical" RA were enrolled in this study. 503 of 634 were identified as those without "severe" instability at baseline. During the initial 5 years, 223 of 503 were prospectively followed and 5 underwent cervical spine surgery. During the last 5 years, 143 of 223 were continuously followed and a patient received surgery. Multivariable survival analysis using the Cox proportional hazards model was designed to identify predictive factors for the development of "severe" instabilities in 143 patients without baseline "severe" instability who took this over 10-year follow-up.

See Disclosure Index pages 40–88.

Presentation #41 (cont.)

Results: As shown in Figure 1, the number of patients with cervical spine instabilities consisting of AAS, VS, and SAS increased from 59 (41.0%) of 143 patients at baseline to 97 (68.8%) at the 5th-year follow-up during the initial 5 years ($p < 0.01$) but not during the last 5 years (110 [76.9%] at the 10th-year follow-up) ($p = 0.09$). The incidence of "severe" instabilities also increased from 0 (0.0%) of 143 patients to 35 (24.5%) at the 5th-year follow-up ($p < 0.01$) but not at the 10th-year follow-up (44 [30.8%]) ($p = 0.23$). 44 cases were thus identified as those who developed "severe" instabilities during over 10 years. The Cox proportional hazards model identified three significant predictors of "severe" instability (Table 1). The most relevant variable in the progression to "severe" instabilities was "baseline mutilating changes" (hazard ratio [HR] 19.14, 95% confidence interval [95% CI] 3.96-92.58, $p < 0.01$). "Corticosteroid administration" (HR 4.00, 95% CI 1.76–9.11, $p < 0.01$), and "previous joint surgery" (HR 1.99, 95% CI, 1.01-3.93, $p = 0.048$) were also significant variables. "Baseline CRP $\geq$ 3.8 mg/dl" and "development of mutilating changes during the follow-up period" demonstrated a significant correlation in the univariable model ($p = 0.03$ and $p < 0.01$, respectively) but not in the multivariable model. "Biologic agent administration" was not significant but showed marginal negative correlation with "severe" instability (HR 0.38, 95% CI, 0.11-1.38, $p = 0.14$).

Conclusion: Predictive risk factor for severe aggravation of cervical spine instabilities in RA patients are revealed to be peripheral mutilating changes at baseline, concomitant corticosteroid administration, and previous joint surgery, all consisting with prior evidence. Further investigations for protective effects of biologic agents are required.

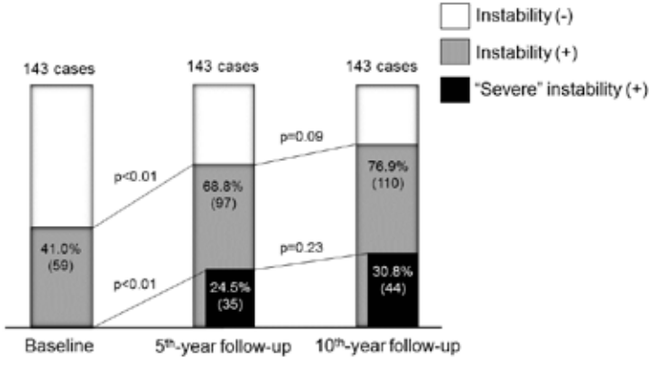


Figure1. The number of patients with cervical spine instabilities and those with "severe" cervical spine instabilities at the 5th- and 10th-year follow-up in 143 patients consecutively followed for over 10 years.

Presentation #41

Variable	HR	95% CI	p Value
Demographics and clinical characteristics			
Male sex	0.37	0.15 - 0.93	0.03
< 56 year old	0.87	0.40 - 1.89	0.72
≥ 65 year old	1.92	0.88 - 4.16	0.10
CRP ≥ 3.8 mg/dl	0.82	0.34 - 1.97	0.65
RF positive	1.23	0.54 - 2.81	0.62
Previous joint surgery at baseline	1.99	1.01 - 3.93	0.048
Medications			
Corticosteroids ≥ 5 mg/day	4.00	1.76 - 9.11	<0.01
MTX	1.45	0.67 - 3.11	0.34
Other DMARDs	1.10	0.54 - 2.23	0.79
Biologics agents at the 5th-year follow-up	0.38	0.11 - 1.38	0.14
RA stages and mutilating changes			
Stage III or IV at baseline	2.95	0.85 - 10.27	0.09
Mutilating changes at baseline	19.15	3.96 - 92.58	<0.01
Development of stages I-IV into mutilating changes during the follow-up period	1.58	0.47 - 5.24	0.46

Table 1. Hazards ratios (HRs), 95% confidence intervals (95% CIs), and p values for the development of "severe" cervical spine instabilities in 143 patients consecutively followed for over 10 years by the multivariable Cox proportional hazards model.

See Disclosure Index pages 40–88.

Presentation #42

Morbidity Rate and Risk Factors of Cervical Lesions in Rheumatoid Arthritis Patients under Current Pharmacological Treatment Paradigm

***Takashi Kaito, MD, PhD**, Suita, Japan*
Hiroyasu Fujiwara, MD, Suita, Japan
Takahiro Makino, MD, DMSc, Suita, Japan
Masafumi Kashii, MD, PhD, Suita, Japan
Yusuke Sakai, MD, Suita, Japan
Kazuo Yonenobu, MD, DMSc, Tokyo, Japan

Introduction: Cervical spine involvement is a common complication of rheumatoid arthritis (RA), and the resultant deformities may cause neurological deficits such as cervical myelopathy, paresis, and even death. Treatment paradigms for RA have recently undergone a major shift. Standard of care now entails initiating immediate treatment using aggressive therapy with disease-modifying antirheumatic drugs (DMARDs) or a combination of DMARDs plus biological agents (Bio). However, the effects of the dramatic shift in pharmacological treatment on cervical lesions are not elucidated. The purpose of this study is to elucidate morbidity rate and risk factors for cervical lesions in RA patients with onset after 2000 under current pharmacological treatment paradigm.

Methods: Of RA patients who have an onset from 2000 to 2009, 151 patients (Female: 33, Male: 118, Mean age: 50.6 years old) who biological agents (Bio) were introduced during their therapeutic process because of high disease activity and received cervical x-ray after 5 years from the onset were included in this study. The mean duration from onset to the x-ray (duration period) was 8.5 years and mean period from onset to the introduction of Bio was 5.9 years. The radiographic definition of cervical lesions was: atlanto-dental interval (ADI) >3 mm for atlanto-axial subluxation (AAS); a Ranawat value <13 mm for vertical subluxation (VS); and listhesis > 2mm for subaxial subluxation (SS). Disease activity score (DAS)-CRP, MMP-3 value, number of swelling and tender joints, Steinbrocker stage and functional class were also investigated. Univariate and multivariate regression techniques were used to assess predictors for progression including age of onset, sex, duration period, period from onset to first Bio, Steinbrocker stage, functional class, dose of prednisolone / methotrexate (MTX), DAS-CRP, MMP-3 value and onset year before or after 2005.

Thursday, December 3, 2015, 4:35–4:41 pm CSRS–2015

Presentation #42

Results: Radiographic evaluation was AAS in 43 cases (28%); and VS in 10 cases (7%), and SS in 6 cases (4%). Morbidity rate of cervical lesion was 32% (48/151) (Table 1). Mean DAS-CRP score and MMP-3 value were 3.8 and 211(ng/dl) at the time when first Bio was introduced. Univariate analysis between the patients w/ or w/o cervical lesions demonstrated that age of onset, duration period, period from onset to first Bio, and onset before 2005 were statistically significant (Table 2). Multivariate regression analysis showed that duration period (p = 0.0002, Odds ratio: 1.2, 95% CI:1.1–1.4) and Steinbrocker stage (p = 0.04, Odds ratio:1.58, 95% CI:1.0–2.5) were predictors for the development of cervical lesions.

Conclusion: Despite of innovative advancement of pharmacological treatment for RA patients, the morbidity rate of cervical lesion was still high (>30%) and the duration period and Steinbrocker stage were the predictors for development of cervical lesions. We have been reported that biological agents were capable of preventing the development of new cervical lesions. However, the results of this study suggest cervical lesions can develop at early years after the onset. Therefore, periodical checkup of cervical lesions still hold a prominent position for the management of cervical lesions in RA patients.

Table 1. Morbidity rate of cervical spine lesions

	N. of Pts	%		N. of Pts	%
None	103	68%	None	103	68%
AAS	43	28.5%	AAS / VS / SS	48	31.8%
VS	10	6.6%			
SS	6	4%			

See Disclosure Index pages 40–88.

Presentation #42 (cont.)

Table 2. Comparison between w/ or w/o cervical lesions (univariate analysis)

	Cervical lesion (+) n=48	cervical lesion (-) n=103	P value
Age	47.3 ± 13.2	52.0 ± 12.4	§ 0.059
Sex (M:F)	9:39	24:79	*0.673
Period From onset to first Bio (y)	6.9±3.5	5.5 ± 3.0	§ 0.017
Duration period (y)	9.5± 2.4	8.1 ± 2.7	§ 0.001
Steinbrocker Stage(I: II: III: IV)	1:12:20:15	6:43:37:17	*0.067
Functional Class(1:2:3:4)	12:33:3:0	35: 67:1:0	*0.113
Prednisolone (mg/day)	7.2 ± 5.8	6.3 ± 4.4	§ 0.580
MTX (mg/w)	7.8 ± 3.8	7.2 ± 3.2	§ 0.277
DAS –CRP	3.9 ± 1.6	3.7 ± 1.1	§ 0.565
MMP-3 (ng/dl)	242.3 ± 256	197.9 ± 145.1	§ 0.482
Onset (< 2005 : ≥ 2005)	36:12	57:46	*0.030

§ ;Mann-Whitney U-test, *; chi-square test

Presentation #43

Prevalence and Imaging Characteristics of Asymptomatic and Symptomatic Spondylotic Cervical Spinal Cord Compression in General Population

***Josef Bednarik, MD, PhD**, Brno, Czech Republic*
Miloš Kerkovský, MD, PhD, Brno, Czech Republic
Zdenek Kadanka, MD, PhD, Brno, Czech Republic
Zdenek Kadanka, Jr., MD, Brno, Czech Republic
Ivana Kovalová, Brno, Czech Republic
Barbora Jurová-Jakubcova, MD, Brno, Czech Republic

Introduction: Magnetic resonance imaging (MRI) is able to detect spondylotic cervical cord compression that could cause cervical spondylotic myelopathy (CSM) but could also remain asymptomatic ("asymptomatic spondylotic cervical cord compression" – ASCCC). The prevalence of both ASCCC and CSM is not known and data in the literature differ widely. Cervical cord impingement or compression was previously found in 27% of subjects accidentally examined with MRI; in individuals older than 64 years the prevalence reached 30% (Teresi et al.1987). Aim of this study was to estimate the prevalence and MRI characteristics of both ASCCC and CSM in a general population above the age of forty.

Methods: One hundred and eighty four randomly chosen healthy volunteers, recruited irrespective of the presence of signs of CSM, 93 women and 91 men, aged 66 (median), 40-80 (range) years participated in the study. All underwent MRI examination on a 1.5 T device using conventional sequences, including T1, T2 and STIR (short-tau inversion recovery) images in the sagittal plane and axial T2 weighted gradient-echo scans and diffusion tensor imaging coherently covering 5 segments of cervical spine from C2/C3 to C6/C7 levels. The clinical status of patients/volunteers was blinded for a neuroradiologist who evaluated cervical spine MRIs. Imaging criteria for cervical cord compression (measured at level of maximum compression level) was defined as:

- Impingement, ie. focal concave defect of spinal cord contour and with preserved subarachnoid space (type I);
- Flat or circular compression with partially preserved subarachnoid space (type IIa) or with lost subarachnoid space (type IIb).

Cross-sectional spinal cord area, anteroposterior and laterolateral diameter of cervical spinal cord, compresion ratio (anteroposterior/laterolateral spinal cord diameter), the presence of spinal cord T2 hyperintensity and of cervical stenosis (anteroposterior diameter of cervical canal < 12 mm) was also detected. Subject with MRI signs of cervical cord compression were subsequently examined clinically.

See Disclosure Index pages 40–88.

Presentation #43 (cont.)

Results: MRI signs of cervical cord compression were found in 99 individuals (53.8%). Clinical signs of symptomatic CSM were found in 2 cases (1.1%), while in 97 cases (52.7%) the compression was asymptomatic. Isolated focal impingement (type I) was present in 31 cases (16.8%), wide compression of type IIa in in 47 subjects (25.5%), and of type IIb in 21 subjects (11.4%). Decreased cross-sectional area at the level of compression < 50 mm^2 was detected in 9 cases (4.9% including two cases with CSM), and T2 hyperintensity in 5 subjects (2.7%; one with symptomatic myelopathy). There were significant differences in some imaging parameters between subgroups with and without signs of compression, especially in compression ratio with lower values in subgroups with compression.

Conclusion: Prevalence of asymptomatic spondylotic cervical cord compression in a population over the age of 40 years is higher than previously reported. In most cases, compression is asymptomatic, less severe, and not accompanied with significant decrease of CSA, presence of T2 hyperintensity and change in DTI parameters compared with findings in subjects without compression. The predictive significance of different types of compression remains to be established in future prospective evaluation of larger group of subjects.

Presentation #44

What is the Most Accurate Radiographic Anterior Cervical Fusion Criteria?

***Kwang-Sup Song, MD**, Seoul, Republic of Korea*
K. Daniel Riew, MD, New York, NY

Introduction: Determination of anterior cervical fusion status is an integral part as evaluating or comparing the surgical outcome after anterior cervical arthrodesis. The determination has been dependent on the various radiographic criteria because the "gold standard", surgical exploration is mostly impractical. Despite its clinical significance, most radiographic fusion criteria are still not validated or standardized. The purpose of this study is to demonstrate the diagnostic accuracy of the criteria for determining anterior cervical fusion status correlated with the results of surgical exploration.

Materials/Methods: The patients who required anterior or posterior exploration of previous anterior cervical arthrodesis of any level(s) ranging from C3-4 to C7-T1 for suspicion of pseudarthrosis or adjacent segment pathology were retrospectively investigated. Inclusion criteria were that the patient should have effective dynamic radiographs and thin cut multi-axial reconstructed CT scan before exploration available on a computer working station and be at least 1-year post-operative from their index anterior arthrodesis. The data from two raters participated in evaluation for all criteria were selected and eighty-two patients with 151 cervical segments were enrolled. Four diagnostic criteria were correlated with the results of surgical exploration: 1. Interspinous motion (ISM) criteria on dynamic radiographs; ISM<1mm with superjacent ISM ≥ 4mm on 150% magnified radiographs, 2. Bone bridging; bridging bone and/or the no radiolucency at graft-vertebral junction, 3. Extra-graft bone bridging (ExGBB); peripheral cortical bridging outside of the graft at operated segment, and 4. Intra-graft bridging bone (InGBB); bone bridging within the confines of the graft at operated segment. The values were expressed Cohen's kappa value.

Results: Inter- and intra-reliability values showed that ExGBB had the highest, 0.887 to 0.947, and then ISM criteria showed 0.860 to 0.906. Both criteria were "nearly perfect" agreement, however, the levels of agreement of Bone bridging and InGBB were "substantial agreement" except the evaluation of Bone bridging of one rater. The validity values correlated with the results of surgical exploration was the highest, 0.889 in ExGBB followed by ISM criteria, 0.776 and Bone bridging, 0.751 (Table 1). InGBB was the lowest kappa value, 0.656. Based on grafts used, all criteria except Bone bridging showed the highest value in auto-cortical graft group and all four criteria demonstrated the lowest validity values in synthetic cages groups. In cases of synthetic cages used, the validity values of ISM criteria and ExGBB were highest, 0.666 and 0.663 respectively, compared to Bone bridging, 0.504 and InGBB, 0.308 (Table 2).

See Disclosure Index pages 40–88.

Presentation #44 (cont.)

Conclusions: Among four diagnostic criteria for anterior cervical fusion status, ExGBB showed the highest accuracy correlated with surgical exploration. ISM criteria demonstrated similar or slightly higher accuracy compared to Bone bridging on CT scan. Based on grafts used, the cases used auto-cortical graft showed mostly highest accuracy in all criteria. Especially, in evaluating fusion status of cervical segment with synthetic cages, careful decision should be needed and ExGBB and ISM criteria could be recommended even all four criteria had low validity values.

Table 1. The kappa values of reliability and validity in each criteria

		ISM<1mm with superjacent ISM≥4 mm	Bone bridging	ExGBB	InGBB
Reliability	Intra-rater A	0.906	0.894	0.933	0.695
	Intra-rater B	0.867	0.755	0.947	0.656
	Inter-rater	0.860	0.755	0.887	0.662
Validity	Rater A	0.805	0.813	0.939	0.642
	Rater B	0.747	0.689	0.840	0.670
	Rater A+B	0.776	0.751	0.889	0.656

Table 2. The kappa values of validity based on grafts used

	Auto-cortical graft (n=23)	Allograft (n=81)	Synthetic cages (n=37)
ISM	0.836	0.753	0.666
Convention bone bridging	0.753	0.802	0.504
ExGBB	1.000	0.912	0.663
InGBB	0.929	0.699	0.308

Presentation #45

Circulating MicroRNAs Reflect Neural Dysfunction in Patients with Cervical Spondylotic Myelopathy: Implications for a Novel Biomarker of Disease Pathobiology

***Alex Laliberte, MSc**, Toronto, ON, Canada*
Spyridon K. Karadimas, MD, PhD, Toronto, ON, Canada
Sukhvinder K. Kalsi-Ryan, BScPT, MSc, PhD, Toronto, ON, Canada
Aria Nouri, MD, Toronto, ON, Canada
Eric M. Massicotte, MD, Toronto, ON, Canada
Michael G. Fehlings, MD, PhD, Toronto, ON, Canada

Introduction: While increasing evidence points to a beneficial role for surgical decompression in CSM, key clinical issues and controversies remain. Approximately 5% of patients with CSM sustain perioperative neurological decline following decompression with the risk factors for this decline remaining unclear. Additionally, patients with significant cord compression on MRI but minimal clinical symptoms represent a significant management challenge. We hypothesize, based on recent work from preclinical animal CSM models, that circulating microRNAs could reflect the pathobiology of the disease and thus could serve as biomarkers of CSM. We report the results of a prospective clinical series that sought to evaluate the potential role of microRNAs as biomarkers for CSM.

Methods: Thirty CSM patients and ten healthy controls were recruited for the initial screening study with another 40 subjects recruited for validation. Exclusion criteria for the screening study included: previous surgery, symptomatic lumbar stenosis, cardiovascular disease, hypertension, systemic infection, reduced liver, kidney or immune function, and diabetes. Blood plasma was collected from all subjects, and 179 microRNAs were screened using the Exiqon miRCURY Serum/Plasma PCR platform. The Normfinder algorithm was used to determine the optimal normalization controls for the dataset. Subjects were divided into healthy control, mild CSM (mJOA $\geq$ 15) and moderate/severe CSM (mJOA < 15) groups and One-Way ANOVA was used to determine significant differences in microRNA expression. Logistic regression models were created to distinguish healthy control versus CSM cases, as well as mild versus moderate/severe CSM cases. Additional validation of the models was performed using a bootstrap re-sampling procedure with 80 replicates.

See Disclosure Index pages 40–88.

Presentation #45 (cont.)

Results: The mean age and mJOA scores were 53.3 ± 10.8/15.9 ± 0.8, 60.1 ± 9.4/12.4 ±1.4, and 51.7 ± 10.9 in mild CSM, moderate/severe CSM and healthy subjects, respectively. The gender ratio was 1:1 in healthy and CSM groups. Following microRNA data normalization, 8 microRNAs had statistically significant ($p < 0.05$) expression differences between groups. Four of those microRNAs (let-7f-5p, miR-34a, let-7c, miR-154-5p) contributed significantly to the logistic regression models. These models discriminated well between healthy control and CSM patients (Figure 1, let-7f-5p [OR = 0.106], miR-34a [OR = 0.232], let-7c [OR = 27.4], AUC = 0.837) and between mild CSM and moderate-severe CSM patients (Figure 2, let-7f-5p [OR = 0.040] and miR-154-5p [OR = 5.5], AUC = 0.930). Model performance with the bootstrap replicates decreased marginally in discrimination of healthy controls versus CSM cases (Figure 1, AUC = 0.713), but remained high for CSM severity discrimination (Figure 2, AUC = 0.889)

Conclusions: The results reported herein demonstrate that plasma microRNA expression can predict the presence and severity of CSM. Based on previous work in the preclinical model, it is plausible that these microRNAs are related to the underlying ischemic and inflammatory mechanisms driving myelopathy. Future work will focus on assessing potential of microRNA in identifying patients at risk for perioperative decline following decompression and those with cord compression and minimal clinical symptoms that are at risk for disease progression.

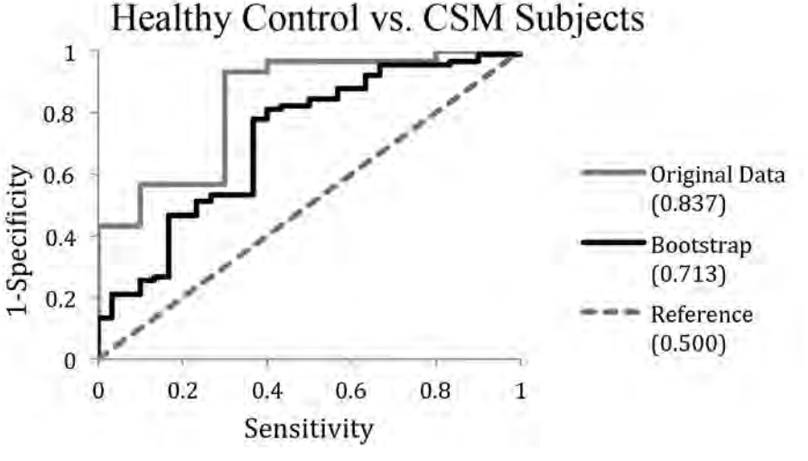


Figure 1. Receiver-operator curves for a logistic regression model discriminating between healthy and CSM subjects.

Presentation #45

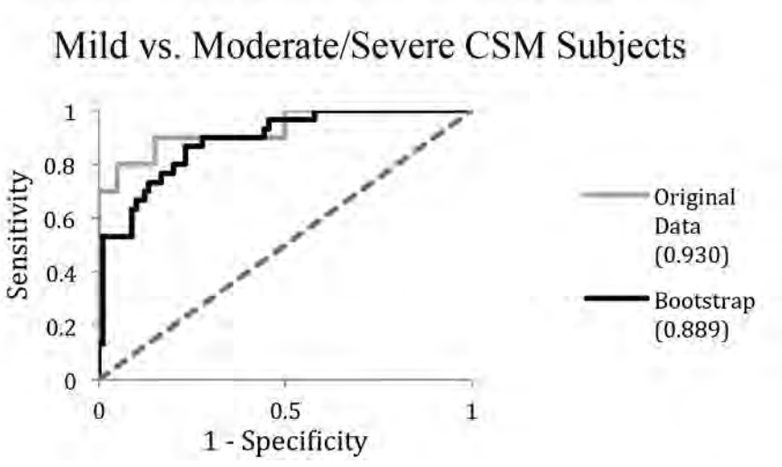


Figure 2. Receiver-operator curves for a logistic regression model discriminating between mild (mJOA ≥ 15) and moderate/severe (mJOA < 15) CSM patients.

See Disclosure Index pages 40–88.

Presentation #46

What is the Fate of the Pseudarthrosis Detected at One Year after Anterior Cervical Discectomy and Fusion?

Jae Hwan Cho, MD, Seoul, Republic of Korea
Jung-Ki Ha, MD, Seoul, Republic of Korea
Choon Sung Lee, MD, PhD, Seoul, Republic of Korea
Chang Ju Hwang, MD, Seoul, Republic of Korea
Sunghun Choi, MD, Seoul, Republic of Korea
Chul Gie Hong, MD, Seoul, Republic of Korea
Youn-Suk Joo, MD, Seoul, Republic of Korea
***Dong-Ho Lee, MD, PhD**, Seoul, Republic of Korea*

Introduction: Pseudarthrosis following anterior cervical discectomy and fusion (ACDF) is one of the most common complications that are related with unsatisfactory postoperative results. It may be an embarrassing situation if surgeons detect pseudarthrosis around 1 year after ADCF since little is known about long-term prognosis of this nonunion segment. The purpose of this study is to investigate what its fate is and what the appropriate management could be in that situation.

Methods: One hundred and two consecutive patients who underwent ACDF for cervical spondylotic radiculopathy and/or myelopathy between 2007 and 2012 were screened for eligibility. Two of them underwent revision surgeries at the same levels before 1 year because of persistent or recurred symptoms. Other 86 patients (M:F = 46:40, age 59.0 ± 11.1 years, follow-up 37.4 ± 13.3 months) with minimum 2-year follow-up were included in this study. In all the patients, ACDF using allografts and plating were performed: 1-level for 51 patients, 2-level for 25 patients, and 3-level for 10 patients (a total of 131 segments). Pseudarthrosis was diagnosed with the interspinous distance (ISD) method (ISD change > 1mm on 150% or more magnified flexion/extension lateral x-rays). Presence of pseudathrosis was evaluated at every fusion level at postoperative 1 year and then the nonunion segments were re-evaluated at postoperative 2 years to see whether they were fused or not. Demographic data including smoking, comorbidities, the surgery levels and the number of fusion segments were assessed to determine the risk factors associated with persistent pseudarthrosis. Neck Disability Index (NDI), Visual Analogue Scale (VAS) of neck/arm pain, and various radiographic parameters were also analyzed in 3 time periods (preoperative, postoperative 1 year and 2 years).

Presentation #46

Results: Pseudarthrosis was detected in 27 patients (31.4%) at postoperative 1 year: 15/51 patients with 1-level, 8/25 with 2-level, and 4/10 with 3-level ACDF. Among them, only 8 patients (29.6%) showed persistent pseudarthrosis at postoperative 2-years: 3/15 patients with previous 1-level, 3/8 with 2-level, and 2/4 with 3-level ACDF. In brief, 27 patients had pseudarthrosis at postoperative 1 year, however, 19 of them (70.4%) were finally fused at postoperative 2 years without any interventions. The patients who underwent 2- or 3-level ACDF had a significantly higher pseudarthrosis rate than those who underwent a single level ACDF with an odds ratio of 2.4 (95% CI, 0.355–16.213; P = 0.021) and 4.0 (95% CI, 0.388–41.228; P = 0.017), respectively. The improvement in VAS of neck pain and NDI score in the persistent pseudarthrosis group were significantly less than those in the final fusion group at postoperative 1 year. There were no significant differences in the other clinical and radiologic parameters between both groups.

Conclusion: The pseudarthrosis segments detected at postoperative 1 year after ACDF could be observed without any interventions because 70.4% of them would be spontaneously fused until 2 years. However, considering that the patients with nonunion following multi-level ACDF and less improvement in neck pain or NDI at postoperative 1 year have a higher risk of persistent pseudarthrosis, early revision surgery could be an option to achieve a solid fusion in these patients.

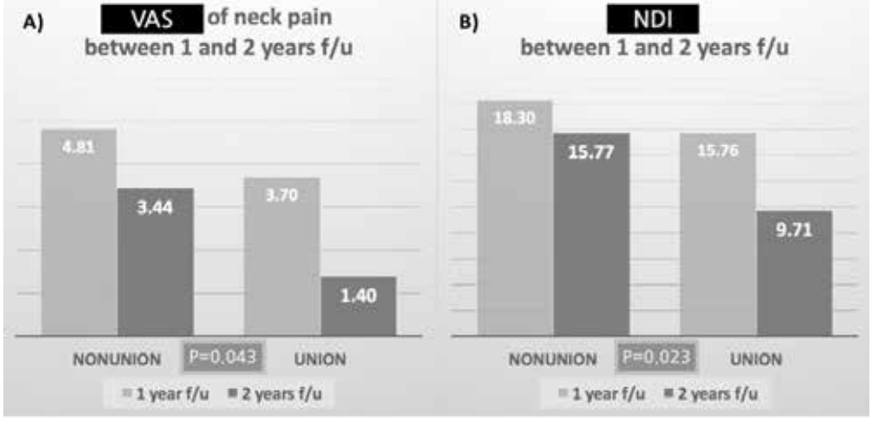
See Disclosure Index pages 40–88.

Presentation #46 (cont.)

Table 1. The risk factors of persistent pseudarthrosis at 2 years follow-up after ACDF

	All	Union Patients	Nonunion Patients	Odds Ratio (95% CI, P)
Gender				
Male	15	11	4	
Female	12	8	4	1.375 (0.262-7.220, P=0.707)
Age				
<60	14	8	6	
≥60	13	6	7	1.016 (0.944-1.094, P=0.670)
Smoking				
No	22	16	6	
Yes	5	3	2	1.778 (0.236-13.405, P=0.577)
Neurology				
CSR	21	15	6	
CSM	4	2	2	2.500 (0.284-22.042, P=0.409)
CSRM	2	2	0	-
Foraminotomy				
No	8	5	3	
Yes	19	14	5	0.113 (0.017-0.744, P=0.061)
Fusion level				
1 level	15	12	3	
2 levels	8	5	3	2.4 (0.355-16.213, P=0.021)
3 levels	4	2	2	4.0 (0.388-41.228, P=0.017)

Figure 1. A) VAS of neck pain and B) NDI with 1-year and 2 years follow-up after ACDF between nonunion group and union group



Presentation #47

ACDF with Total En Bloc Resection of Uncinate in Foraminal Stenosis of the Cervical Spine: Comparison with Conventional ACDF

***Kyung-Soo Suk, MD, PhD**, Seoul, Republic of Korea*
Hak-Sun Kim, MD, PhD, Seoul, Republic of Korea
Seong-Hwan Moon, MD, PhD, Seoul, Republic of Korea
Hwan-Mo Lee, MD, PhD, Seoul, Republic of Korea
Jae-Ho Yang, MD, Seoul, Republic of Korea
Sung-Yub Jin, MD, Seoul, Republic of Korea
Pierre M. Mella, MD, Seoul, Republic of Korea

Introduction: Foraminal stenosis is a major cause of radiculopathy. Most of the foraminal stenosis is due to hypertrophied uncinate process or osteophyte from uncovertebral joints. To relieve the radiculopathy, ACDF is the most frequently performed procedure. No studies have been performed comparing ACDF with and without uncinate resection. Purpose of this study was to find out any differences in clinical outcomes of ACDF depending on uncinate resection or not.

Methods: 606 patients who underwent ACDF due to foraminal stenosis were included in this study. Minimum follow-up was 2 years. ACDF due to soft disc herniation, myelopathy, AP combined surgery, or follow up less than 2 years were excluded in this study. Group U was consisted of 275 patients who underwent uncinate resection and group N was consisted of 331 patients who did not undergo uncinate resection. Total en bloc resection of uncinate was performed using osteotome. After resection of uncinate, we observed the nerve root and completely released any compression (Figure 1). Clinical outcomes were measured by preoperative and follow up neck pain visual analogue scale (VAS), arm pain VAS, neck disability index (NDI), and patient reported subjective improvement rate. Follow up was performed on postoperative 6 weeks, 3, 6, 9, 12, 18, and 24months. Statistical analysis was performed by independent sample t-test and paired sample t-test.

Results: Preoperative Neck pain, arm pain, and NDI were similar between the two groups. Neck pain VAS, arm pain VAS, NDI, and patient reported subjective improvement rate were all improved significantly after the surgery (at 6-week follow-up) in both groups and the improved outcomes were maintained during 24 month follow-up. There were no significant differences between the two groups in overall clinical outcomes including neck pain VAS, NDI, subjective improvement rate. There were significant differences between the two groups in arm pain at all times. Arm pain was significantly less in uncinate resection group at all times (Figure 2).

See Disclosure Index pages 40–88.

Presentation #47 (cont.)

Conclusion: Overall clinical outcomes were significantly improved at 6 weeks after the ACDF depending on uncinate resection or not. After 6 weeks, there was no significant improvement. There were no significant differences between the two groups in terms of neck pain, NDI, and subjective improvement rate. However, arm pain was significantly less in uncinate resection group at all times.

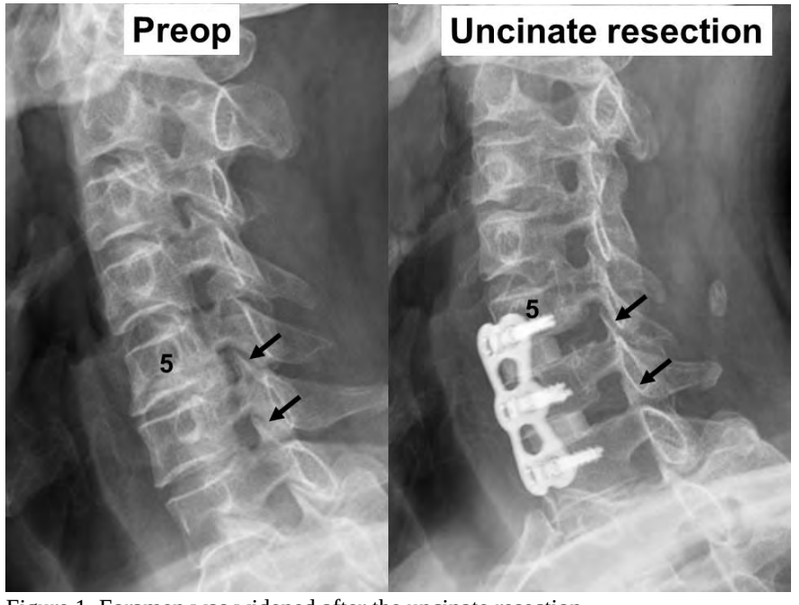


Figure 1. Foramen was widened after the uncinate resection

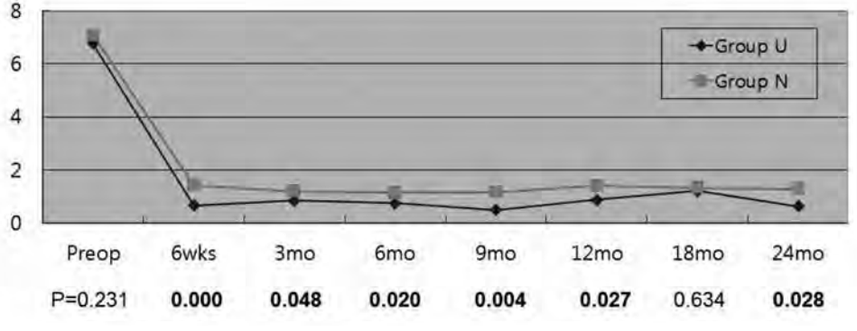


Figure 2. Arm pain VAS

Presentation #48

Predictors of Extended Hospital Stay after Cervical Disc Replacement or Anterior Cervical Discectomy and Fusion: Results from 1,004 Patients in an FDA Trial

S. Tim Yoon, MD, PhD, Decatur, GA
***Aaron J. Greenberg, MD**, Decatur, GA*
Praveen V. Mummaneni, MD, San Francisco, CA

Introduction: Extended hospital stay after surgery is costly to the healthcare system and can be distressing to the patient and family. While many studies have shown that the type of surgery influences length of hospital stay, there is a paucity of data on factors that extend hospital stay after single level anterior cervical surgery. We used the data from a large series of patients involved in two FDA Trials comparing one level cervical disc replacement to one level ACDF to identify factors that contribute to prolonged hospital stay.

Materials/Methods: Data from 1004 patients involved in the Investigational arm (n = 518) and Control arm (n = 486) of the Brian/Prestige CDR Trial were analyzed. The dependent variable of this analysis was LOS (length of hospital stay). The independent variables analyzed for their affect on LOS after CDR/ACDF included the following: *Demographic characteristics*, *Preoperative efficacy measurements* (NDI, SF-36, etc.) *Preoperative medical conditions and medication, Preoperative Neurologic Status* (motor function, Nurick-Gait, etc.) and *Intraoperative factors* (Operative time, EBL, etc.)
Subjects with a LOS (defined as date of discharge – date of initial surgery) of zero days (same day discharge) or one day (over-night discharge) were compared to those with a length of stay greater than one day.

Results: An initial logistic regression analysis was carried out. Treatment group was found not to be a significant factor in length of hospital stay between CDR and ACDF. Because of this, a second logistic regression model was created using all-comers data and included eight independent variables (Race, Tobacco Used, Weak Narcotic Medications, Arm Pain Score, SF-36 MCS, Preoperative Sensory, Gait and Operative Time) identified to be significant (p-value < 0.05) in the preliminary analysis.
A total of 912 (90.84%) patients had a Length of stay less than or equal to one day (one midnight) and 92 patients (9.16%) had an extended length of stay greater than one day (two or more midnights).
Three variables were determined to have a significant affect on increasing the length of hospital stay: Weak Narcotic Medications Usage (P = .021, O.R. 1.72), Nurick-Gait (P = .019, O.R. 1.796), and Operative Time. In particular, Operative Time is was found to be highly significant with p-value < 0.0001. With a one-hour increase in the operative time, the odds of longer hospital stay increase by 2.062. Comorbid factors such as Cardiac, DM, other diseases were found not to affect the hospital length of stay after CDR and ACDF.

See Disclosure Index pages 40–88.

Presentation #48 (cont.)

Conclusion: We used the high quality data from a large cohort of patients involved in FDA trials and found Nurick-Gait, Operative Time, and History of Weak Narcotic Usage to be drivers of extended hospital stay. Importantly, we also found that there is no correlation between comorbidities such as Cardiac, DM, other diseases with length of hospital length of stay after CDR and ACDF. These data may be useful in preoperatively counseling patients, developing quality metrics for hospitals, and to help create financial models for cost/DRG reimbursement for single level anterior cervical surgery.

Presentation #49

Effect of Inclusion of Asymptomatic Spondylotic Levels on Adjacent Segment Disease following ACDF

***Caleb J. Behrend, MD**, Roanoke, VA*
Paul W. Millhouse, MD, Philadelphia, PA
Vismay Thakkar, MD, Springfield, IL
Alexander R. Vaccaro, III, MD, PhD, Philadelphia, PA
Alan S. Hilibrand, MD, Philadelphia, PA
Todd J. Albert, MD, New York, NY

Introduction: This study examined the incidence of symptomatic adjacent segment disease with new radiculopathy or myelopathy referable to a motion segment adjacent the site of a previous anterior arthrodesis of the cervical spine.

Materials/Methods: A consecutive series of 570 patients, who had a total of 603 anterior cervical arthrodesis for the treatment of cervical spondylosis with radiculopathy, myelopathy or both, were followed for a maximum of thirteen years after the index operation. The annual incidence of symptomatic adjacent-segment disease was defined as the percentage of patients who had been disease-free at the start of a given year of follow-up in whom new disease developed in that year leading to subsequent surgical intervention. The prevalence was defined as the percentage of all patients in whom symptomatic adjacent-segment disease developed within a given period of follow-up. Kaplan-Meier survivorship analysis was used to characterize the natural history of disease. The hypothesis was that the application of neuroradiology, evolving technology, and differing clinical decision making with inclusion of asymptomatic spondylotic levels, would be associated with a decreased incidence of symptomatic adjacent segment disease following ACDF.

Results: Symptomatic adjacent-segment disease occurred at a relatively constant incidence of 1.6 percent per year (range 0.0 to 2.8 percent) during the ten years after the index operation. Survivorship analysis predicted that 14.5 percent of the patients (95 percent confidence interval, 7.3 to 21.7 percent) who had an anterior cervical arthrodesis would have new disease at an adjacent level within ten years after the operation (Figure 1). No statistically significant difference was observed in rates of adjacent segment disease between groups based on number of levels fused (Figure 2).

Conclusion: Inclusion of asymptomatic spondylotic levels was associated with lower rates of adjacent segment degenerative disease in the presented study population.

See Disclosure Index pages 40–88.

Presentation #49 (cont.)

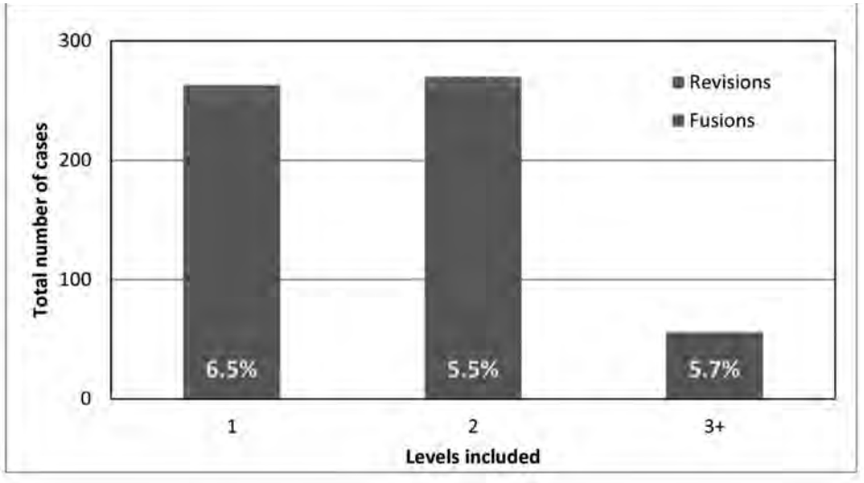


Figure 1. Number levels fused related to rate of revision surgery

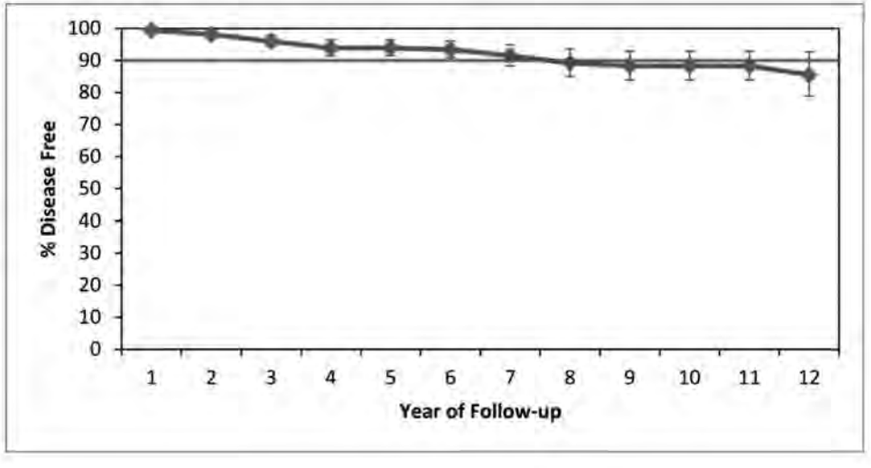


Figure 2. Kaplan-Meier survivorship curve

Presentation #50

Adjacent Segment Range of Motion does not Increase Two-Years after Single-Level Cervical Arthrodesis

William Anderst, PhD, *Pittsburgh, PA*
Tyler West, Pittsburgh, PA
William F. Donaldson, III, MD, Pittsburgh, PA
Joon Yong Lee, MD, Pittsburgh, PA
James D. Kang, MD, Pittsburgh, PA

Introduction: The purpose of this longitudinal study was to determine if adjacent segment motion progressively increases following single-level anterior cervical discectomy and fusion (ACDF). It was hypothesized that adjacent segment range of motion (ROM) would increase with time post-surgery, and that adjacent segment ROM 2 years post-surgery would be significantly greater than ROM at corresponding motion segments in age-matched controls.

Methods: Eight C5-C6 ACDF patients (1 M, 7 F; Age = 45 ± 9 years, tested 7 ± 1 months and 28±6 months post-surgery) and ten asymptomatic controls (4 M, 6 F; Age = 45 ± 6 years) performed full range of motion (ROM) head axial rotation and flexion/extension while biplane radiographs were collected at 30 images per second. Bone motion was tracked with sub-millimeter accuracy using a validated volumetric model-based tracking technique that matched subject-specific bone models (obtained from CT) to the biplane radiographs. Six degree-of-freedom range of motion (ROM) was calculated for motion segments between C3 and C7. Global head ROM was determined using reflective markers placed on the head and torso. Differences in intervertebral and global head ROM were identified between a) the control and ACDF group 7 months post-surgery, b) the control and ACDF group 28 months post surgery, and c) the ACDF group 7 months and 28 months post-surgery. Significance was set at $p < .05$ for all tests.

Results: Operated site ROM in ACDF patients was significantly less than in controls, and decreased significantly from 7 months to 2 years post-surgery (Figure 1, Figure 2). Adjacent segment ROM was not significantly different between controls and patients 7-months post-ACDF (all $p \geq 0.86$ and all $p \geq 0.43$ for rotation and flexion\extension, respectively). Adjacent segment ROM increased slightly from 7 months to 2 years post-surgery, however, these increases did not reach statistical significance (all $p \geq 0.1$ for rotation; all $p \geq 0.052$ for flexion\extension) (Figure 1, Figure 2).
Global head ROM was less in ACDF patients than in age-matched controls 7 months and 2 years after ACDF. However, these differences were not statistically significant in rotation (ACDF 7 Months: 109±24°, $p = 0.06$; ACDF 2 Years: 122 ± 13°, $p = 0.20$; controls 130 ± 25°) or in flexion\extension (ACDF 7 Months: 71 ± 13°, $p = 0.09$; ACDF 2 Years: 74 ± 15°, $p = 0.68$; controls 81±11°).

Presentation #50 (cont.)

Conclusion: The current results contradict previous in vitro studies and indicate that during in vivo dynamic flexion\extension and axial rotation of the head, adjacent segment ROM is not significantly increased 7 months or 2 years after arthrodesis. This suggests that in vitro test protocols do not adequately reflect in vivo conditions and that adjacent segment degeneration following ACDF is not due to excessive motion in adjacent segments following ACDF. These results call into question the need for "motion-preserving" disc replacement devices that are intended to reduce the (presumed) increased stress on adjacent segments (due to the presumed increased adjacent segment motion) following fusion. Longer-term follow-up data will be necessary to determine if and when adjacent segment ROM significantly increases beyond that found in age-matched asymptomatic controls.

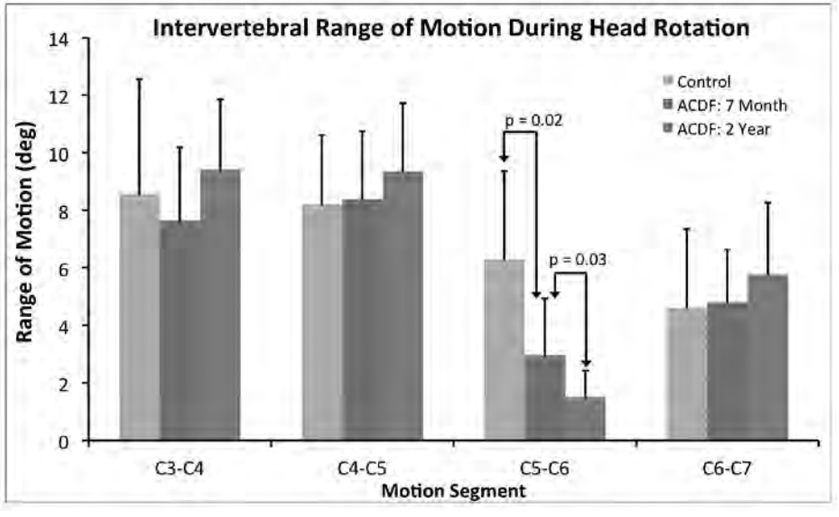


Figure 1. Intervertebral rotation ROM during head axial rotation. All surgeries were performed at the C5-C6 level. Error bars represent ± 1 SD.

Presentation #50

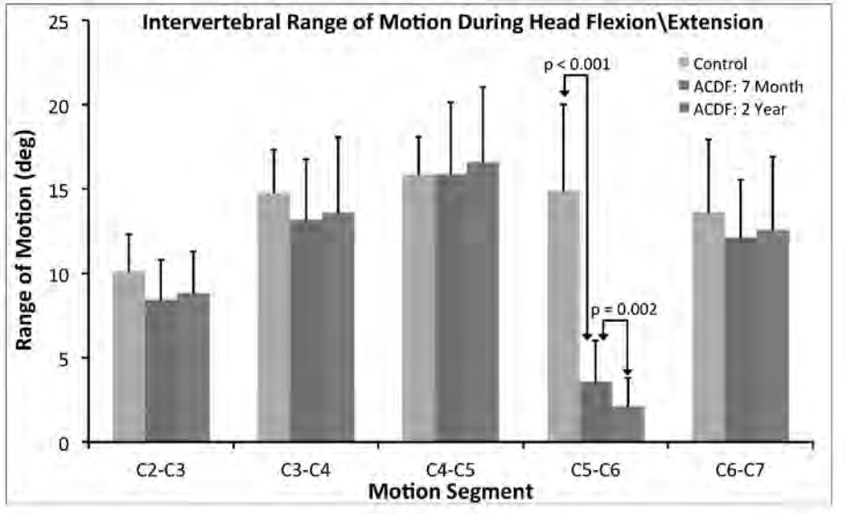


Figure 2. Intervertebral flexion\extension ROM during head flexion\extension. All surgeries were performed at the C5-C6 level. Error bars represent ± 1 SD.

See Disclosure Index pages 40–88.

Presentation #51

- **Prospective Comparison of Dysphagia following Anterior Cervical Discectomy and Fusion (ACDF) with and without rhBMP-2**

Michael R. Murray, MD, Atlanta, GA
Steven K. Leckie, MD, Atlanta, GA
Bradley W. Moatz, MD, Atlanta, GA
***Adam J. Schell, MD**, Cleveland, OH*
Ajay Premkumar, BS, Atlanta, GA
John G. Heller, MD, Atlanta, GA

** Infuse Bone Graft – Medtronic*

Introduction: The safety profile of rhBMP-2 in anterior cervical spine surgery remains incompletely understood. BMP might worsen dysphagia after ACDF due to soft tissue swelling, although dysphagia is a common complication of ACDF without BMP. A retrospective chart review identified a significant increase in the severity of dysphagia after two level ACDF with BMP compared to patients who did not receive BMP. However, to date this problem has not been studied prospectively.

Methods: Patients undergoing 1- or 2-level ACDF with allograft alone or allograft plus 0.5mg rhBMP-2/level (according to patient and surgeon preference) were prospectively enrolled in this IRB approved study. All surgeries were performed at a single institution with the same brand of plate and allograft. Patients who received BMP also received parenteral dexamethasone followed by an oral taper upon hospital discharge. Patients were followed prospectively at multiple time-points (pre-op, post-op 7 days, 6 weeks, 3 months, 6 months, 1 year) with the SWAL-QOL questionnaire, which has been previously utilized to detect dysphagia after anterior cervical spine surgery. Multivariable repeated-measures analysis was applied to data gathered thus far, and patient enrollment and follow-up to one year is ongoing.

Results: Fifteen patients underwent 1- or 2-level ACDF with BMP, of which 11 were followed to the six- month time-point. Thirty-one patients underwent 1- or 2-level ACDF without BMP, of which 19 were followed to the six-month time-point. Mean retractor time was 63 minutes. There was no statistically significant time-effect in either group (SWAL-QOL scores pre-op compared to post-op; p = 0.339). There was no statistically significant difference in SWAL-QOL scores between the BMP group and the non-BMP group at any time-point (p= 0.185), as shown in the figure. There was no significant increase in SWAL-QOL score with longer retractor time (p = 0.90). When adjusted for Mallampati scores, there were still no statistically significant differences in pre-op and post-op SWAL-QOL scores at any time point between the two groups (p = 0.66). There were no incidents of airway compromise in either group.

Presentation #51

Conclusion: These preliminary data suggest that the use of low dose rhBMP-2 does not significantly increase postoperative dysphagia after 1- or 2-level ACDF with allograft.

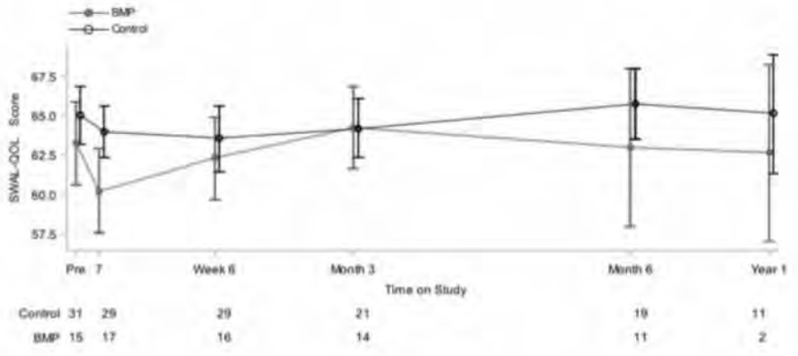


Figure 1. Adjusted pre-op and post-op SWAL-QOL scores (Mean and 95% CI)

See Disclosure Index pages 40–88.

Presentation #52

Influence of the Neck Postural Change on Cervical Spine Motion and Angle during Swallowing

***Jun Young Kim, MD**, Suwon, Republic of Korea*
Il Sup Kim, MD, PhD, Suwon, Republic of Korea
Sung Hoon Im, MD, Suwon, Republic of Korea
Jae Taek Hong, MD, PhD, Suwon, Republic of Korea

Introduction: Cervical retraction position after occipito-cervical fixation is dangerous because of post-operative dysphagia. Reduction of the occipito-C2 angle makes the mandible shift posteriorly, resulting in oropharyngeal airway stenosis. In normal position, the cervical spine moves to reduce physiological lordosis during swallowing. To our knowledge, there are no data demonstrating an association between cervical posture change and cervical spine motion/angle during swallowing. The purpose of the study was to investigate influence of the neck postural change on cervical spine motion and angle during swallowing.

Materials/Methods: A total of 37 healthy volunteers (18 men; 19 women; mean age, 42.7 years) with no evidence of cervical spine disease swallowed 10 mL of diluted barium solution in a ‘‘normal and retraction’’ position. The angle and position changes of each cervical segment from occiput to seventh cervical vertebrae (C0–C7) between oral and pharyngeal phase of swallowing were analyzed and compared between two postures.

Results: In the pharyngeal phase of neutral position, C1, C2 and C3 were flexed (the angle change in C2 was the most significant with a mean flexion angle of 1.94˚), while C5, C6 and C7 were extended (the angle change in C6 was the most significant with a mean extension angle of 0.74˚) in reference to the oral phase. Regarding cervical spine motion, C3, C4, C5, C6 and C7 moved posteriorly (the movement in C4 was the most significant, mean = 1.50 mm). All cervical levels except C5 moved superiorly (the movement in C2 was the largest, mean = 0.87 mm). In the pharyngeal phase of retraction position, C0 and C1 were flexed (the angle change in C2 was the most significant with a mean flexion angle of 0.77˚), while C6 was extended (the angle change in C6 was the most significant with a mean extension angle of 0.58˚). All cervical levels moved posterior (the movement in C4 was the most significant, mean = 2.11 mm). C1, C2, C3 and C4 moved superiorly (the movement in C4 was the largest, mean = 0.61 mm).

Conclusion: In the neutral position, cervical spine move posterior and extend to reduce physiological lordosis during swallowing. In the retraction position, posterior translation of each cervical spine is increased and angle change is decreased compared to the neutral position.

Presentation #52

This data suggest that retraction posture could be a risk factor of postoperative dysphagia especially in the cases with long level cervical fusion and severe cervical spondylosis.

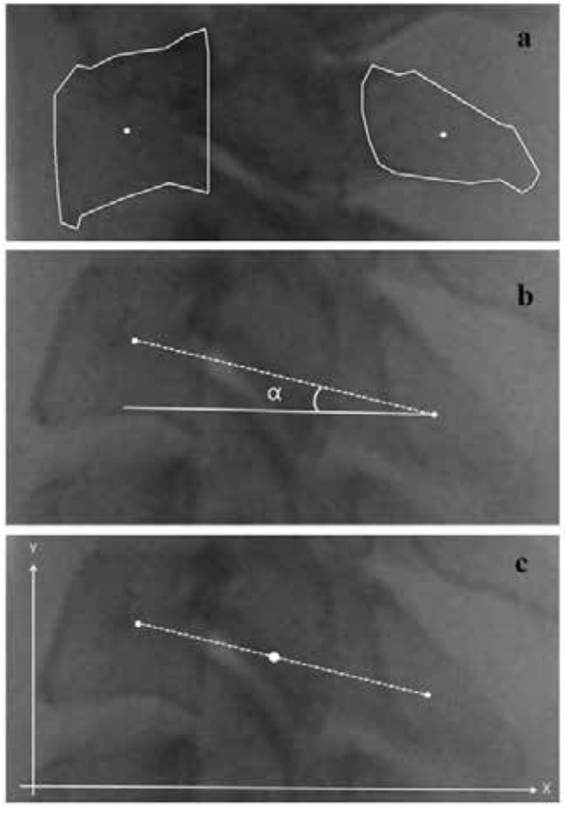


Figure 1.
a. Reference points in the vertebral body and spinous process. The white square in a is clarified by magnifying by 500 % and changing the contrast and brightness. The lines are the margins of the vertebral body and spinous process. The two white dots are the center of gravity of the vertebral body and spinous process.
b. Angle α. The white dotted line connects the two white points. The white solid line is a horizontal line. The angle is adefined by these two lines.
c. Reference point of the position. The midpoint of the line connecting the center of gravity of the vertebral body and spinous process is shown as a white dot and white arrow.

The anteriorposterior coordinate is X, and the superior-inferior coordinate is Y.

See Disclosure Index pages 40–88.

Presentation #54

Impact of Local Intraoperative Steroid Application on Patient-Reported Swallow Function following an Anterior Cervical Discectomy and Fusion: Preliminary Results

Junyoung Ahn, BS, Chicago, IL
Junho Ahn, BS, Baltimore, MD
Daniel D. Bohl, MD, MPH, Chicago, IL
Ehsan Tabaraee, MD, Chicago, IL
Gabriel Duhancioglu, MS, Chicago, IL
Rahul Kamath, MS, Chicago, IL
Daniel J. Johnson, BS, Chicago, IL
Dustin H. Massel, BS, Chicago, IL
***Kern Singh, MD**, Chicago, IL*

Introduction: Intraoperative local steroid application has been theorized to reduce swelling and to improve swallowing in the immediate postoperative period following an anterior cervical discectomy and fusion (ACDF). As such, the purpose of this study is to quantify the impact of intraoperative local steroid application on patient-reported swallow function following ACDF procedures.

Materials and Methods: As part of a prospective randomized trial, 28 patients undergoing primary 1- or 2-level ACDF procedures for degenerative spinal pathology were randomized via a computer number generator into depomedrol (DEPO, 1cc - 40mg) and no depomedrol (NODEPO, 1cc - saline) cohorts. Responses to the SWAL-QOL (Quality of Life in Swallowing Disorders) questionnaire were compared between cohorts.

Results: Of the 28 randomized patients, 14 patients (50.0%) were randomized to the DEPO cohort and received the intervention, while 14 patients (50.0%) were randomized to the NODEPO group and received the placebo (Table 1). The DEPO patients were more likely to undergo 2-level procedures than the NODEPO patients. However, no differences were demonstrated in demographics, comorbidity, smoking status, or body mass index. Similarly, estimated blood loss, operative time, and length of hospitalization did not differ between cohorts (Table 2). Finally, no differences were demonstrated in the preoperative, 6-week-postoperative, or 12-week-postoperative scaled total SWAL-QOL score between DEPO and NODEPO patients (Table 3). Critically, there was no difference in the mean change in scaled total SWAL-QOL score from preoperative to 12-wk postoperative assessments between the DEPO and NODEPO patients (-1.4 ± 15.3 vs. -1.8 ± 5.8, p = 0.95, respectively). No cases of esophageal perforation or retropharyngeal abscess were noted.

Presentation #54

Conclusions: The preliminary results of the present study do not demonstrate an impact of local intraoperative steroid application on patient-reported swallowing function following an ACDF. Enrollment of additional patients will be required before the impact of local intraoperative steroid application on patient-reported swallow function can be fully understood.

Table 1. Patient demographics. (N = 28 patients)

	NODEPO	DEPO	p-value*
Total number of patients (n)	100% (14)	100% (14)	
Age (n)			1.00
18-49 years	50.0% (7)	50.0% (7)	
50-59 years	35.7% (5)	35.7% (5)	
60-69 years	14.3% (2)	14.3% (2)	
≥70 years	0	0	
Sex (n)			0.26
Male	64.3% (9)	57.1% (8)	
Female	35.7% (5)	42.9% (6)	
Ethnicity (n)			0.13
White/Caucasian	92.9% (13)	78.6% (11)	
Black/African American	0	21.4% (3)	
Hispanic/Latino	7.1% (1)	0	
Asian	0	0	
Other	0	0	
Smoking (n)			0.07
Smoker	0	21.4% (3)	
Non-smoker	100% (14)	78.6% (11)	
Operative Levels (n)			**<0.05**
C3-4	14.3% (2)	7.1% (1)	
C4-5	0	7.1% (1)	
C5-6	0	21.4% (3)	
C6-7	64.3% (9)	21.4% (3)	
C4-6	0	28.6% (4)	
C5-7	21.4% (3)	14.3% (2)	
Body Mass Index (kg/m^2)†	27.3±3.5	29.7±6.9	0.26
Comorbidity Index (CCI)	1.9±1.5	2.4±1.7	0.35
Preoperative VAS	4.2±2.5	6.1±3.3	0.10

CCI = Charlson comorbidity index; VAS = Visual Analogue Scale
*__Boldface__ indicates statistical significance.
†Mean ± Standard Deviation

See Disclosure Index pages 40–88.

Presentation #54 (cont.)

Table 2. Perioperative variables.

	NODEPO	DEPO	p-value
Estimated blood loss (cc)	28.6±9.1	32.1±11.7	0.38
Operative time (min)	52.4±26.6	54.6±14.1	0.80
Length of hospitalization (hours)	16.4±13.4	21.0±10.4	0.34

Table 3. SWAL-QOL results.*

	NODEPO	DEPO	p-value
Preoperative	95.2±6.6	93.2±8.1	0.47
Postoperative (6-wk)	92.4±11.4	89.8±12.9	0.57
Postoperative (12-wk)†	93.8±7.9	92.5±11.4	0.80
Preoperative to 6-wk postoperative difference	-2.8±9.1	-3.4±12.3	0.88
Preoperative to 12-wk postoperative difference†	-1.8±5.8	-1.4±15.3	0.95

SWAL-QOL = Quality of Life in Swallowing Disorders Survey.
*Scale 0-100; 0 = Worse swallowing; 100 = Better swallowing.
†Includes 16 patients

Presentation #55

The Effect of Local Intraoperative Steroid Administration on the Rate of Post-Operative Dysphagia following ACDF: A National Database Study of 245,754 Patients

***Jourdan M. Cancienne, MD**, Charlottesville, VA*
Brian C. Werner, MD, Charlottesville, VA
Anuj Singla, MD, Charlottesville, VA
Hamid Hassanzadeh, MD, Baltimore, MD
Frank H. Shen, MD, Charlottesville, VA
Adam L. Shimer, MD, Charlottesville, VA

Introduction: Literature on the effectiveness of intraoperative local steroid administration following ACDF has been limited to small institutional studies describing conflicting results. The PearlDiver database was utilized to compare rates of postoperative dysphagia following short and long ACDF in patients who received intraoperative local steroids and those who did not. We hypothesized that intraoperative local administration of steroids was associated with decreased rates of postoperative dysphagia in patients undergoing ACDF, without any increase in infection.

Methods: The PearlDiver database was utilized to characterize and compare rates of dysphagia within 90 days postoperatively in patients who received intraoperative local steroid during short (1-2 level) ACDF (n = 1,310) and a control group of short ACDF patients that did not (n = 198,690); patients who received intraoperative local steroid during long (3 or more level) ACDF (n = 257) and a control group without local steroid (n = 45,497). Subsequent 90-day postoperative dysphagia rates, 90-day infection and wound complication rates and average length of stay (LOS) were then evaluated and compared. Odds ratios (OR), 95% confidence intervals (CI) and P values were calculated using SPSS.

Results: Use of intraoperative local steroid was associated with a significantly lower rate of postoperative dysphagia in patients who underwent long ACDF (9.3% vs. 14.6%, OR 1.7, p = 0.022), but not in patients who underwent short ACDF (7.3% vs. 8.4%, OR 1.1, p = 0.195) (Table 1). The mean difference in average LOS was 1 day less for patients who received intraoperative local steroid for both short and long ACDF (p < 0.0001) (Table 1). The combined rate of infection/wound complications was not significantly different between those patients who received local steroids and those who did not (1.5% vs. 1.6%, OR 0.9, 95% CI 0.6–1.4, p = 0.811).

See Disclosure Index pages 40–88.

Presentation #55 (cont.)

Conclusion: Use of local intraoperative steroid is associated with a significantly reduced rate of postoperative dysphagia after long (3 level or greater) ACDF and a reduced average length of stay for both long and short (1 to 2 level) ACDF without any observed association with increased rates of postoperative infection or wound complications. Additionally, use of local steroid was associated with a significantly reduced length of stay in both ACDF groups.

Table 1. Dysphagia and Length of Stay Following ACDF in Patients with and without Intraoperative Local Steroid

	With Local Steroid	Without Steroid (Controls)	Statistical Comparison	
Short (1 - 2 Level) ACDF				
Number of Patients	*1,310*	*198,690*	*O.R. [95% C.I.]*	*P*
Dysphagia: n (%)	96 (7.3%)	16,611 (8.4%)	1.1 [0.9 - 1.4]	*0.195*
Length of Stay: days (std. dev)	1 day (1.1 days)	2 days (2.2 days)	-	*< 0.0001*
Long (3+ Level) ACDF				
Number of Patients	*257*	*45,497*	*O.R. [95% C.I.]*	*P*
Dysphagia: n (%)	24 (9.3%)	6,635 (14.6%)	1.7 [1.1 - 2.5]	*< 0.0001*
Length of Stay: days (std. dev)	2 days (1.3 days)	3 days (2.8 days)	-	*< 0.0001*

Presentation #56

The Application of a Novel Sensitive Gait Assessment Method to Optimize the Evaluation of Patients with Degenerative Cervical Myelopathy

***Sukhvinder K. Kalsi-Ryan, BScPT, MSc, PhD**, Toronto, ON, Canada*
Alex Laliberte, MSc, Toronto, ON, Canada
Spyridon K. Karadimas, MD, PhD, Toronto, ON, Canada
Eric M. Massicotte, MD, Toronto, ON, Canada
Mohammed F. Shamji, MD, PhD, Toronto, ON, Canada
Michael G. Fehlings, MD, PhD, Toronto, ON, Canada

Introduction: Disrupted locomotion plays a significant role in the disability of individuals with degenerative cervical myelopathy (DCM), more so as the disease progresses. Current gait assessments fail to demonstrate sensitivity of subtle gait changes in DCM. The purpose of this study is to define the significance of using spatio-temporal gait parameters in the assessment of the DCM population, to define severity of disease particularly in the earliest stages and to measure change in the natural history of the disease and most importantly assess change secondary to intervention. The objectives of this study were to characterize altered locomotion in patients with DCM using a novel computerized gait assessment tool and to assess the changes in gait parameters with standardized myelopathy outcomes tools.

Methods: A prospective observational cross sectional study (n = 107) was conducted in patients with a diagnosis of DCM (including CSM and OPLL; positive MRI for spinal cord compression, 1 clinical symptom and 1 neurological sign). A computerized GAITRite walkway analysis, Modified Japanese Orthopaedic Association Assessment (mJOA) and the Berg Balance Scale (BBS) were administered. Analysis: Paired T-tests were used to compare the severity groups to a control group and discriminant functional analysis was used to define the most significant parameters in creating a general gait profile for DCM.

Results: The 5 parameters of variability (stride time SD, swing time SD, stance time SD, DST SD, SST SD) detect mild instabilities of gait even when parameters such as velocity, base of support, step and stride length remain normal. Step and stride length and base of support are parameters that detect mild changes of gait, however, are dependent on height, weight and gender, thus not reliable in confirming mild deficit. The above mentioned spatio-temporal parameters detect very early changes in the disrupted gait pattern ($p < 0.05$), prior to clinically detectable gait impairment. As severity increases to moderate or severe, velocity, cadence, single and double stance time, and variability in stepping show significant ($p < 0.05$) differences from normative values.

See Disclosure Index pages 40–88.

Presentation #56 (cont.)

Conclusions: With mild DCM gait impairment is not obvious from clinical observation alone. However, with computerized gait analysis we have identified the cardinal spatio-temporal parameters that are useful in detecting subtle differences that can be applied longitudinally while others are more discriminant among a cross sectional sample. Velocity, stride length, base of support and double stance time, are more useful as parameters to be used longitudinally. Whereas, the 5 parameters of variability (stride time SD, swing time SD, stance time SD, double stance time SD and single stance time SD) are useful for discrimination among groups when detecting even the most subtle differences. The identification of the most sensitive parameters for DCM is unique as other neurological and musculoskeletal disorders rely on different parameters to detect disease. The impact of being able to detect subtleties in this disease is very progressive for the field as it enables clinicians and researchers to study the disease with much more accuracy. Thus enhancing the measurement in efficacy studies and early detection of disease. This measurement capability provides insights for both clinical and research settings.

Table 1. Control and DCM values of significant spatio-temporal gait parameters that define the disease severity.

	Control	Mild (17-15) X (SD)	Moderate (14-12) X (SD)	Severe (< 12) X (SD)
Velocity	134 (14)	126 (18)	106 (28)	76 (27)
Step Length	70 (5.40)	65.3 (8.60)	57.6 (11)	46 (10)
Stride Length	141 (11)	131 (17)	116 (22)	94 (22)
Base of Support	8.3 (2.50)	10.5 (3)	10.7 (3.90)	14 (4)
Step length Difference	1.3 (0.90)	2.1 (1.80)	2.3 (1.60)	2.8 (2.80)
Stride Time SD	0.027 (0.02)	0.046 (0.03)	0.065 (0.05)	0.047 (0.04)
Swing Time SD	0.013 (0.005)	0.023 (0.01)	0.029 (0.03)	0.019 (0.01)
Stance Time SD	0.023 (0.01)	0.037 (0.28)	0.054 (0.05)	0.039 (0.02)
Double Stance Time SD	0.017 (0.005)	0.027 (0.02)	0.045 (0.04)	0.031 (0.02)
Single Stance Time SD	0.014 (0.007)	0.226 (0.01)	0.029 (0.03)	0.027 (0.02)

This table defines values of each spatio-temporal parameter that is sensitive to differences in the control and mild DCM groups. Yellow variables only approach significance for a difference between the control and mild groups. White variables show significant differences between all groups and controls, however, can be dependent on height, weight, and gender. Blue variables can be compared among any individual and show the values that identify all severity groups as well as normative values for comparison

Presentation #56

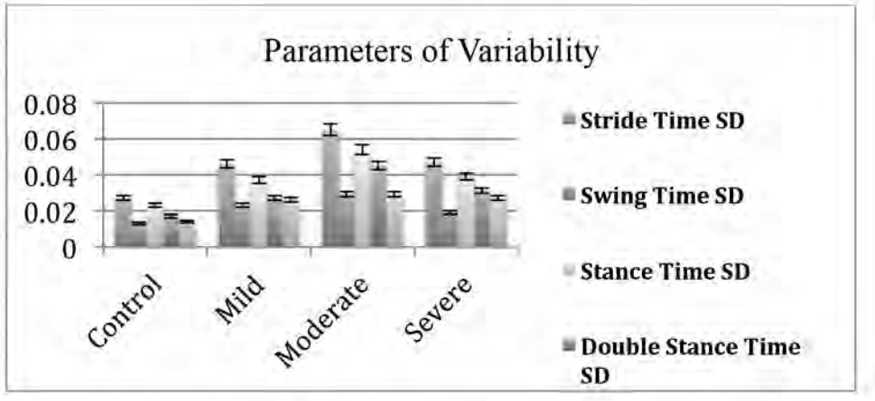


Figure 1. Defines visually how the 5 parameters of variability change across disease severity, showing that variability of gait increases as severity increases.

See Disclosure Index pages 40 – 88.

Presentation #57

Surgical Decompression in an Experimental Model of Cervical Spondylotic Myelopathy induces a Neuroinflammatory Response: Implications for Perioperative Clinical Management

***Pia M. Vidal, BS, PhD**, Toronto, ON, Canada*
Spyridon K. Karadimas, MD, PhD2, Toronto, ON, Canada
Antigona Ulndreaj, BA, Toronto, ON, Canada
Stefania Forner, PhD, Florianópolis, SC, Brazil
Alex Laliberte, MSc, Toronto, ON, Canada
Michael G. Fehlings, MD, PhD, Toronto, ON, Canada

Introduction: Cervical spondylotic myelopathy (CSM) is the most common cause of spinal cord impairment in the world. There is increasing evidence to support the role of surgical decompression for CSM. However, neurological complications including delayed C5 palsy occur in at least 5% of cases with surgical management. Based on evidence from experimental models of CSM that an ischemia reperfusion injury (IRI) may accompany surgical decompression, we sought to characterize the mechanistic basis for the post-decompression IRI mediated inflammatory response and to identify potential therapeutic targets.

Materials and methods: Experiments were undertaken in C57B/L mice in which a model of progressive cord compression at C5-6 was created by inserting a biomaterial strip under the laminae at these levels. Afterwards animals were surgically decompressed at 3 and 9 weeks after symptoms manifestation, to resemble a moderate and more severe compression, respectively (Figure 1 Ai-ii). We evaluated pain response, overground locomotion, grip and muscle strength as well as hand dexterity using Von Frey, Catwalk, wire hang test and Capellini handling test respectively. Flow cytometry, western blot, ELISA were used to characterise systemic and local changes in the immune system.

Results: Surgical decompression for CSM caused a local increase of cytokines and chemokines around the level of compression at 24 hours after surgery (Figure 1 Bi-C, E, G, I, K, M; *p < 0.05; **p < 0.01), as well as changes in the recruitment of microglia/macrophages. In addition, there were significant changes in the subpopulations of circulating monocytes after decompressive surgery. Decompression for the moderate CSM group (3 weeks after symptoms manifestation) led to a substantial reduction in the deterioration of hand dexterity function (*p < 0.05), grip/muscle strength as well as a decrease in pain response (**p < 0.01). Interestingly, surgical decompression after severe CSM (9 weeks after symptoms manifestation) caused a prolonged secretion of cytokines and chemokines (fig. 1 Bii, D, F, H, J, L, N; *p < 0.05; **p < 0.01; ***p < 0.001) (up to 5 weeks after surgical decompression) without any noticed neurological improvement.

Presentation #57

Conclusions: This study represents the first basic evidence demonstrating that early decompression results in neurological improvement in contrast with late decompression. Most importantly, our data suggest this is accompanied by an increase in circulating monocytes as well as the production of cytokines and chemokines in the spinal cord. Finally, this study paves the way for the development of novel therapeutic strategies targeting the inflammatory response to seek attenuating or preventing the decompression mediated IRI and improve the long term neurological outcomes after surgery.

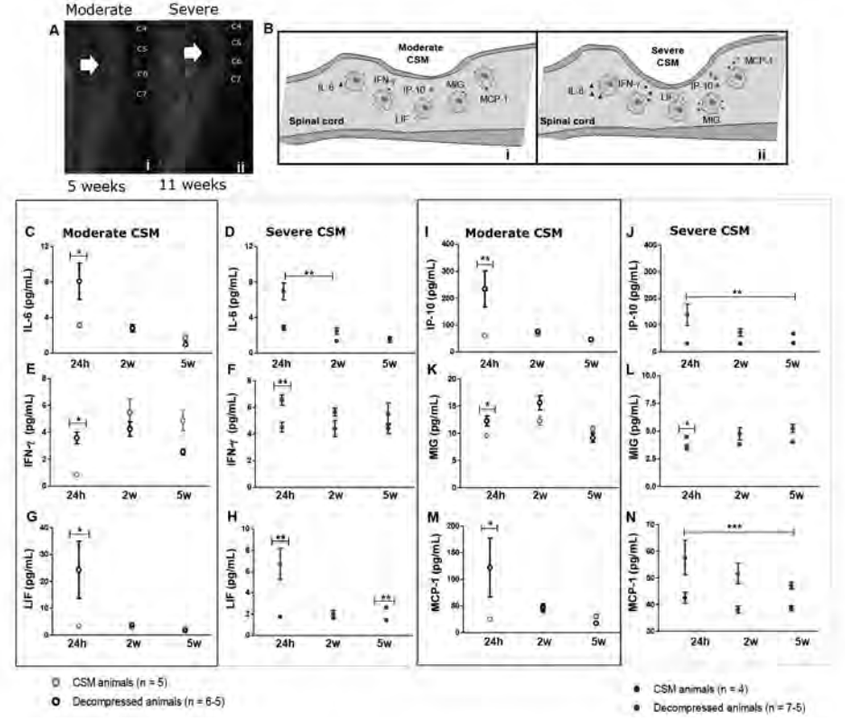


Figure 1. Surgical decompression increases production of pro-inflammatory factors. A) Representative MRI images of the compressed spinal cord in moderate CSM (Ai) and severe CSM (Aii) groups one week before surgical decompression, respectively. B) Scheme of the increased secretion of cytokines and chemokines after surgical decompression for moderate (Bi) and severe CSM (Bii). C, E, G, I, K, M) ELISA results from homogenized spinal cord tissue showed an increasing production of pro-inflammatory factors (IL-6, IFN-g, LIF, IP-10, MIG and MCP-1) during the acute phase after decompressive surgery for moderate CSM (*p < 0.05; **p < 0 .01). D, F, H, J, L, N) Surgical decompression after severe CSM induces a sustained inflammatory response (*p< 0.05; **p < 0.01; ***p < = .001). Data are presented as mean ± SEM. Moderate group: Open red circle: CSM animals (n = 5); Black open circle: Decompressed animals (n = 6). Severe group: Blue circle: CSM animals (n = 4); Purple circle: Decompressed animals (n = 7-6)

See Disclosure Index pages 40–88.

Presentation #58

The Fall and Fracture Risk of Medicare Patients with Cervical Myelopathy

***Daniel J. Blizzard, MD, MS**, Durham, NC*
Michael A. Gallizzi, MD, MS, Durham, NC
Charles Sheets, PT, Durham, NC
Colin T. Penrose, BA, BS, Durham, NC
Robert E. Isaacs, MD, Durham, NC
Christopher R. Brown, MD, Durham, NC

Introduction: A significant breadth of literature has documented the potential fall risk of patients with neurological diseases including stroke, dementia and Parkinson's disease. Slowed velocity, unsteady/neuropathic gait, increased double support time and shorter strides have all been linked to an increase risk in falls. However, no studies to date have assessed the frequency and impact of falls in patients with cervical myelopathy. Knowledge of the fall risk and resultant injuries of patients with gait abnormalities can play a pivotal role in determining treatment of the gait disturbance as the morbidity of repeated falls may outweigh the morbidity associated with an operative intervention. The purpose of the study herein is to determine the fall and injury risk of patients with cervical myelopathy and evaluate the potential protective effect of operative intervention.

Methods: The PearlDiver database was used to search the Medicare sample from 2005-2012 using International Classification of Disease, 9th Edition (ICD-9) codes. This search yielded 35,997,166 control patients without cervical myelopathy, vestibular disease or Parkinson's disease. ICD-9 codes for cervical myelopathy identified a total 601,390 patients. ICD-9 procedure codes identified 77,346 patients that first had a diagnosis of cervical myelopathy and subsequently underwent cervical decompression with or without fusion. Incidence (IN), risk ratios (RRs) and respective 95% confidence intervals (CIs) were recorded over the sample period.

Results: Patients with cervical myelopathy had a statistically significant increase incidence of all complications compared to the control group (Figure 1): 11.3% incidence of falling (RR 8.08), 3.7% of hip fracture (RR 2.62), 5.9% incidence of leg and ankle fractures (RR 2.57), 0.8% incidence of femur fracture (RR 3.61) and 6.2% incidence of head injury (RR 7.34). The subset of patients with cervical myelopathy that underwent cervical decompression surgery had a significant reduction in falls (RR: 0.83), head injuries (0.87) and skull fractures (RR: 0.78), and leg and ankle fractures (RR: 0.88), but no improvement in the incidence of hip, femur or pelvis fractures (Figure 2).

Presentation #58

Conclusions: Cervical myelopathy has a very significant, negative effect on patient morbidity. The relative risk of sustaining falls, lower extremity fractures, and head injuries if 2.6-8.1 times more likely in patients with cervical myelopathy compared to controls. Cervical decompression reduced the incidence of falls, but did not reduce the incidence of all musculoskeletal complications measured. The reduction in falls and injuries is likely more significant than the data reflects given the inherent treatment bias of patients with more severe disease and, presumably, higher rates of falls and injuries undergoing operative treatment. The high rate of falls and resultant injuries in this population should be considered when determining myelopathy treatment and when managing musculoskeletal injuries sustained in this population to choose treatments that emphasize protection and stability.

Figure 1. Forest Plot depicting the relative risk (RR) of complications for patients with cervical myelopathy compared to healthy, age-matched controls. The vertical line corresponds to a RR of 1, or equivalent risk, to controls.

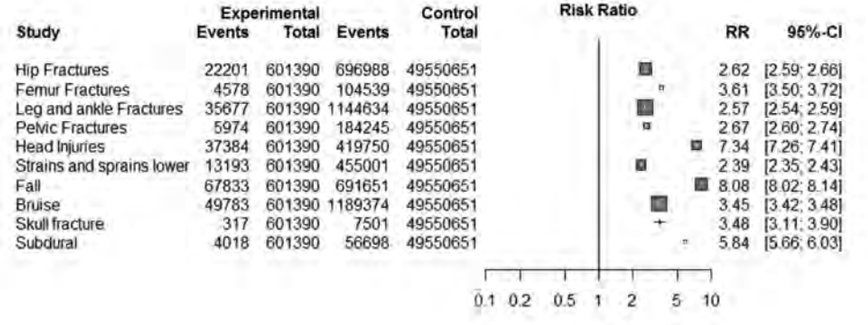
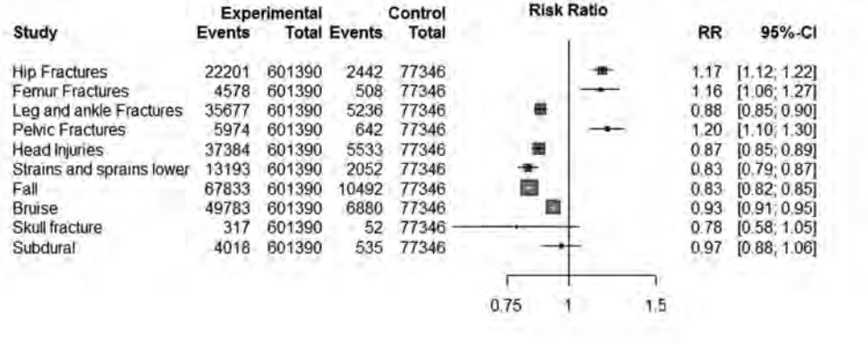


Figure 2. Forest Plot depicting the relative risk (RR) of complications for patients with cervical myelopathy that underwent cervical decompression surgery compared to patients with cervical myelopathy that did no undergo operative treatment. Values to the left of the vertical RR = 1 line define complications with reduce incidence in the cervical decompression group.



See Disclosure Index pages 40 – 88.

Presentation #59

Minimum Clinically Important Difference (MCID) of the JOA Score and 10-Second Test in Cervical Myelopathy Disorders

***Eiji Wada, MD**, Matsuyama, Japan*

Introduction: When we evaluate the degree of myelopathy, Japanese Orthopaedic Association (JOA) score and the 10-second test are usually used. However, the minimum clinically important difference (MCID) for these measures is rarely reported. The purpose of this study was to evaluate MCIDs for JOA score and 10-second test in cervical myelopathy disorders.

Patients and Method: The JOA decided to revise the JOA score for patients with cervical myelopathy and to develop a new outcome measure. In part of the project, a total of 304 patients with cervical myelopathy disorders, whose symptoms were supposed to be stable, completed the questionnaire (including JOA score and the 10-second test) twice to verify the reliability. Of those 304 patients, 205 patients who did not have other joint disease were included in the current study. We evaluated: 1) Pearson's correlation coefficient (ρ) for first and second JOA scores and 10-second test values; 2) distribution of differences between the first and second values; 3) standard error of the mean (SEM) for differences between the first and second values; and 4) the 95% confidence interval for minimum detectable change (MDC95). SEM was calculated using the formula: $SEM = s\sqrt{(1 - r)}$, where s = standard deviation (SD) of the difference between the first and second values, and r = Pearson's correlation coefficient between the first and second values. MDC95 was calculated using the formula: $MDC95 = SEM \times \sqrt{2} \times 1.96$.

Results: 1) Correlation coefficients were ρ = 0.89 for JOA score, ρ = 0. 93 for the 10-second test of the right hand, ρ = 0.93 for the 10-second test of the left hand, and ρ = 0.92 for the 10-second test of the more severely affected side. 2) Mean and SD of the difference between the first and second values was -0.20 ± 1.43 for JOA score (Figure 1), -0.57 ± 2.86 for the 10-second test of the right hand, -0.49 ± 2.80 for the 10-second test of the left hand and -0.59 ± 2.93 for the 10-second test of the more severely affected side (Figure 2).

Discussion and Conclusions: We must consider MCID when interpreting the results of clinical measures. This study verified the MCID of JOA score and the 10-second test by statistically evaluating differences between the two evaluations of patients with stable symptoms. A change less than MDC95 is taken statistically as representing a measurement error. In conclusion, we could judge myelopathy as improved (deteriorated) in cervical myelopathy disorders only when the JOA score showed a change of more than 2 points (MDC95 = 1.3) and the 10-second test showed a change of more than 3 cycles (MDC95 = 2. 0~2.2).

Friday, December 4, 2015, 10:18 – 10:24 am **CSRS – 2015**

Presentation #59

Figure 1. The Bland-Altman plot (JOA score)

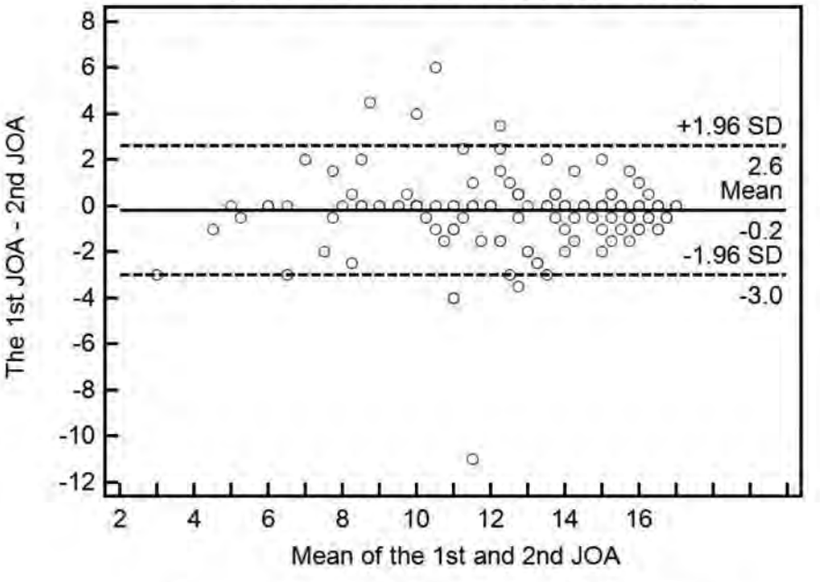
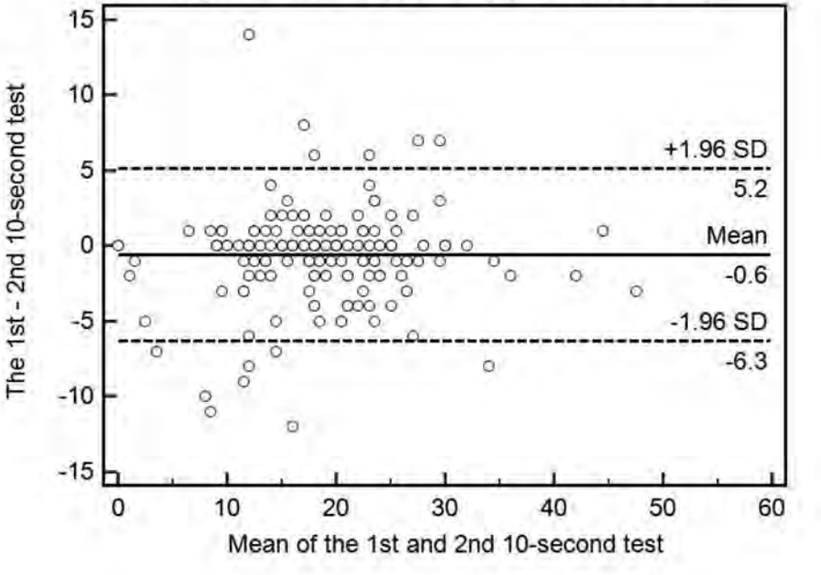


Figure 2. The Bland-Altman plot (10-second test)



See Disclosure Index pages 40 – 88.

Presentation #60

The Minimum Clinically Important Difference of the Modified Japanese Orthopaedic Association Scale in Patients with Degenerative Cervical Myelopathy

***Lindsay Tetreault, HBSc**, Toronto, ON, Canada*
Branko Kopjar, MD, PhD, Seattle, WA
Pierre Cote, DC, PhD, Toronto, ON, Canada
Aria Nouri, MD, Toronto, ON, Canada
Michael G. Fehlings, MD, PhD, Toronto, ON, Canada

Introduction: The modified Japanese Orthopaedic Association (mJOA) score is the most frequently used clinician-administered tool to assess functional status in patients with degenerative cervical myelopathy (DCM). By defining the minimum clinically important difference (MCID) for this scale, clinicians can evaluate treatment outcomes for this condition and better interpret evidence from clinical studies. This study aims to establish the MCID of the mJOA in patients with CSM.

Methods: Three different methods were used to determine the MCID of the mJOA: 1) distribution-based, 2) anchor-based and receiver operating characteristic (ROC) analysis and 3) professional opinion. The first two methods were accomplished using data from 517 patients enrolled in the AOSpine CSM-North America or CSM-International studies. Distribution-based methods were used to estimate the MCID by computing the half standard deviation and standard error of measurement. Using anchor-based methods, mJOA at 12-months after surgery was compared between patients who "slightly improved" on the Neck Disability Index (NDI) and those who were "unchanged." ROC analysis was then performed to compute a discrete integer value for the MCID that yielded the smallest difference between sensitivity and specificity. Finally, MCID estimates were obtained by surveying members of AOSpine International. We repeated the anchor-based methods for patients with mild (mJOA: 15–17), moderate (mJOA: 12–14) and severe disease (mJOA < 12).

Results: Our cohort consisted of 315 men and 202 women, with ages ranging from 21 to 86 years (mean age: 56.37 ± 11.60). The mean baseline mJOA score was 12.48 ± 2.71. One hundred and twenty-nine patients were classified as mild (mJOA = 15-17) preoperatively, 208 as moderate (mJOA = 12-14) and 180 as severe (mJOA < 12). Based on the NDI at 12 months following surgery, 76 (14.70%) patients worsened (NDI < -7.5), 130 (25.15%) were unchanged (-7.5 ≤ NDI < 7.5), 87 (16.83%) slightly improved (7.5 ≤ NDI < 15) and 224 (43.33) showed marked improvements (15 ≤ NDI). The half standard deviation of the baseline mJOA was 1.36 and the standard error of measurement was 1.21. The difference in mJOA between patients who "slightly improved" on the NDI and those who were "unchanged" was 1.11 (Table 1).

Presentation #60

ROC analysis yielded a value of 2 for the MCID (Figure 1). The survey of 416 spine professionals confirmed these estimates: The mean response was 1.65 ± 0.66, although the most commonly selected answer was 2 (39.42%). The MCID significantly varied depending on myelopathy severity: ROC analysis yielded a threshold of 1 for mild patients, 2 for moderate patients and 3 for severe patient (Figure 1).

Conclusions: The MCID of the mJOA is estimated to be between 1 and 2 points and varies significantly with myelopathy severity. This knowledge will enable clinicians to identify meaningful functional improvements in surgically treated CSM patients.

Table 1. The mJOA Change Scores in Patients Classified as "Worsened," "Unchanged," "Slightly Improved" and "Markedly Improved" based on the NDI.

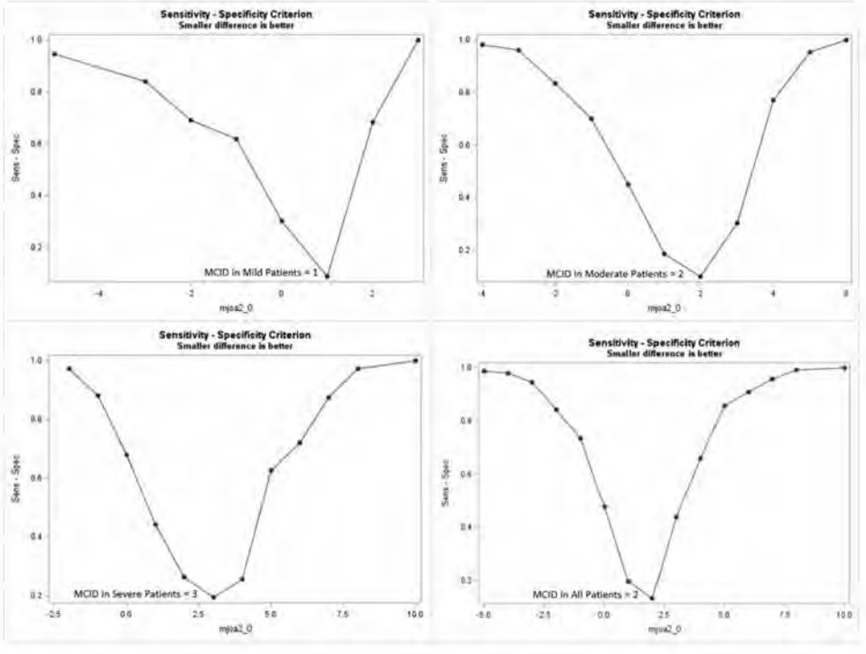
Change in mJOA	Worsened (NDI<-7.5)	Unchanged (-7.5≤NDI<7.5)	Slightly Improved (7.5≤NDI<15)	Markedly Improved (15≤NDI)
All Patients	1.71±2.87	1.56±2.37	2.67±2.50	3.20±2.82
Mild (mJOA: 15-17)	-0.56±2.34	0.57±1.64	1.00±2.22	1.15±1.67
Moderate (mJOA: 12-14)	1.56±2.37	1.77±2.45	2.21±1.53	2.76±1.94
Severe (mJOA<12)	3.18±2.84	2.43±2.62	4.19±2.34	4.90±3.11

mJOA: modified Japanese Orthopaedic Association scale; NDI: Neck Disability Index; SF-36 PCS: Short-Form-36 Physical Component Score. The minimal clinically important difference (MCID) is 7.5 for the NDI. The difference in ΔmJOA (between baseline and 12-months after surgery) between patients who were "unchanged" and those who "slightly improved" was taken to be the MCID.

See Disclosure Index pages 40–88.

Presentation #60 (cont.)

Figure 1. ROC Analysis and the Difference between Sensitivity and Specificity: Mild, Moderate, Severe and All Patients



mJOA2_0: change in mJOA between preoperative visit and 12-months postoperative.

Presentation #61

The Association Between Preoperative Mental Distress and Patient Reported Outcome in Patients Treated Surgically for Cervical Radiculopathy

Martin Skeppholm, MD, PhD, Lowenstromska, Sjukuset, Sweden
***Claes Olerud, MD, PhD**, Uppsala, Sweden*

Introduction: Poor mental status has been proposed to affect postoperative outcome adversely. In this prospective study of a cohort from a multicenter RCT between cervical artificial disc replacement (ADR) and fusion (ACDF), the aim was to evaluate preoperative risk factors, with special reference to anxiety and depression.

Methods: 151 patients were included in the RCT. 48% were women and mean age was 47 years. Primary outcome was measured with Neck Disability Index (NDI) and secondary outcome measures were EQ-5D, VAS arm and neck. Preoperative data concerning age, gender, smoking and different aspects of work status were also registered. Moreover, anxiety and depression was evaluated with the hospital anxiety and depression scale (HAD). All data was blinded to the participating surgeons before intervention. All potential preoperative risk factors were analyzed in a linear regression model. The cohort was divided into HAD high scorers (HAD-H) and low scorers (HAD-L) and were compared concerning outcome variables at baseline and two-year follow-up.

Results: Outcome data was available for 136 patients at the two-year follow-up. There was no statistical significant difference between the ADR and ACDF group. Forty-six patients were classified as HAD-H. There were no significant differences between the HAD groups at baseline concerning age, gender, unemployment, duration of pain, sick leave or duration of sick leave. The multiple regression analysis with two-year NDI as dependent variable showed that HAD was the preoperative variable with the highest association (beta = 0.51, adjusted R2 = 0.25), $p < 0.001$. The HAD-H group showed higher mean NDI values at baseline than the HAD-L group, 70 and 60 respectively, but no differences in VAS-levels between the groups at baseline. All outcome variables were significantly worse at the two-year follow-up in the HAD-H group compared to the HAD-L group; NDI (mean 52 and 34 respectively, $p < 0.01$), EQ-5D (mean 0.78 and 0.54 respectively, $p < 0.01$), VAS arm (mean 31 and 16 respectively, $p < 0.01$) and VAS neck (mean 31 and 23 respectively, $p < 0.01$).

Conclusion: Patients with high preoperative levels of anxiety and depression did not improve to the same extent and had a worse outcome overall. More studies are needed to investigate whether this group of patients may achieve better results if other treatments are offered, either non-surgical treatment alone or as an adjunct to surgery.

See Disclosure Index pages 40–88.

Presentation #62

PROMIS Physical Function: A Better Patient Reported Outcome Measure in Cervical Spine Patients

***Darrel S. Brodke, MD**, Salt Lake City, UT*
Brandon D. Lawrence, MD, Salt Lake City, UT
W. Ryan Spiker, MD, Salt Lake City, UT
Ashley M. Neese, BS, Salt Lake City, UT
Man Hung, PhD, Salt Lake City, UT

Introduction: High quality patient reported outcome (PRO) measures are needed for better understanding patient response to treatment of cervical disorders and for comparative effectiveness studies. There are significant concerns about the Neck Disability Index (NDI) regarding its validity, as currently used, and its psychometric properties (coverage in particular). Better measures are required. The NIH funded PROMIS Physical Function domain, delivered by Computerized Adaptive Testing (PF CAT) has been shown to outperform other disease specific measures in the spine patient population, though assessment specifically in patients with cervical spine disorders and direct comparisons with legacy measures have not been performed. This study directly compares the psychometric performance of the PROMIS PF CAT to the standard NDI-10, the shortened NDI-5, and the SF36 Physical Function Domain (SF-36 PFD) in the same patient population, and aims to generate conversion equations between scores for cross utilization.

Methods: Standard Rasch analysis was performed to directly compare the psychometrics of the PF CAT, NDI-10, NDI-5, and SF-36 PFD. Regression analyses were then performed to predict the PF CAT scores from the NDI-10 and SF36 PFD and vice versa. Pearson correlations were computed to compare the actual and predicted scores for each.

Results: 566 patients completed both the NDI and PROMIS PF CAT assessments. Of those, 490 also completed the SF-36 PFD. The average time for completion was: NDI-10 (183 seconds); NDI-5 (99 seconds); SF-36 PFD (123 seconds); PF CAT (62 seconds). The number of questions administered for the instruments were: NDI-10 (10 questions); NDI-5 (5 questions); SF-36 PFD (10 questions); PF CAT (mean = 4.33 questions, median = 4 questions, min and max = 4 and 12 questions).

Presentation #62

The psychometric properties were significantly better for the PROMIS PF CAT than the NDI or SF-36 PFD in the cervical spine patient population. The ceiling and floor effects were excellent for the PF CAT (1.94% and 4.06%), while the ceiling effects were fine (4.77%, 7.60%, and 11.84%) and the floor effects were quite poor (45.58%, 48.59% and 21.55%) for the NDI-10, NDI-5, and SF-36 PFD, respectively. The NDI-10 also has the additional challenge of extremely poor raw score to measure correlation. The legacy scale scores significantly predicted the PROMIS PF CAT scores ($p<0.0001$), with fair correlation for the PF CAT and NDI-10 (0.53) and good correlation of PF CAT and SF-36 PFD (0.62), allowing use of conversion equations to predict scores, which were generated.

Discussion and Conclusion: The PROMIS PF CAT outperforms the standard NDI-10, the NDI-5, and the SF-36 PFD in the cervical spine patient population. It has better coverage, while taking less time to administer with fewer questions to answer. The PF CAT can be predicted from either the NDI or SF-36 PFD scores, allowing conversion from one to the other when comparing older collected data to new scores.

See Disclosure Index pages 40–88.

Presentation #63

Outcomes and Complications of Fusions from the Cervical Spine to the Pelvis: Series of 46 Cases with Average 2.7-Year Follow-up

***Sravisht Iyer, MD**, New York, NY*
Han-Jo Kim, MD, New York, NY
Alexander A. Theologis, MD, San Francisco, CA
Venu M. Nemani, MD, New York, NY
Todd J. Albert, MD, New York, NY
Lawrence G. Lenke, MD, New York, NY
Shane Burch, MD, San Francisco, CA
Oheneba Boachie-Adjei, MD, New York, NY
Vedat Deviren, MD, San Francisco, CA
Themistocles S. Protopsaltis, MD, New York, NY
Justin S. Smith, MD, PhD, Charlottesville, VA
Justin K. Scheer, BS, Chicago, IL
Jun Mizutani, MD, Nagoya City, Japan
Eric O. Klineberg, MD, Sacramento, CA
Christopher P. Ames, MD, San Francisco, CA

Introduction: The increasing incidence of adult deformity sometimes requires primary or revision operations with fusions extending up into the cervical spine. The purpose of this study is to determine outcomes in this subset of patients utilizing the Scoliosis Research Society 22 (SRS-22r) questionnaire, Oswestry Disability Index (ODI) and Neck Disability Index (NDI) health related quality of life measures (HRQOLs).

Methods: A multicenter retrospective review was performed to identify patients with a UIV at any level in the cervical spine and an LIV in the sacrum/pelvis. Those with infectious or acute trauma related deformities were excluded. Patients included in the trail had surgery between 2003 and 2014. Patient demographics, medical history, diagnosis, operative procedure and HRQOLs were analyzed. Students T-tests (continuous variables), a Kruskal-Wallis tests (ordinal variables) or X2 Tests (categorical variables) were used as appropriate; significance was set at $p < 0.05$ for all tests

Results: 55 patients were identified and 46 (84%) had sufficient data for analysis. The average age at the time of surgery was 44 years. The average follow up time was 2.7 years. Proximal Junctional Kyphosis (PJK) was the most common indication for fusion to the cervical spine (28%), followed by kyphosis (21%) and kyphoscoliosis (15%). The most common UIV was C2 (28%) or C7 (28%). There was a significant improvement in radiographic outcomes with an average 31-degree correction in maximum kyphosis and a 3.3cm improvement in SVA.

Presentation #63

Complications data was available in a subset of 28 patients. In these patients, the rate of all types of complications was 71%. The incidence of major complications was 39.3% and minor complications 53.6%. The rate of medical complications was 61% while the rate of surgical complications was 43%. Of these 28 patients, 15 (53.6%) required reoperation. The rate of pseudarthrosis was 29.1%.

There was an improvement of the SRS score from 3.0 ± 0.7 pre-operatively to 3.5 ± 0.9 at the most recent follow up visit ($p < 0.01$); this is greater than the MCID for the SRS-22r total score. Improvement was greatest for the SRS Mental Health (ΔSRS Mental Health = 0.9, $p < 0.01$) and Pain (ΔSRS Pain = 0.6, $p < 0.01$) domains. There were no significant differences in pre and post-op scores for the NDI or ODI.

Conclusion: When necessary, fusions that extend from the C-Spine to the Pelvis can result in improvements in HRQOLs. Our data demonstrated a significant improvement in SRS-22r outcomes and radiographic parameters with operative intervention in this subset of patients.

See Disclosure Index pages 40–88.

Presentation #64

Impact of Adverse Events on Clinical Outcome: Results through Five-Year Follow-up

***Michael S. Hisey, MD**, Flower Mound, TX*
Donna D. Ohnmeiss, MD, Dr Med, Plano, TX
Hyun W. Bae, MD, Los Angeles, CA
Jack E. Zigler, MD, Plano, TX

Introduction: In FDA-regulated trials, adverse events (AEs) are documented and assessed as a primary metric evaluating safety of an investigational treatment. AEs are typically defined as any clinically adverse sign, symptom, syndrome, or illness that occurred or worsened during or after treatment, regardless of cause. The purpose of this study was to determine if AEs were related clinical outcomes in patients undergoing cervical spine surgery.

Materials/Methods: A total of 186 anterior cervical discectomy and fusion patients and 389 total disc replacement patients treated at one or two contiguous levels were included. The study was based on a post hoc analysis of data collected during an FDA-regulated, randomized, prospective trial across 24 sites. Clinical outcome measures were the Neck Disability Index (NDI), visual analog scales (VAS) assessing pain, and SF-12. AEs were evaluated and classified by a clinical events committee composed of two orthopedic surgeons and one neurosurgeon. Patients were categorized as demonstrating: 1) at least one definitely or possibly device-related AE, 2) unrelated AEs only, or 3) no AEs that were ongoing at the given timepoint. Examples of device-related AEs included neck pain, device complications, and headache. Unrelated AEs included cardiovascular, gastrointestinal, trauma, respiratory, and noncervical events. ANOVA and Tukey's test for multiple comparisons were used to determine statistically significant differences between groups.

Results: At 60 months, 55 patients were classified as having device-related AE's, 363 patients as having unrelated AE's, and 77 patients as having no AE's. A significant difference was observed between groups for each outcome at 24, 36, 48 and 60 months ($p < 0.0001$). At each timepoint, the average NDI, VAS Neck, and SF-12 scores were significantly worse for both the device-related and unrelated AE groups compared to patients with no AEs ($p < 0.01$). Patients with device-related AE's demonstrated the poorest clinical outcomes on NDI, VAS, and SF-12 mental and physical component scores (Table 1).

Presentation #64

Conclusions: Patients with treatment-related AEs had poorer clinical outcomes compared to patients without AEs. Patients with AEs unrelated to study treatment also exhibited poorer clinical outcomes, including disease-specific outcomes, compared to patients without AEs. Results through 60 months suggest that AEs unrelated to the investigational treatment may negatively influence patient pain and function scores. The occurrence of AEs, even those not related to the study device, significantly impact commonly used outcome measures and thus may explain some of the outcome variation seen in clinical trials.

Table 1. Mean scores (+/- standard deviation) in each of the AE categories at 60 month follow-up.

	Device related AE	Non-device related AEs	No AEs	p-value
NDI	34.4 ± 20.5	19.3 ± 17.9	5.8 ± 9.8	p<0.0001
VAS neck pain	41.3 ± 31.9	21.0 ± 27.2	5.7 ± 10.0	p<0.0001
SF-12 MCS	45.6 ± 12.3	50.7 ± 10.7	56.1 ± 5.5	p<0.0001
SF-12 PCS	40.4 ± 10.6	45.4 ± 11.3	53.2 ± 7.8	p<0.0001

See Disclosure Index pages 40–88.

Presentation #65

Quality of Life and General Health following Elective Surgery for Cervical Spine Pathologies: Determining Valid and Responsive Metric of Heath State Utility

Silky Chotai, MD, Nashville, TN
Scott L. Parker MD, Nashville, TN
Ahilan Sivaganesan, MD, Nashville, TN
***J. Alex Sielatycki, MD**, Nashville, TN*
Joseph B. Wick, BA, Nashville, TN
Matthew J. McGirt, MD, Charlotte, NC
Clinton J. Devin, MD, Nashville, TN

Background: As a part of affordable care act, health utility metrics are being investigated to define cost-effective value based health-care model. EuroQOL (EQ)-5D and Short Form-6D (SF-6D) are commonly used quality of life instruments. Domains in EQ-5D questionnaire are thought to be less responsive in measuring quality of life following cervical surgery. We set forth to evaluate validity and responsiveness of SF-6D and EQ-5D in determining health and quality of life following cervical spine surgery.

Methods: Patients undergoing elective cervical spine surgery over a period of two-years were enrolled into a prospective longitudinal registry. Patient reported outcomes (PRO): NDI, VAS-Neck and Arm pain (NP,AP), EQ-5D and SF-12 were recorded. Based on previously published equations, SF-6D was calculated using NDI and SF-12 scores. Patients were asked whether "surgery met their expectations" (meaningful improvement). Correlation of SF-6D with each PRO was analyzed. To assess the validity of SF-6D (NDI), SF-6D (SF-12) and EQ-5D to discriminate between meaningful and non-meaningful improvement, receiver-operating characteristic curves were generated, the greater the area under the curve(AUC) the more valid the discriminator. To determine the relative responsiveness, difference between standardized response means (SRMs) in patients reporting meaningful improvement versus not was calculated.

Results: SF-6D (NDI) (AUC-0.69) was more valid discriminator of meaningful improvement compared to SF-6D (SF-12) (AUC-0.65) and EQ-5D (AUC-0.62). SF-6D (NDI) was also more responsive measure compared to SF-6D (SF-12) and EQ-5D (SRM difference 0.66, 0.48 and 0.44 respectively).

Conclusion: SF-6D derived from NDI is more valid and better responsive measure of general health and quality of life compared to EQ-5D. Cost-effective studies should use SF-6D as a measure of QALYs following cervical spine surgery.

Presentation #66

Cervical Facet Dislocations in the Pediatric Population: A Report of 21 Cases at a Level-1 Trauma Center from 2004-2014

Alireza K. Anissipour, DO, Seattle, WA
Carlo Bellabarba, MD, Seattle, WA
***Richard J. Bransford, MD**, Seattle, WA*

Introduction: Cervical facet dislocation in the pediatric population is rare. 10 total patients to date have been reported to date. When compared to the adult population, the distinctive anatomical and biomechanical differences lead to distinctive clinical manifestation in the setting of cervical facet injuries. The purpose of this study is to present a series of 21 pediatric patients with cervical facet dislocations that presented to our institution in order to identify the unique features of their injury.

Method: Between 2004 and 2014, a retrospective review at Harborview Medical Center identified 141 patients with unilateral or bilateral dislocated facet(s). 21 pediatric patients were identified. Demographic data, initial neurological exams, surgical data, radiographic findings, and follow-up records were reviewed.

Results: Of the 21 pediatric facet dislocations, 7 were unilateral and 14 were bilateral. The mean age was 14.9 years; (range, 12 to 17). Male female ratio was 15:6. 1 of 18 (5.5%) patients that had a preoperative MRI had a cervical disc herniation. C6-7 was the most common level of dislocation. 9 of 21 (43%%) had a facet fracture (8 unilateral and 1 bilateral). 11 (50%) presented as a complete spinal cord injury (SCI) (AISA A), 4 presented as an incomplete SCI (ASIA B, C, D) and 6 were neurologically intact (ASIA E).

Conclusion: Cervical facet dislocations are a rare but devastating injury in the pediatric population. We believe that in the pediatric spine is more resilient to injury, thus requiring a high-energy injury to cause a dislocation. As a result, it appears that when a cervical facet dislocation in a pediatric patient occurs, it results in a high rate of SCI and a low rate of cervical disc herniation.

See Disclosure Index pages 40–88.

Presentation #67

Comparison of the Vacuum Mattress vs. the Spine Board Alone for Immobilization of the Cervical Spine Injured Patient: A Biomechanical Cadaveric Study

***Mark L. Prasarn, MD**, Houston, TX*
Per Kristian Hyldmo, MD, Kristiansand, Norway
MaryBeth Horodyski, PhD, Gainesville, FL
Glenn R. Rechtine, II, MD, Asheville, NC

Purpose: Trauma patients in the United States are immobilized on a spine board with a cervical collar almost universally. In many other parts of the world vacuum mattresses are used for trauma patients, with the proposed advantages of improved comfort and better immobilization of the spine, pelvis, and extremities. We sought to determine the amount of motion generated in an unstable cervical spine fracture with use of the vacuum mattress versus the spine board alone.

Methods: Unstable C5-C6 ligamentous injuries were surgically created in five fresh whole human cadavers and cervical collars applied. Electromagnetic sensors were placed on the lamina of C5 and C6. The amount of angular and linear motion during testing was measured using a Fastrak, three-dimensional, electromagnetic motion analysis device (Polhemus Inc., Colchester, VT). The measurements recorded in this investigation included maximum displacements during application and removal of the device, while tilting to 90 degrees, during a bed transfer, and a lift onto a gurney. Application and removal onto the spine board was performed using the manual log-roll as is commonly practiced. A scoop stretcher was used for application of the vacuum mattress and a six-plus person lift was used for removal. In both cases the cadaver was strapped onto a spine board for the remainder of the maneuvers.

Results: There was more motion in all six planes of motion during the application process with use of the spine board alone, and this was statistically significant for axial distraction ($p = 0.035$), medial-lateral translation ($p = 0.027$), and anteroposterior translation ($p=0.026$). During tilting to 90 degrees there was more motion with just the spine board, but this was only statistically significant for anteroposterior translation ($p = 0.033$). With lifting onto the gurney there was more motion with the spine board in all planes and this was statistically significant for all planes except lateral bending. There were no differences during a bed transfer with either for the devices. During the removal process there was more motion with the spine board alone, and this was statistically significant for axial rotation ($p = 0.035$), lateral bending (0.044), and axial distraction ($p = 0.023$).

Presentation #67

Conclusions: There was more motion when using a spine board alone during typical maneuvers performed during early management of the spine injured patient, and this reached statistical significance in almost half of the planes of motion tested. Based on the results of the present study there may be benefit of use of the vacuum mattress versus the spine board alone in preventing motion at an unstable, subaxial cervical spine injury.

See Disclosure Index pages 40 – 88.

Presentation #68

The Incidence and Associated Risk Factors of Cervical Spine Epidural Hematoma following Adult Trauma

***Pedro A. Ricart, MD, MS**, Valhalla, NY*
Ravi Verma, MD, MBA, New York, NY
Steven J. Fineberg, MD, Valhalla, NY
Kyle Fink, Valhalla, NY
David E. Asprinio, MD, Valhalla, NY
Louis F. Amorosa, MD, Valhalla, NY

Introduction: Spinal epidural hematoma (SEH) is an uncommon clinical entity, but an important source of spinal cord compression, with several causes reported in the literature. The objective of our study is to determine the incidence and associated risk factors for epidural hematoma in the setting of cervical spine trauma.

Materials/Methods: We conducted a retrospective review of a prospectively collected state trauma registry; identifying all patients with cervical spine injuries who presented to a tertiary care Level I trauma center between the years 2010 and 2014. Institutional Review Board approval was obtained prior to initiating this study. Exclusion criteria were limited to age (range 18-90 years) to decrease risk of identification. Using ICD-9 codes specific for cervical injury, patients with cervical seh (CEH) following trauma were classified into one group and those without SEH into group 2 (NEH). A subgroup analysis of the CEH arm was performed, based on the presence of cord compression or stenosis associated with the epidural hematoma. Demographic information was collected and the following risk factors were compared between groups: admitting INR/PT, PTT, aspirin and clopidogrel assay, albumin, platelets levels, and injury severity score (ISS).

Results: A total of 636 patients with cervical spine injuries were identified, of which 497 subjects had a spinal MRI available for review. 46 patients (9.3%) were found to have a posttraumatic cervical SEH (group CEH). Table I shows comparison demographic data for the CEH and NEH groups. Only the ISS and presence of Ankylosing spondylitis (AS) were found to be significant ($p = 0.02$ & $p < 0.001$, respectively), with a higher ISS for patients in the CEH group. Comparing the NEH group to the CEH group, there was no difference in INR/PT, PTT, platelets, albumin, aspirin and clopidogrel essay (table 2). In the subgroup analysis of patients in the CEH group with spinal cord compression or stenosis (CC), ISS and AS were statistically significant ($p = 0.01$ & $p = 0.001$, respectively) (Table 1&2). Ankylosing spondylitis was present in five cases of cervical SEH (11%) following trauma; three presented with cord compression (CC) and two without (NCC) (11.1% versus 0.4%, respectively).

Presentation #68

Conclusion: The incidence of cervical spinal epidural hematoma following trauma was found to be 9.3% in our study, of which 59% presented with spinal cord compression or stenosis. We found that the greater the Injury Severity Score was in the setting of spine trauma, the higher the risk of cervical epidural hematoma with cord compression. Ankylosing spondylitis patients sustaining trauma to their cervical spine are at a higher risk of developing an epidural hematoma with cord compression. Admitting INR/PT, PTT, aspirin and clopidogrel assay, albumin, and platelets levels had no effect on the incidence of epidural hematoma.

Table 1.

	CEH	NEH	P	CC	NCC	P
N	46 (9.3%)	451 (90.7%)		27 (5.4%)	470 (94.6%)	
Sex			*0.1*			*0.2*
Male	35 (76.1%)	288 (63.9%)		21 (77.8%)	302 (64.3%)	
Female	11 (23.9%)	163 (36.1%)		6 (22.2%)	168 (35.7%)	
Age	55 y	53.7 y	*0.7*	56 y	53.7 y	*0.6*
Race			*0.8*			*0.7*
white	33 (71.7%)	316 (70.1%)		18 (66.7%)	331 (70.4%)	
african american	6 (13%)	42 (9.3%)		44 (9.4%)	44 (9.4%)	
asian	1 (2.2%)	12 (2.7%)		0	13 (2.8%)	
other	6 (13%)	80 (17.7%)		5 (18.5%)	81 (17.2%)	
unknown	0	1 (0.2%)		0	1 (0.2%)	
Length of stay (days)	12.9	11	*0.3*	11.9	11.2	*0.8*
ISS	19.8	16.2	*0.02**	21.4	16.3	*0.01**
Mechanism			*0.94*			*0.7*
assault	0	4 (0.9%)		0	4 (0.9%)	
fall	20 (43.5%)	173 (38.4%)		13 (48.1%)	180 (38.3%)	
mva	24 (52.2%)	246 (54.5%)		13 (48.1%)	257 (54.7%)	
sports injury	0	4 (0.9%)		0	4 (0.9%)	
falling object	1 (2.2%)	7 (1.6%)		1 (3.7%)	7 (1.5%)	
suicide/self injury	0	5 (1.1%)		0	5 (1.1%)	
other	1 (2.2%)	12 (2.7%)		0	13 (2.8%)	
AS	5	0	*<0.001**	3 (60%)	2 (40%)	*0.001**

*statistically significant
ISS (injury severity score), AS (ankylosing spondylitis)
expressed as Mean (%)

Table 2.

	CEH	NEH	P	CC	NCC	P
INR	1.5 (2.1)	1.12 (0.7)	*0.2*	1.8 (2.7)	1.12 (0.7)	*0.2*
PT	13.4 (6.4)	11.7 (2.8)	*0.1*	14.6 (8)	11.7 (2.7)	*0.08*
PTT	25.7 (6.1)	25.6 (4)	*1*	25.7 (7.5)	25.6 (3.9)	*0.9*
Platelets	207k (61.8k)	218.6k (63.2k)	*0.2*	210k (74.1k)	218k (62.4k)	*0.5*
Albumin	3.8 (0.5)	3.9 (0.5)	*0.2*	3.8 (0.5)	3.9 (0.5)	*0.4*
ASA essay	589.6 (85.4)	581 (86.3)	*0.6*	585.8 (80.8)	581.5 (86.6)	*0.8*
Clopidogrel essay	281.4 (65.5)	291.2 (70.3)	*0.5*	282.3 (72)	290.7 (69.7)	*0.6*

INR (international normalized ratio), PT (prothrombin time), PTT (partial thromboplastin time)
expressed as Mean (standard deviation)

See Disclosure Index pages 40–88.

Presentation #69

Dens Fractures Displacement is Dependent on The Sagittal Alignment of the Subaxial Cervical Spine Rather than the Force of Injury

***Jung U. Yoo, MD**, Portland, OR*
Sabina R. Blizzard, BA, Portland, OR
Natalie L. Zusman, BS, Portland, OR
Matthew S. Shinseki, BS, Brooklyn, NY
Marcel W. Betsch, MD, Portland, OR
Bala Krishnamoorthy, PhD, Vancouver, WA

Introduction: The treatment of dens fractures is often determined by the fracture angulation and displacement. It is generally believed that the magnitude of fracture displacement is proportional to the magnitude of the force applied to the cervical spine at the time of injury. However, there is no literature to support this belief. We examine in this abstract, the causes of displacement in dens fracture.

Materials/Methods: Fifty-seven trauma patients who sustained a dens fracture between 2008 and 2011 were included in the study. This study received Institutional Review Board Approval. The angular and translational displacements of the fracture were measured for each patient. Cervical lordosis was measured using the Cobb method between C2 and T1 and the slopes of disc spaces measured using the measurement method of determining sacral slope. Sagittal alignment was measured by comparing the sagittal position of the C2 body relative to the C7 body. The degree of fracture angulation and magnitude of horizontal displacement were compared with age, cervical lordosis, disc space slope and mechanism of injury. We employed support vector regression for function estimation within 10-fold cross validation to build predictive models for fracture angulation and displacement. We tested each variable individually, and then all input variables together as well as subsets of all variables.

Results: Patient age ranged from 19 to 97 years; 63.1 ± 24.9 years for males and 74.7 ± 14.3 years for females. Fracture angle was 3.3 ± 11.7˚ for motor vehicle accident patients, 7.5 ± 2.3˚ for those who sustained high level falls and 18.8 ± 14.0˚ for ground level fall ($p = .01$). Translational displacement was 2.6 ± 2.6mm for MVA, 2.0 ± 2.1mm for higher fall, and 2.7 ± 2.9mm for ground level fall. ($p > .05$)

Saturday, December 5, 2015, 7:27–7:33 am CSRS–2015

Presentation #69

There was a positive correlation between angular displacement for both C5-6 ($R^2 = 0.45$, $p = < .01$) and C6-7 disc ($R^2 = .37$, $p < .01$) slopes. There were positive correlations between translational displacement and C6-7 disc slope ($R^2 = .20$, $p < .01$) and sagittal alignment ($R^2 = .10$, $p = < .01$). The predictive model using all 10 variables (age, sex, C3-4 slope, C4-5 slope, C5-6 slope, C6-7 slope, lordosis, fracture mechanism, fracture type, and sagittal alignment) demonstrated that angular displacement of fractures is only dependent on C5-6 disc space slope, and that the horizontal displacement was dependent only on C6-7 slope and sagittal balance.

Conclusion: Contrary to the conventional belief there was no positive correlation between the force of injury and amount of displacement. The only factors that contributed to the magnitude of displacement were the sagittal alignment and the slope of the lower cervical disc spaces. The greater slope of the disc represents more flexion of the disc space in relation to the vertical axis of the patient. This relatively flexed posture of the sub-axial spine forces the upper spine to be extended as the patient tries to maintain a horizontal gaze, resulting in greater displacement of the dens post fracture. Better understanding of this deforming force may aid in improving the treatment of this complex fracture.

See Disclosure Index pages 40–88.

Presentation #70

Risk Factors for Dysphagia in Acute Cervical Spinal Cord Injury

***Tetsuo Hayashi, MD, PhD**, Fukuoka, Japan*
Takeshi Maeda, MD, PhD, Fukuoka, Japan
Hiroaki Sakai, MD, Fukuoka, Japan
Yuichiro Morishita, MD, PhD, Fukuoka, Japan
Keiichiro Shiba, MD, PhD, Fukuoka, Japan

Introduction: Dysphagia following traumatic cervical spinal cord injury (CSCI) is an under-recognized complication that can lead to aspiration pneumonia, which is a significant cause of morbidity and mortality. Several authors have investigated dysphagia associated with CSCI, however, risk factors for dysphagia are still not well understood. The objective of this study was to elucidate the incidence and risk factors of dysphagia in patients with acute CSCI.

Methods: A total of 464 consecutive patients with traumatic cervical spinal injury with and without spinal cord damage were treated at our institute and were registered in a database from January 2007 to December 2014. All patients underwent CT, MRI, and neurological examination on admission. We retrospectively selected 298 patients based on following criteria: (1) admission within 3 days following injury, (2) patients with paresis or paralysis, (3) patients without brain injury. Neurological impairment scale was evaluated according to ASIA impairment scale (AIS), and level of injury was identified using CT and MRI. We analyzed the factors postulated to increase the risk for dysphagia, including the patient's age, neurological impairment scale grade, level of injury, tracheostomy, and operative treatment, using a multiple logistic regression model to compute odds ratios (ORs) and 95% confidence intervals (95% CI).

Results: 298 eligible patients (256 males and 42 females) with an average age 61.4 ± 17.3 (range, 14–91 yr.) were identified during 8-year study period. 21 of 298 patients appeared to be suffering from dysphagia after CSCI (7.0%). All of them experienced evident aspiration and had to stop eating their meals due to aspiration. The neurological status revealed that 13 of those patients were AIS A, 6 patients were AIS B, and 2 patients were AIS C. 12 of 21 patients (57.1%) received tracheostomy (Table 1). Multivariable logistic regression analysis revealed that age > 72 years (OR: 2.97, 95% CI: 1.01–9.02, p = 0.04), AIS A or B (OR: 8.00, 95% CI: 1.92–54.7, p = 0.003), presence of tracheostomy (OR: 13.8, 95% CI: 4.62–44.3, p < 0.001) were significant risk factors (Table 2).

Conclusions: The incidence of dysphagia after acute CSCI was 7.0%. Old age, severe neurological impairment scale, and presence of tracheostomy may be at risk for dysphagia after acute CSCI. When treating CSCI, understanding the risk factors of dysphagia is important to prevent aspiration pneumonia.

Saturday, December 5, 2015, 7:34 – 7:40 am CSRS – 2015

Presentation #70

Table 1. Distribution of dysphagia in acute CSCI

	Dysphagia (+) n=21, n (%)	**Dysphagia (-)** n=277, n (%)	**p value†**
Age (yr)			
≤72	10 (48)	210 (76)	
>72	11 (52)	67 (24)	0.004
AIS			
C, D	2 (10)	168 (56)	
A, B	19 (90)	117 (44)	<0.001
Level of injury			
≦C5/6	5 (24)	103 (35)	
≧C4/5	16 (76)	174 (65)	0.218
Treatment			
Conservative treatment	14 (67)	185 (62)	
Operative treatment	7 (33)	92 (38)	0.991
Tracheotomy			
negative	9 (43)	263 (88)	
positive	12 (57)	14 (12)	<0.001

†P value was calculated by the chi-square test

See Disclosure Index pages 40–88.

Presentation #70 (cont.)

Table 2. Risk factor of dysphagia in acute CSCI

	Crude OR (95% CI)	Adjusted OR (95% CI)
Age (yr), n (%)		
≤72	Reference	Reference
>72	3.44 (1.39-8.62) *	2.96 (1.01-9.02) *
AIS, n (%)		
C, D	Reference	Reference
A, B	12.9 (3.67-82.52)*	8.01 (1.92-54.70)*
Level of injury, n (%)		
≦C5/6	Reference	Reference
≧C4/5	1.89 (0.71-5.92)	2.73 (0.73-11.51)
Treatment, n (%)		
Conservative treatment	Reference	Reference
Operative treatment	1.01 (0.37-2.50)	0.85 (0.22-3.16)
Tracheotomy		
negative	Reference	Reference
positive	25.05 (9.19-71.71)*	13.82 (4.62-44.2)*

P < 0.05 by univariate or multivariate logistic analysis
OR: odds ratio, CI: confidence interval

Presentation #71

Does Age affect Surgical Outcomes in Patients with Degenerative Cervical Myelopathy? Results from the Prospective, Multicenter AOSpine International Study on 479 Patients

***Hiroaki Nakashima, MD**, Toronto, ON, Canada*
Lindsay Tetreault, HBSc, Toronto, ON, Canada
Narihito Nagoshi, MD, PhD, Toronto, ON, Canada
Aria Nouri, MD, Toronto, ON, Canada
Michael G. Fehlings, MD, PhD, Toronto, ON, Canada

Introduction: Currently, the global population is experiencing a shift in its age structure. With this aging of the population, clinicians worldwide will be required to manage an increasing number of degenerative cervical myelopathy (DCM) related to the elderly. However, there is controversy whether surgical decompression is equally effective and safe in elderly patients as it is in younger patients. This study aims to determine whether age truly is an independent predictor of surgical outcome and to provide evidence to guide practice and decision-making.

Materials/Methods: A total of 479 symptomatic DCM patients were prospectively enrolled in the CSM-International study at 16 centers. Our sample was divided into a younger (< 65 years) and elderly (≥ 65 years) group. Each subject was neurologically examined at baseline and 24-months postoperatively and evaluated using a variety of functional outcome measures, including the Neck Disability Index (NDI), SF-36 physical component summary (PCS) and mental component summary (MCS), and the modified Japanese Orthopaedic Association scale (mJOA). A mixed model analytic approach was used to evaluate differences in these outcome measures between groups. We first created an unadjusted model between age and surgical outcome and then developed two adjusted models that accounted for variations in 1) baseline characteristics and 2) both baseline and surgical factors.

See Disclosure Index pages 40–88.

Presentation #71 (cont.)

Results: Of the 479 patients, 360 (75.16%) were < 65 years and 119 (24.84%) were ≥ 65 years. There were no significant differences in gender (p=0.82) or duration of symptoms (p = 0.82) between the two age groups (Table1). However, elderly patients had a significantly higher number of co-morbidities (p < 0.0001). In addition, elderly patients were functionally more impaired preoperatively based on the mJOA (p < 0.0001) and Nurick (p < 0.0001) scales and had a lower SF-36 PCS (p = 0.048). The majority of younger patients (64.96%) underwent anterior surgery, whereas the preferred approach in the elderly group was posterior (58.62%) (p < 0.0001). Elderly patients had a greater number of decompressed levels (4.14 ± 1.30) than younger patients (3.50 ± 1.23) (p < 0.0001). Three hundred and eight-nine patients (81.21%) attended their 24-month follow-up appointment. Younger patients achieved a higher postoperative mJOA (p < 0.0001) and a lower Nurick score (p < 0.0001) than elderly patients (Table 2). SF-36 PCS scores were also significantly higher in the younger group (p = 0.033). There were no significant differences in postoperative NDI or SF-36 MCS between age groups. After adjustments for patient and surgical characteristics, these differences in postoperative outcome scores decreased but remained significant (Table 2). On average, elderly patients had a significantly longer length of postoperative hospital stay (12.99 ± 13.56 days) than younger patients (9.53 ± 8.67 days) (p = 0.0086). There were no significant differences between the two age groups with respect to rates of perioperative complications (p = 0.47).

Conclusion: Older age is an independent predictor of functional status in patients with DCM. However, patients over 65 with DCM still achieve functionally significant improvement after surgical decompression. Potential explanations for this lower functional outcomes in older patients include that the elderly 1) increased degenerative pathology, including a decrease in number of anterior horn cells and number of myelinated fibers 2) co-morbidities, 3) reduced physiological reserves and 4) age-related changes to the spinal cord.

Presentation #71

Table 1. Demographics and Baseline Severity Scores of Younger (<65 years) and Elderly (≥65 years) Patients

	Younger Patients (<65 years)	Elderly Patients (≥65 years)	p-value
Demographics			
Age (years)	51.32±8.77	71.63±5.34	<0.0001
Gender (%)	65.00 M, 35.00 F	63.87 M, 36.13 F	0.82
Duration of Symptoms (months)	27.40±35.34	25.96±32.68	0.82
Smoker (%)	32.78 Y, 67.22 N	10.92 Y, 89.08 N	<0.0001
Co-morbidities (%)	53.76 Y, 46.24 N	21.85 Y, 78.15 N	<0.0001
Co-morbidity Score	1.13±1.51	2.51±2.13	<0.0001
Number of Co-morbidities	1.00±1.25	1.74±1.31	<0.0001
Diabetes (%)	9.44 Y, 90.56 N	21.85 Y, 78.15 N	0.0004
Cardiovascular (%)	36.49 Y, 63.51 N	64.71 Y, 35.29 N	<0.0001
Respiratory (%)	7.54 Y, 92.46 N	12.61 Y, 87.39 N	0.09
Gastrointestinal (%)	15.08 Y, 84.92 N	15.13 Y, 84.87 N	0.99
Renal (%)	1.40 Y, 98.60 N	4.20 Y, 95.80 N	0.13
Psychiatric (%)	9.22 Y, 90.78 N	4.20 Y, 95.80 N	0.08
Rheumatologic (%)	1.68 Y, 98.32 N	6.72 Y, 93.28 N	<0.001
Neurological (%)	3.63 Y, 96.37 N	6.72 Y, 93.28 N	0.15
Baseline Functional Status			
mJOA	12.86±2.76	11.41±2.89	<0.0001
Nurick	3.16±1.21	3.75±1.23	<0.0001
Baseline Quality of Life			
Neck Disability Index	37.52±19.59	39.15±22.31	0.70
SF36v2 Physical Functioning	32.51±11.94	28.47±12.18	<0.001
SF36v2 Role Limitation Physical	29.46±10.65	28.90±12.14	0.24
SF36v2 Bodily Pain	35.96±10.75	38.05±12.52	0.15
SF36v2 General Health	41.16±10.36	41.12±9.96	0.91
SF36v2 Emotional Well-being	38.35±12.93	40.95±12.78	0.06
SF36v2 Role Limitation Emotional	31.68±14.27	31.62±16.35	0.93
SF36v2 Social Functioning	35.98±12.86	34.89±13.00	0.41
SF36v2 Energy/Fatigue	42.59±11.09	43.56±11.16	0.38
SF36v2 Physical Component Score	34.69±9.03	32.90±8.91	0.048
SF36v2 Mental Component Score	38.94±13.10	40.79±12.94	0.16

mJOA: modified Japanese Orthopaedic Association scale. Means were compared using the appropriate t-test and frequencies were compared using the Chi-square test.

See Disclosure Index pages 40–88.

Presentation #71 (cont.)

Table 2. Functional Status and Quality of Life at 24-months following Surgery

	Outcome	Younger Patients (<65 years)	Elderly Patients (≥65 years)	Difference	p-value
Unadjusted*	mJOA	15.45 (15.18, 15.72)	14.08 (13.61, 14.56)	1.36 (0.81, 1.92)	<0.0001
	Nurick	1.64 (1.48, 1.81)	2.44 (2.15, 2.73)	-0.80 (-1.13, -0.46)	<0.0001
	NDI	23.83 (21.76, 25.90)	23.99 (20.51, 27.46)	-0.16 (-4.20, 3.89)	0.94
	SF-36v2 PCS	41.87 (40.73, 43.00)	39.36 (37.38, 41.36)	2.50 (0.21, 4.80)	0.033
	SF-36v2 MCS	47.34 (45.96, 48.72)	46.72 (44.31, 49.13)	1.41 (-2.16, 3.40)	0.66
Adjustment Model 1†	mJOA	14.02 (13.23)	12.72 (11.86, 13.58)	1.31 (0.73, 1.87)	<0.0001
	Nurick	2.52 (2.02, 3.01)	3.20 (2.67, 3.74)	-0.69 (-1.04, -0.33)	0.0002
	NDI	30.63 (24.16, 37.10)	29.61 (22.52, 36.70)	1.02 (-3.96, 6.01)	0.69
	SF-36v2 PCS	38.02 (34.41, 41.63)	35.90 (31.96, 39.83)	1.21 (-0.25, 4.50)	0.080
	SF-36v2 MCS	46.70 (41.87, 51.54)	47.71 (42.45, 52.97)	-1.01 (-4.19, 2.17)	0.53
Adjustment Model 2[x]	mJOA	13.80 (12.86, 14.74)	12.55 (11.55, 13.55)	1.25 (0.68, 1.82)	<0.0001
	Nurick	2.58 (2.00, 3.17)	3.22 (2.59, 3.85)	-0.63 (-0.99, -0.27)	0.0006
	NDI	27.79 (20.16, 35.42)	26.84 (18.60, 35.07)	0.95 (-4.08, 5.99)	0.71
	SF-36v2 PCS	38.87 (34.64, 43.10)	36.91 (32.37, 41.44)	1.96 (-0.48, 4.40)	0.16
	SF-36v2 MCS	48.64 (43.01, 54.26)	48.92 (42.89, 54.96)	-0.29 (-3.54, 2.96)	0.86

*****adjusted for preoperative severity
†adjusted for differences in patient characteristics between age groups ($p<0.05$ in univariate analysis, table 1): baseline severity score, smoking status, co-morbidity score, diabetes, cardiovascular disease and rheumatologic disorders
[x]adjusted for differences in patient and surgical characteristics ($p<0.05$ in univariate analysis, tables 1 and 2): all clinical factors from adjustment model 1 and surgical approach and number of decompressed levels.

Presentation #72

A Clinical Prediction Rule for Functional Outcomes in Patients Undergoing Surgery for Severe Degenerative Cervical Myelopathy: Analysis of an International AOSpine Prospective Multicentre Dataset of 254 Subjects

Lindsay Tetreault, HBSc, Toronto, ON, Canada
Branko Kopjar, MD, PhD, Seattle, WA
Pierre Cote, DC, PhD, Toronto, ON, Canada
Paul M. Arnold, MD, Kansas City, KS
***Michael G. Fehlings, MD, PhD**, Toronto, ON, Canada*

Objectives: Patients with cervical spondylotic myelopathy (CSM) may be severely impaired, have reduced quality of life and present with deleterious signs and symptoms. Patients with severe myelopathy (mJOA < 12) often improve following surgery; however, some may not achieve a minimum clinically important difference (MCID), whereas others may have exceptional outcomes. Due to varying prognoses among this group, it is important to predict outcome in these patients and use this knowledge to manage expectations. This study aims to determine the most important clinical predictors of surgical outcome in patients with severe CSM.

Methods: Of the 757 patients enrolled in the CSM-North America or International studies, 254 (33.55%) presented with severe myelopathy as classified by a mJOA < 12 points. A prediction model was developed to distinguish between patients who improve to mild or moderate myelopathy postoperatively (mJOA ≥ 12) and those who remain significantly impaired (mJOA < 12). Univariate analyses evaluated the relationship between this outcome and various clinical predictors. Multivariate Poisson regression was used to formulate the final prediction model and to compute the relative risks. A secondary model was constructed to predict which patients would achieve a MCID on the mJOA, defined as a change score of three or more points in patients with severe disease.

Results: Our cohort consisted of 153 men and 101 women with ages ranging from 28 to 86 (mean: 60.09 ± 12.06 years). The mean preoperative mJOA was 9.42 ± 1.67. One hundred and fifty-four (60.63%) patients improved to a score ≥ 12 at 1-year postoperative, whereas 145 (57.09%) achieved a MCID on the mJOA. Baseline severity score (RR: 1.07, 95%C.I.: 1.02–1.13), hyperreflexia (RR: 0.83, 95%C.I.: 0.72-0.96), lower limb spasticity (RR: 0.75, 95%C.I.: 0.65–0.86), and age (RR: 0.97, 95%C.I.: 0.95–0.99) were significant predictors of an mJOA ≥ 12 following univariate analysis (Table 1).

See Disclosure Index pages 40–88.

Presentation #72 (cont.)

The final model consisted of three statistically significant variables and one clinically relevant predictor: baseline severity score (RR: 1.09, 95%C.I.: 1.03–1.15), duration of symptoms (RR: 0.94, 95%C.I.: 0.89–0.99), co-morbidity score (RR: 0.96, 95%C.I.: 0.91–1.00) and the sign lower limb spasticity (RR: 0.76, 95%C.I.: 0.66–0.87) (Table 2). The AUC for this model was 0.75 (95%C.I.: 0.67, 0.83). Improvement by the MCID could not be effectively predicted by a combination of clinical variables.

Conclusion: Severe patients were more likely to achieve a score ≥ 12 on the mJOA if they had a higher preoperative mJOA score and a shorter duration of symptoms; a lower co-morbidity score (fewer and less severe concomitant disease); and did not have lower limb spasticity.

Presentation #72

Table 1. Univariate Analyses Evaluating the Association between Various Clinical Predictors and a mJOA score ≥12 at 1-year following Surgery in Patients with Severe CSM (mJOA<12)

Predictor	Relative Risk	95% C.I.	p-value
Baseline Severity Score	1.07	1.02, 1.13	0.010
Age*	0.97	0.95, 0.99	0.0014
Gender (REF=Female)	0.98	0.84, 1.14	0.81
Duration of symptoms†	0.96	0.92, 1.01	0.087
Smoking status (REF=non-smoker)	1.00	0.85, 1.19	0.97
Co-morbidities (REF=absence)	0.97	0.83, 1.14	0.72
Co-morbidity Score	0.96	0.92, 1.01	0.10
Cardiovascular	0.89	0.76, 1.03	0.12
Respiratory	0.79	0.56, 1.12	0.18
Gastrointestinal	0.95	0.74, 1.21	0.67
Renal	1.15	0.87, 1.51	0.32
Endocrine	1.05	0.88, 1.25	0.59
Psychiatric	0.94	0.72, 1.23	0.67
Rheumatologic	0.93	0.66, 1.30	0.66
Neurological	0.98	0.73, 1.31	0.88
Symptoms (REF=absence)			
Numb hands	0.83	0.68, 1.02	0.080
Clumsy hands	0.93	0.75, 1.15	0.50
Impaired gait	0.87	0.66, 1.14	0.32
Bilateral arm paresthesia	0.90	0.77, 1.04	0.15
L'Hermitte's phenomena	0.84	0.70, 1.02	0.087
Weakness	0.92	0.73, 1.17	0.51
Signs (REF=absence)			
Corticospinal motor deficits	0.93	0.79, 1.10	0.40
Atrophy of intrinsic hand muscles	1.03	0.89, 1.20	0.68
Hyperreflexia	0.83	0.72, 0.96	0.010
Positive Hoffman's sign	0.88	0.76, 1.03	0.10
Upgoing plantar responses	0.94	0.80, 1.09	0.40
Lower limb spasticity	0.75	0.65, 0.86	<0.0001
Broad-based unstable gait	0.89	0.75, 1.06	0.19

Co-morbidity score is comprised of both number and severity of co-morbidities. A 1-point increase reflects either an increase in disease severity or number of co-morbidities.
Relative risk for each variable was calculated using log-binomial regression.
*Relative risk for age is by decade
†Relative risk for duration of symptoms is by group (1) <3 months, 2) >3, ≤6 months, 3) >6, ≤12 months, 4) >12, ≤24 months, 5) >24 months)
C.I.: confidence interval; mJOA: modified Japanese Orthopedic Association

See Disclosure Index pages 40–88.

Presentation #72 (cont.)

Table 2. Final Clinical Prediction Model to Determine Functional Status (mJOA≥12) at 1-year following Surgery in Patients with Severe CSM (mJOA<12)

Predictor	Relative Risk	95% C.I.	p-value
Lower limb spasticity (REF=absence)	0.76	0.66, 0.87	<0.0001
Baseline severity score (mJOA)	1.09	1.03, 1.15	0.0028
Duration of symptoms	0.94	0.89, 0.99	0.012
Co-morbidity score	0.96	0.91, 1.00	0.066

This model serves to distinguish between patients with mild to moderate myelopathy postoperatively (mJOA≥12) and those with severe neurological impairment (mJOA<12).
Relative risk for each covariate was computed using Poisson regression.
Baseline severity score: 0-18 points; co-morbidity score is comprised of both number and severity of co-morbidities; duration of symptoms 1) <3 months, 2) >3, ≤6 months, 3) >6, ≤12 months, 4) >12, ≤24 months, 5) >24 months.
C.I.: confidence intervals; mJOA: modified Japanese Orthopedic Association;

Presentation #73

Signal Intensity Ratio on Magnetic Resonance Imaging and Neurological Status as Prognostic Factors in Patients with Cervical Compressive Myelopathy

***Jun-Jae Shin, MD, PhD**, Seoul, Republic of Korea*

Objectives: Many authors have reported prognostic factors that may influence the neurological outcome such as, patient age, symptom duration, the severity of symptoms, the compression ratio of spinal cord, and the signal changes on magnetic resonance imaging (MRI). Particularly, intramedullary signal intensity (SI) changes on T2-weighted imaging (T2WI) have been discussed to be a controversial issue in cervical compressive myelopathy. Some authors reported that patients with increased intramedullary SI show a poor prognosis after surgical decompression, while others asserted that there is no clear relationship between the SI and the prognosis after the surgery. One reason for the controversy is that there was no comprehensive and proper quantitative evaluation methods to assess MRI signal intensity. In this study, we attempted to quantify the SI on MRI by using signal intensity ratio and evaluated the relationship between intramedullary signal changes on MR T1- and T2-weighted images and neurological outcome of cervical compressive myelopathy.

Methods: A total of 112 patients with cervical compressive myelopathy at one or two levels, underwent anterior cervical discectomy and fusion (ACDF). We assessed cord compression ratio, cervical curvature, the severity of SI change on T2WI, and surveyed neurological outcome using the Japanese Orthopedic Association (JOA) score for cervical myelopathy. The MRI SI was evaluated by grade: grade 0, no change in signal intensity; grade 1, light signal change; and grade 2, bright signal change on T2WI. Also, we performed quantitative analysis of MR signal changes on both T1- and T2WI using the signal intensity ratio (SIR; the ratio between the region of interest (ROI) of intramedullary signal intensity and ROI of the normal C7-T1 level). Then, we evaluated the correlations between SIR on T1- and T2WI and symptom duration, cord compression ratio, preoperative JOA scores and JOA recovery ratio.

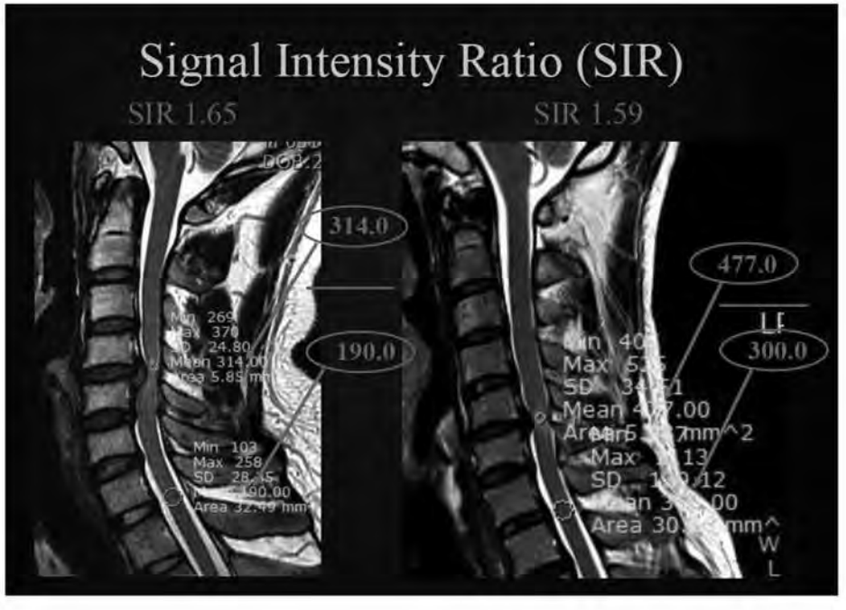
Results: There were significant differences in symptom duration ($p = 0.00515$), preoperative JOA score ($p = 0.00287$), SIR on T2WI ($p < 0.001$), and JOA recovery ratio ($p = 0.00218$) among the 3 groups (SI grade 0, 1, 2). However, there was no significant difference in patient age, cord compression ratio, cervical curvature, and SIR on T1WI in those groups. We found that not SIR on T1W1 but preoperative JOA score and SIR on T2WI had a correlation with postoperative neurological outcome. The symptom duration is correlated positively with SIR on T2WI but not with SIR on T1WI.

See Disclosure Index pages 40–88.

Presentation #73 (cont.)

Conclusions: Initial neurological status and high intramedullary SI in the preoperative phase were related to poorer postoperative outcomes. The neurological outcome was particularly poor in patients who showed increased intramedullary SI on T2WI, especially when they had higher SIR on T2WI preoperatively. Signal intensity ratio in the preoperative T2WI seems to be correlated with poor neurological outcome after surgical operation. We suggest that the quantification of signal intensity changes in patients with cervical compressive myelopathy should be used to assess the correlation between the intramedullary signal changes and clinical outcome.

Keywords: cervical compressive myelopathy; Intramedullary signal intensity; Magnetic resonance imaging; Region of interest



Presentation #73

Results

	Grade 0 (n=41)	Grade 1 (n=44)	Grade 2 (n=20)	P
Age (yr)	52.6 ± 10.7	51.3 ± 10.6	50.3 ± 11.5	0.702
Symptom duration (wks)	5.9 ± 5.5	10.4 ± 12.5	18.1 ± 15.0	< 0.001
Compression ratio (%)	36.1 ± 7.1	32.2 ± 7.4	30.6 ± 9.6	0.015
Cervical curvature (°)	12.7 ± 10.2	12.1 ± 8.5	14.1 ± 6.8	0.453
SIR on T2WI	1.18 ± 0.15	1.44 ± 0.29	2.03 ± 0.47	< 0.001
SIR on T1WI	1.31 ± 0.16	1.36 ± 0.22	1.42 ± 0.28	0.127
Preoperative JOA	12.1 ± 2.1	11.0 ± 2.3	9.5 ± 2.4	< 0.001
Postoperative JOA	15.7 ± 1.1	14.6 ± 1.7	13.2 ± 1.8	< 0.001
Recovery rate (%)	73.0 ± 19.2	62.3 ± 18.7	49.3 ± 18.1	< 0.001

T2WI, T2-weighted image; T1WI, T1-weighted image; JOA, Japanese Orthopedic Association score

See Disclosure Index pages 40–88.

Presentation #74

Clinical Outcomes following Surgical Management of Coexistent Parkinson's Disease and Cervical Stenosis with Myelopathy

Roy Xiao, BA, Cleveland, OH
***Jacob A. Miller, BS**, Cleveland, OH*
Daniel Lubelski, MD, Cleveland, OH
Thomas E. Mroz, MD, Cleveland, OH
Edward C. Benzel, MD, Cleveland, OH
Ajit A. Krishnaney, MD, Cleveland, OH
Andre Machado, MD, PhD, Cleveland, OH

*No grants, technical or corporate support were received in conducting this study or writing this abstract. No relevant conflicts of interest. IRB approval (15-135) was obtained prior to start of study.

Introduction: The presentation of myelopathy in patients with concomitant cervical stenosis (CS) and Parkinson's disease (PD) complicates diagnosis and treatment because of similarities in presentation and disease progression. While CS with myelopathy is treated with surgical decompression, PD patients suffer poor outcomes after spine surgery. No studies have examined this unique population, and the outcomes following decompression for myelopathic patients with coexisting PD and CS are unknown. The purpose of this study was to define the demographic features and presenting symptoms of patients with PD and CS and to investigate their outcomes following surgery.

Materials/Methods: A retrospective review of all myelopathic patients diagnosed with PD and CS before undergoing cervical decompression surgery at a single tertiary-care institution between January 1996 and December 2014 was conducted. Each study patient with PD was matched to a control myelopathic patient of the same gender, ASA classification, and operation parameters (procedure, year, and surgeon) without PD but with CS. Matched patients were separated by at most five years in age and had differences in total operated vertebral levels of at most one level. Symptoms were recorded along with severity of myelopathy assessed using the Nurick scale (larger scores indicate greater severity) and the modified Japanese Orthopaedic Association (mJOA, smaller scores indicate greater severity) classification of disability. The two groups were compared with respect to numeric variables using Student's *t*-tests and categorical variables using Fisher's exact tests.

Results: Forty-two patients were reviewed with 21 matched pairs. Mean age was 67 and 66 for the PD and control groups, respectively, and mean BMI was 27.1 and 28.4, respectfully (Table 1). Smoking was more prevalent in control patients (67% v. 29%, p=0.03).

Presentation #74

Mean duration of symptoms was 13.4 months for PD patients and 9.4 months for control patients (Table 2, p = 0.24). The C4-C5 level was the most common operated level (88% of cases). The most common operation was laminectomy with fusion (62%) followed by anterior cervical discectomy and fusion (24%). Postoperative symptoms improved in both groups. Despite limited differences in preoperative symptoms (Table 2), back pain, myelopathy, radiculopathy, and bowel/bladder dysfunction were more common in PD patients at last follow-up (LFU). PD patients suffered more severe myelopathy before and after surgery with poorer improvement. Mean preoperative Nurick score was worse for PD patients (3.2 vs. 2.3, p= 0.03). At LFU, Nurick (3.2 vs. 1.2, $p < 0.0001$) and mJOA scores (13.2 vs. 15.2, $p < 0.01$) were worse for PD patients. Control patients experienced greater improvement in myelopathy by Nurick (-1.0 vs. 0.0, $p < 0.001$) and mJOA (2.5 vs. 0.9, $p < 0.01$) scales at LFU compared to preoperative assessment.

Conclusions: This study is the first to characterize the clinical outcomes of cervical decompression surgery in treating myelopathic patients with PD and CS. Myelopathic patients with PD and CS improve after surgery, although less than those without PD. Surgery should be considered for these patients, with PD patients being informed that myelopathy symptoms are less likely to be alleviated completely.

Table 1. Patient Characteristics

Characteristic	PD		Control		*p*-value*
N	21		21		
Female	5	24%	5	24%	1.00
Age at Surgery (years)	67.4 ± 9.4		66.0 ± 8.8		0.55
BMI	27.1 ± 3.5		28.4 ± 4.2		0.37
Comorbidities					
Smoking	6	29%	14	67%	0.03†
Alcohol Abuse	0	0%	2	10%	0.49
Hypertension	13	62%	15	71%	0.74
Dyslipidemia	8	38%	6	29%	0.74
Diabetes	1	5%	6	29%	0.09
Depression/Anxiety	5	24%	5	24%	1.00
Congestive Heart Failure	2	10%	0	0%	0.49
Coronary Artery Disease	4	19%	4	19%	1.00
Cancer	3	14%	4	19%	1.00
History of Falls	6	29%	7	33%	1.00

N, Number; BMI, body mass index; PD, Parkinson's disease.
Note: Mean ± standard deviation for continuous variables, count (percent) for categorical variables.
* *t*-test for continuous variables, Fisher's exact test for categorical variables.
† Statistically significant: $p \leq 0.05$.

See Disclosure Index pages 40–88.

Presentation #74 (cont.)

Table 2. Clinical Outcomes

Characteristic	PD		Control		*p*-value*
Vertebral Levels Operated On	3.7 ± 1.4		4.1 ± 1.2		0.18
Duration of Symptoms (months)	13.4 ± 11.0		9.4 ± 7.1		0.24
Time to LFU (months)	14.3 ± 15.0		20.9 ± 26.3		0.22
Preoperative Symptoms					
Neck Pain	13	62%	16	76%	0.51
Back Pain	12	57%	8	38%	0.35
UE/LE Pain	14	67%	13	62%	1.00
Myelopathy	21	100%	21	100%	1.00
Radiculopathy	14	67%	14	67%	1.00
Bowel/Bladder Dysfunction	6	29%	6	29%	1.00
UE/LE Weakness	19	90%	18	86%	1.00
Postoperative Symptoms					
Neck Pain	5	24%	6	29%	1.00
Back Pain	10	48%	4	19%	0.10
UE/LE Pain	11	52%	9	43%	0.76
Myelopathy	12	57%	5	24%	0.06
Radiculopathy	11	53%	6	29%	0.21
Bowel/Bladder Dysfunction	5	24%	1	5%	0.18
UE/LE Weakness	9	43%	9	43%	1.00
Preoperative Myelopathy					
Nurick Disability Scale	3.2 ± 1.0		2.3 ± 1.1		0.03 †
mJOA Scale	12.3 ± 1.6		12.7 ± 1.9		0.57
LFU Myelopathy					
Nurick Disability Scale	3.2 ± 1.1		1.2 ± 1.1		< 0.0001 †
mJOA Scale	13.2 ± 1.5		15.2 ± 1.7		< 0.01 †
Change in Myelopathy					
Nurick Disability Scale	0.0 ± 0.4		–1.0 ± 0.9		< 0.001 †
mJOA Scale	0.9 ± 1.1		2.5 ± 2.1		< 0.01 †

PD, Parkinson's disease; LFU, last follow-up; UE/LE, upper/lower extremity; mJOA, modified Japanese Orthopaedic Association
Note: Mean ± standard deviation for continuous variables, count (percent) for categorical variables. Nurick Disability and mJOA changes in score represent the change in the respective score following surgery.
* *t*-test for continuous variables
† Statistically significant: $p \leq 0.05$.

Presentation #75

Symptomatic Lumbar Spinal Stenosis Increases the Risk of Spondylotic Cervical Spinal Cord Compression and Cervical Spondylotic Myelopathy

***Josef Bednarik, MD, PhD**, Brno, Czech Republic*
Blanka Adamova, MD, PhD, Brno, Czech Republic
Miloš Kerkovský, MD, PhD, Brno, Czech Republic
Ivana Kovalová, Brno, Czech Republic
Zdenek Kadanka, Jr., MD, Brno, Czech Republic
Zdenek Kadanka, MD, PhD, Brno, Czech Republic

Introduction: Spondylosis frequently affects not just one segment of the spine; it is generally more widespread. The most commonly affected regions are the lumbar and cervical spine. Concurrent cervical and lumbar stenosis is usually recorded as "tandem stenosis." The aim of this prospective cross-sectional observational comparative study was to determine the prevalence of spondylotic cervical cord compression (SCCC) and symptomatic cervical spondylotic myelopathy (CSM) in patients with symptomatic lumbar spinal stenosis (LSS) in comparison with a general population sample and to seek to identify predictors for the development of CSM.

Methods: A group of 78 patients with LSS (48 men, median age 66 years) was compared with a randomly selected age- and sex-matched group of 78 volunteers (38 men, median age 66 years). We evaluated magnetic resonance imaging (MRI) findings from the cervical spine and neurological examination. MRI was performed on a 1.5-T MR scanner. The protocol of cervical spine MRI involved conventional sequences for the evaluation of the spine and spinal cord morphology, including T1, T2 and STIR (short-tau inversion recovery) images in the sagittal plane and axial T2 weighted gradient-echo scans coherently covering 5 segments of cervical spine from C2/C3 to C6/C7 levels. The clinical status of patients/volunteers was blinded for a neuroradiologist who evaluated cervical spine MRIs. For classification of cervical cord compression severity we used a grading system that classified compression as impingement, i.e. focal concave defect of the spinal cord contour with at least partially preserved subarachnoid space (type I); flat spinal cord compression with either partial obliteration of subarachnoid space (type IIa); or with diminished subarachnoid space (type IIb).

Results: The presence of SCCC was demonstrated more frequently in patients with LSS (84.6%) in comparison with a sample of volunteers randomly recruited from the general population (57.7%; $p < 0.001$), and LSS patients had more serious types of compression ($p = 0.006$). Clinically symptomatic CSM was found in 16.7% of LSS patients in comparison with 1.3% of volunteers ($p = 0.001$). Multivariable logistic regression proposed an Oswestry Disability Index of 43% or more as the only independent predictor of symptomatic CSM in LSS patients (OR = 9.41, $p = 0.008$).

See Disclosure Index pages 40–88.

Presentation #75 (cont.)

Conclusions: The presence of symptomatic LSS increases the risk of SCCC; the prevalence of SCCC is higher in patients with symptomatic LSS in comparison with the general population, with an evident predominance of more serious types of MRI-detected compression and a clinically symptomatic form (CSM). Symptomatic CSM is more likely in LSS patients with higher disability as assessed by the Oswestry Disability Index.

Presentation #76

Variations in Sagittal Alignment Parameters based on Age: A Prospective Study of Normal Patients using EOS Imaging

***Sravisht Iyer, MD**, New York, NY*
Lawrence G. Lenke, MD, St. Louis, MO
Venu M. Nemani, MD, PhD, New York, NY
Michael C. Fu, MD, New York, NY
Grant D. Shifflett, MD, New York, NY
Todd J. Albert, MD, New York, NY
Brenda A. Sides, MA, St. Louis, MO
Lionel N. Metz, MD, St. Louis, MO
Matthew E. Cunningham, MD, PhD, New York, NY
Han-Jo Kim, MD, New York, NY

Introduction: EOS allows for simultaneous capture of coronal and sagittal standing images from the occiput to the lower extremity without stitching or vertical distortion. This provides an ideal method to evaluate measures of global alignment and relate measures of sagittal alignment to horizontal gaze. In the cervical spine, this new imaging modality allows for measurement of occipito-cervical parameters that are not ordinarily visible on traditional lateral cervical radiographs. It also allows us the opportunity to correlate cervicothoracic parameters such as the thoracic inlet angle (TIA) to occipitocervical alignment.

Methods: Adults with no back or neck symptoms were recruited. Age, BMI, Neck Disability Index (NDI) and Oswestry Disability Index (ODI) scores were recorded. All radiographic parameters were measured at different time points by two reviewers. We sought to examine occipital alignment using the following parameters: Orbital Tilt (OrT), Orbital slope (OrS) – defined as 90-OrS, Occipital slope (OS) and occipital incidence (OI) (Figure 1). We defined OI as a morphometric parameter wherein OI = OS + OrT. Thoracic Inlet Angle (TIA), Neck tilt (NT) and T1 Slope (T1S) were also measured in addition to cervical lordosis (CL, C2-C7), Occiput-C2 angle (O-C2), Cervicothoracic angle (C6-T4), Chin brow vertical angle (CBVA) and Occipital Slope (OS). Kyphosis was considered positive and lordosis negative. Intraclass correlation coefficient (ICC) was calculated. ICC > 0.6 was considered acceptable and > 0.9 was excellent. Comparisons of sagittal alignment parameters between different age groups were performed. Bivariate Pearson correlations was used to determine relationships amongst the variables. Significance was set at $p < 0.05$.

See Disclosure Index pages 40–88.

Presentation #76 (cont.)

Results: 98 patients were included. The average age was 49.2 years (range 22–77). The average NDI score was 3.3 (range 0–30) and ODI score was 1.3 (range 0–26). ICC was acceptable for all variables (range 0.69–0.99). Average value for OrT was 68.9, OS was 9.1 and OI was 77.9. Average NT was 51.0, T1S was 25.8 and TIA was 76.9. Normative values by decade are shown in Table 1. Increasing age was correlated with increasing CL ($r = -0.34$, $p < 0.01$), T1S ($r = 0.4$, $p < 0.01$) and TIA ($r = 0.4$, $p < 0.01$). Similar to the relationship between pelvic incidence, lumbar lordosis and sacral slope, we were able to show a similar chain of correlation between cervicothoracic alignment and occipital alignment. TIA was correlated to T1S ($r = 0.56$, $p < 0.01$), T1S was correlated to CL ($r = -0.63$, $p < 0.01$), CL was correlated to O-C2 angle ($r = -0.32$, $p < 0.01$), O-C2 was correlated to OS ($r = -0.53$, $p < 0.01$), OS was correlated to OrT ($r = -0.86$, $p < 0.01$) and OI ($r = 0.34$, $p < 0.01$) and OrT was correlated to OrS ($r = -0.86$, $p < 0.01$).

Conclusion: This study on 98 asymptomatic adult volunteers presents normative values of occipitocervical and cervicothoracic alignment. Age-related changes are described. These values may be used for future reference in adult spine surgery. We describe OrT and OrS which may be important parameters for surgical planning given the importance of horizontal gaze in cervical deformity correction. Similar to pelvic incidence and lumbar lordosis, we show that NT, TIA and T1S affect CL and CL affects OrS and OrT.

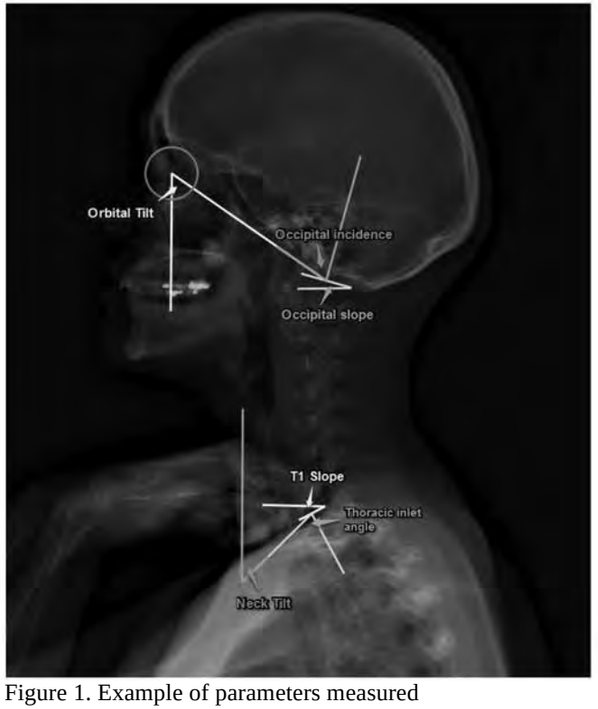


Figure 1. Example of parameters measured

Presentation #76

	Age 21 - 30 (N = 21)		Age 31 - 40 (N = 12)		Age 41 - 50 (N = 19)		Age 51 - 60 (N = 14)		Age 61 - 70 (N = 21)		Age > 71 (N = 10)	
	Mean	Std Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Orbital Tilt (OrT)	72.8	5.9	67.9	11.1	67.1	7.7	66.6	7.8	68.7	11.1	70.1	5.1
Occipital Slope (OS)	5.4	7.3	8.1	11.1	10.3	7.3	11.2	8.7	11.1	10.4	8.0	9.3
Occipital Incidence (OI)	63.9	12.9	60.4	12.3	68.0	10.5	66.2	13.9	71.1	20.1	63.7	17.7
Orbital Slope (OrS)	31.6	11.3	37.6	12.6	31.8	12.1	34.8	12.8	29.1	19.1	35.1	10.1
O-C2	-27.3	8.6	-27.2	11.3	-29.5	9.4	-26.5	8.4	-25.9	9.4	-31.1	10.8
Cervical Lordosis (C2-C7)	-4.5	14.3	-9.4	10.3	-8.7	13.7	-17.1	12.8	-17.9	12.7	-14.9	14.2
Cervicothoracic junction (C6-T4)	6.5	6.6	2.8	7.0	4.2	6.7	5.1	7.3	5.2	9.7	8.6	11.3
CBVA	-4.2	6.0	-.8	10.8	-1.4	6.2	.3	7.3	-.8	9.7	-7.1	6.4
T1 Slope (T1S)	21.7	8.1	24.5	5.9	23.6	7.1	26.0	5.9	28.4	9.9	34.3	9.6
Neck Tilt (NT)	46.6	6.4	49.9	14.3	54.7	10.7	53.5	4.9	53.1	7.0	47.0	9.3
Thoracic Inlet Angle (TIA)	73.4	10.7	79.9	12.5	81.7	10.8	85.8	6.4	79.8	20.2	83.0	11.3
C2-7 SVA	24.6	11.5	19.2	5.0	19.6	9.3	17.2	5.5	22.3	9.9	34.5	12.6

Table 1. Age-stratified normative values

See Disclosure Index pages 40–88.

Presentation #77

Cervical Deformity Surgery does not Result in Acute Post-operative Dysphagia: Preliminary Results from a Prospective Cervical Deformity Study

***Han-Jo Kim, MD**, New York, NY*
Sravisht Iyer, MD, New York, NY
Justin S. Smith, MD, PhD, Charlottesville, VA
Michael P. Kelly, MD, St. Louis, MO
Michael F. O'Brien, MD, Plano, TX
Munish C. Gupta, MD, Sacramento, CA
Todd J. Albert, MD, New York, NY
Themistocles S. Protopsaltis, MD, New York, NY
Gregory M. Mundis, MD, San Diego, CA
Peter G. Passias, MD, New York, NY
Eric O. Klineberg, MD, Sacramento, CA
Christopher P. Ames, MD, San Francisco, CA
International Spine Study Group, Brighton, CO

Introduction: Although dysphagia after cervical spine surgery has been described, prior studies have focused primarily on degenerative cases. We aimed to describe the incidence of dysphagia in patients undergoing surgery for cervical deformity. We hypothesized that posterior cervical deformity surgery would not result in post-operative dysphagia.

Methods: This was a prospective cohort study seeking to enroll operative cervical deformity (CD) patients. The inclusion criteria were: cervical kyphosis (CK) >10°, cervical scoliosis (CS) >10°, C2-7 SVA > 4cm and/or chin-brow vertical angle (CBVA) > 25°. Demographic, operative and radiographic variables were all recorded. Dysphagia was recorded using a validated measure of swallowing dysfunction – the Quality of Life in Swallowing Disorders (SWAL-QOL) survey. Paired t-tests (continuous variables), Kruskal-Wallis test (ordinal variables) and bivariate Pearson correlations were performed as appropriate. A p-value of <0.05 was considered significant for all tests.

Results: 57 pts met the inclusion criteria and 52 had complete data for analysis. The average age was 62 yrs. There were 41% primary and 59% revision cases (27% had prior anterior cervical fusion (ACF) and 17% had posterior cervical fusion (PCF)). Body Mass Index ($r = 0.33$, $p = 0.02$) and Charlson Comorbidity Index ($r = 0.35$, $p = 0.01$) were correlated with baseline swallowing dysfunction. Patients with prior ACF had worse pre-op SWAL-QOL (68 vs. 82, p=0.02), while those who had undergone a prior PCF did not (74 vs. 79, $p = 0.42$).

Presentation #77

Surgery did not result in a decline in SWAL-QOL at 3-month follow-up ($p = 0.25$) and 50% had improved scores. The number of levels for ACF averaged 3.8 (range 2–6) and did not correlate with 3 month SWAL-QOL scores ($p = 0.07$) or change in SWAL-QOL scores ($p = 0.29$). There was no correlation between SWAL-QOL and the number of levels with PCF ($p = 0.93$). There was no difference in post-op SWAL-QOL scores based on UIV, surgical approach or osteotomy. Steroids were used in 58% of patients but there was no difference in SWAL-QOL scores (74 vs. 80, $p = 0.78$). Similarly, posterior BMP use did not affect total SWAL-QOL scores (73 vs. 77, $p = 0.11$); SWAL-QOL correlated with global measures of disability such as NDI ($r = 0.51$, $p < 0.01$) and EQ5D ($r = 0.51$, $p < 0.01$) and mJOA ($r = 0.33$, $p = 0.02$).

Conclusions: Surgery for correction of CD did not result in significant dysphagia in the 3 month post-operative period as measured by the SWAL-QOL in this prospective series of CD patients. There was no correlation between the # of levels fused with dysphagia and no difference in post-op SWAL-QOL scores based on UIV, surgical approach or osteotomy. Patients with previous anterior cervical fusion (ACF) had worse baseline SWAL-QOL scores compared to those who had prior posterior cervical fusion (PCF).

See Disclosure Index pages 40–88.

Presentation #78

Cervical Kyphosis does not Imply Cervical Deformity: Predicting Cervical Curvature Required for Horizontal Gaze Based on Spinal Global Alignment and Thoracic Kyphosis

***Bassel G. Diebo, MD**, New York, NY*
Jonathan H. Oren, MD, New York, NY
Matthew A. Spiegel, BA, New York, NY
Shaleen Vira, MD, New York, NY
Elizabeth M. Tanzi, NP, New York. NY
Barthelemy Liabaud, New York, NY
Renaud Lafage, MS, New York, NY
Jensen K. Henry, BA, New York, NY
Themistocles S. Protopsaltis, MD, New York, NY
Thomas J. Errico, MD, New York, NY
Frank J. Schwab, MD, New York, NY
Virginie C. Lafage, PhD, New York, NY

Introduction: Cervical kyphosis is often considered a marker of cervical deformity, but this may not be valid since recent studies are suggesting that: 1) Cervical curvature (CC) is affected by thoracic and global alignment; 2) There is a large variability in normative CC ranging from lordotic to kyphotic alignment in the setting of asymptomatic subject. This study investigates the effect of thoracic and global alignment on CC in maintenance of horizontal gaze. The investigators hypothesized that cervical kyphosis may be a physiologic alignment necessary for the maintenance of horizontal gaze depending on underlying thoracolumbar (TL) alignment.

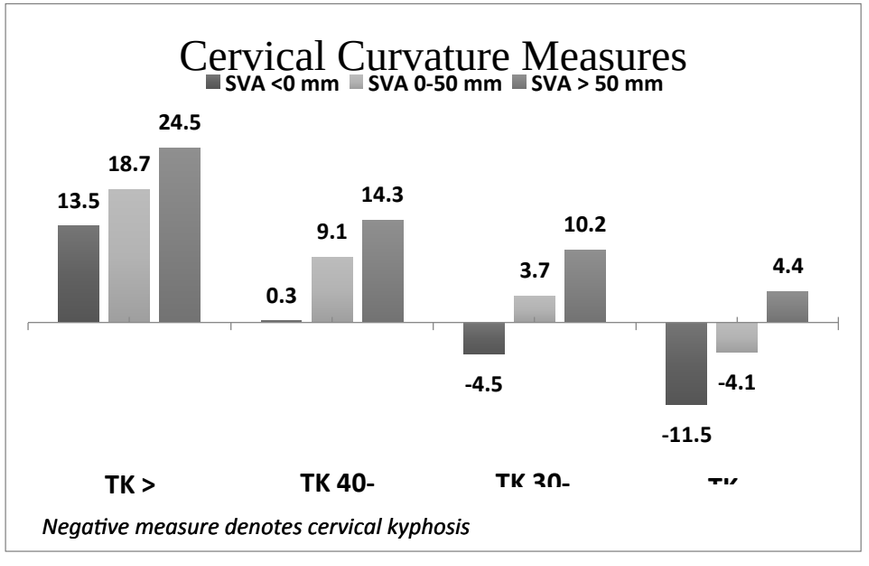
Methods: This is a retrospective review for patients who underwent full-body imaging between 2012 and 2014. For formula development, full body x-rays of 744 patients without presenting cervical complaints or existing fusions higher than T3 were studied. Only patients who maintained their horizontal gaze (CBVA -5° and 17° or McGregor's slope between -6° and 14°) were included. Patients were stratified based on thoracic kyphosis (TK) into (> 50, 40–50, 30–40 and < 30). Patients were sub-stratified by SRS-Schwab sagittal vertical axis (SVA) modifier into (posterior alignment SVA < 0, aligned 0–50 and malaligned > 50mm). C2-C7 cervical curvature was assessed among SVA grade in every TK group. Stepwise linear regression analysis was applied. A simplified formula was validated on random selection of 1905 patient visits from same database.

Presentation #78

Results: In each thoracic kyphosis group (n = 265, 172, 163, 144), cervical curvature was significantly more lordotic by increased Schwab SVA grade (Figure 1). In SVA < 0, CC was neutral for TK 40–50°, and kyphotic for TK < 40°. All patients with SVA < 50 mm, and TK < 30° were kyphotic. Regression analysis revealed lumbar lordosis LL minus TK (LL-TK) as an independent predictor (r = 0.653, r2 = 0.426) with formula: CC = 10 – (LL-TK)/2. Validation of the formula revealed error of 1.2° between predicted CC and real CC (r = 617, r2 = 381).

Conclusions: Kyphotic cervical alignment is necessary in the maintenance of horizontal gaze in some well aligned and some sagittal backward patients depending on thoracic curvature. Questioning the ability of kyphotic cervical alignment to maintain the gaze for patients with thoracolumbar malalignment (SVA > 50 mm). CC can be predicted from underlying TK and lumbar lordosis, which can be clinically relevant in cervical deformity correction with respect to patient specific thoracolumbar alignment.

Figure 1.



Cervical curvature measures in four thoracic kyphosis and three sagittal alignment groups.

See Disclosure Index pages 40–88.

Presentation #79

Does Spinopelvic Alignment Change after Cervical Laminoplasty in Patients with Cervical Spondylotic Myelopathy?

***Jun Ouchida**, Nagoya, Aichi, Japan*
Yasutsugu Yukawa, MD, PhD, Nagoya, Aichi, Japan
Masaaki Machino, MD, Nagoya, Aichi, Japan

Introduction: In the treatment of adult patients with spinal deformity, global spine balance has been featured as radiographical parameter reflecting disability and quality of life. Although some have reported the influence of cervical laminoplasty on regional cervical alignment, no study reported that on grobal spine balance nor thoracolumbar sagittal alignment after cervical laminoplasty. The purpose of this study was to evaluate an influence of cervical laminoplasty to grobal spine balance and thoracolumbar sagittal alignment after cervical laminoplasty in patients with cervical spondylotic myelopathy.

Materials/Methods: A hundred and sixty-five patients with cervical spondylotic myelopathy were prospectively enrolled. Cobb angle were measured in C2-7 lordosis, Th1-12 kyphosis, L1-5 lordosis and C2-7 sagittal vertical axis (SVA), T1 slope, sacral slope, cranial center of gravity (CGC)-SVA, C7-SVA, were measured to assess regional and global spine alignment in whole-spine standing radiographs before and a year after the operation. The subjects who underwent surgical intervention that might change the spinal alignment during follow-up period were excluded.

Results: These included 100 of 165 (60 males and 40 females with an average age of 63.1 years) patients with cervical spondylotic myelopathy. The mean pre- and post-operative C2-7 lordosis were 10.5 ± 12.1 degree and 14.8 ± 14.1 degree ($p<0.001$), for Th1-12 kyphosis 35.4 ± 11.7 degree and 38.1 ± 11.8 degree ($p<0.001$), for L1-5 lordosis 33.0 ± 11.8 degree and 33.5 ± 11.7 degree ($p=0.16$), for C2-7 SVA 53.6 ± 23.7 mm and 58.6 ± 24.3 mm ($p<0.05$), for T1 slope 23.8 ± 8.55 degree and 27.0 ± 8.16 degree ($p<0.001$), for sacral slope 35.3 ± 6.9 degree and 35.1 ± 6.9 degree ($p=0.61$), for CGC-SVA 84.3 ± 78.7 mm and 70.4 ± 75.4 mm ($p=0.07$), for C7-SVA 51.8 ± 67.3 mm and 40.5 ± 72.2 mm ($p<0.05$) respectively.

Conclusions: This study showed that C2-C7 lordosis and Th1-12 kyphosis and C2-C7 SVA increased after cervical laminoplasty. And there showed also significant increase of T1 slope and C7-SVA. Cervical laminoplasty can affect the global spine balance not only regional cervical alignment. We suggest that global spine balance should be assessed before and after cervical laminoplasty with adult spinal deformity.

Presentation #80

Changes in Sagittal Cervical Alignment after Posterior Spinal Fusion for Adolescent Idiopathic Scoliosis: An Evaluation of 141 Patients

***Joshua M. Pahys, MD**, Philadelphia, PA*
Jahangir K. Asghar, MD, Miami, FL
Alexander A. Theologis, MD, San Francisco, CA
Suken A. Shah, MD, Wilmington, DE
Patrick J. Cahill, MD, Philadelphia, PA
Amer F. Samdani, MD, Miami, FL
Christopher P. Ames, MD, San Francisco, CA

Introduction: Loss of normal thoracic kyphosis (TK: T2-T12 Cobb) is often seen in patients with adolescent idiopathic scoliosis (AIS). However, its effect on the cervical sagittal alignment before and after posterior spinal fusion (PSF) has been less well studied. Cervical kyphosis (CK) is strongly associated with reduced health related quality of life measures and increased disability scores in adults, however its effects in the AIS population is unknown.

Methods: A multicenter, prospective AIS database retrospectively identified 141 patients with minimum 2-year followup after PSF with preop, initial postop, and 2 year postop radiographs that included the skull to pelvis. CK was defined as a positive: C2-C7 Cobb>0°, while cervical lordosis (CL) was negative: C2-C7 Cobb<0°.

Results: Factors associated with developing post-op CK were: preop CK ($p = 0.001$, $r = 0.28$), lower preop/postop TK ($p < 0.01$, $r = -0.37$), lower preop/postop T1 slope ($p < 0.01$, $r = -0.62$), and negative postop C7 sagittal vertical axis ($p = 0.04$, $r = -0.39$). (Figure 1) 75% of patients with preop CK remained kyphotic at 2 years ($p = 0.001$) and had lower preop/postop SRS scores (pain, function, total score; $p < 0.05$). At 2 years, mean TK measured 32.9° +/- 10.3°, which was an increase of only 17.3% from preop ($p = 0.6$). 76 patients (54%) had an increase in TK, while TK decreased in 65 patients (46%). Sub-analysis revealed that patients with a postop TK > 40°, reliably maintained or achieved postop CL ($p = 0.007$) (Figure 2). However, TK > 40° was seen in only 23% of patients.

See Disclosure Index pages 40–88.

Presentation #80 (cont.)

Conclusion: This is the largest study to date to evaluate the cervical alignment in adolescent idiopathic scoliosis (AIS) patients before and after posterior spinal fusion (PSF). Preoperative cervical kyphosis (CK) led to a higher rate of cervical kyphosis and decreased SRS scores at 2 years postop. Postoperative thoracic kyphosis > 40° consistently resulted in maintaining and/or achieving cervical lordosis. In our cohort, however, cervical lordosis was only present in 35.6% of patients at 2 years postop. This study further highlights the importance of proper sagittal plane restoration during deformity correction for AIS. In this multicenter study, the majority of patients demonstrated suboptimal cervical and thoracic sagittal alignment after surgery, which resulted in lower quality of life scores at two years postoperative.

Figure 1. Postoperative results of patients with preoperative cervical kyphosis/lordosis

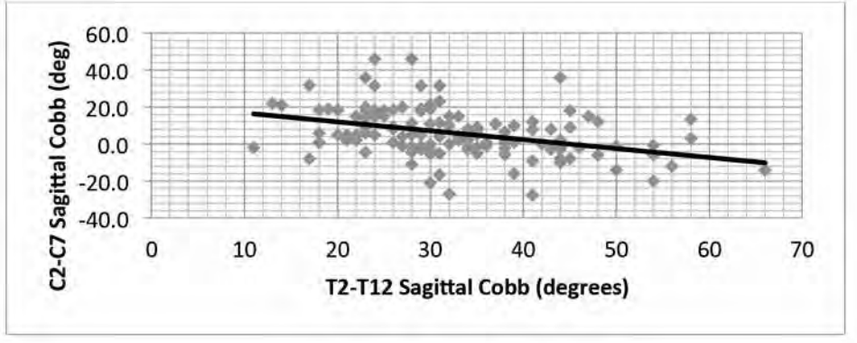
	2 year PO Cervical Kyphosis (CK) (n=91)	2 year Postop Cervical Lordosis (CL) (n=50)	P value
Preop C2-C7 Sagittal Cobb	4.2°	(-)1.6°	**0.01**
2yr PO C2-C7 Sagittal Cobb	12.9°	(-)7.0°	**<0.0001**
Preop T2-T12 Sagittal Cobb	30.2°	36.8°	**0.005**
2yr PO T2-T12 Sagittal Cobb	30.3°	37.6°	**<0.0001**
Preop T1 Slope	20.1°	23.4°	**0.01**
2yr PO T1 Slope	15.2°	24.1°	**<0.0001**
Preop C7 SVA	1.2mm	1.8mm	0.9
2yr PO C7 SVA	(-)10.1mm	1.1mm	**0.04**

2yr PO: 2 year postoperative
SVA: Sagittal Vertical Axis
CK: Cervical Kyphosis
CL: Cervical Lordosis

Saturday, December 5, 2015, 10:40–10:46 am CSRS–2015

Presentation #80

Figure 2. Sagittal cervical alignment in relation to thoracic kyphosis at 2 years postoperative.



See Disclosure Index pages 40–88.

Presentation #81 P

- **540° Cervical Realignment Procedure for Extensive Cervical OPll with Kyphotic Deformity**

***Sang-Hun Lee, MD, PhD**, Seoul, Republic of Korea*
Ki-Tack Kim, MD, Seoul, Republic of Korea
Jung-Hee Lee, MD, Seoul, Republic of Korea
Kyung-Chung Kang, MD, Seoul, Republic of Korea
Sang-Phil Hwang, MD, Seoul, Republic of Korea
Soo-Jin Jang, MD, Seoul, Republic of Korea

** Cervical lateral mass screw, cervical pedicle screw*

Introduction: Decision of surgical strategy for extensive cervical OPLL with kyphotic deformity is highly controversial. Neurological injury and dural defect would be complications of anterior surgery and poor clinical outcomes caused by incomplete decompression would be problems of posterior approach. The authors performed a novel, two staged posterior-anterior-posterior (540°) procedure to get a realignment of the cervical spine and neural decompression to overcome the shortcomings of conventional procedures. The purpose of this study is to present outcomes and feasibility of 540° procedures for extensive cervical OPLL with kyphotic deformity.

Methods: We retrospectively analyzed consecutive cases underwent staged, 540° cervical realignment procedure for OPLL (> 3 vertebral body levels) with kyphotic deformity. The surgical techniques consist of two stages. The first stage (posterior): posterior decompression and facet joint release with segmental screw fixations only, and the second stage (anterior-posterior) one week after initial surgery: anterior osteotomy of OPLL mass at the intervertebral disc level(s) without decompression and placement of lordotic graft(s), and posterior rod assembly with fusion (Figure 1 and 2). To assess the radiographic parameters, extent of OPLL, maximal canal occupying ratio (%), a distance from the maximal compression to K-line, C2-7 angle and C2-7 sagittal vertical axis (SVA) were analyzed. Clinically, we analyzed intraoperative estimated blood loss (EBL), hospitalization period, VAS of neck and arm pain, NDI, JOA score, and complications.

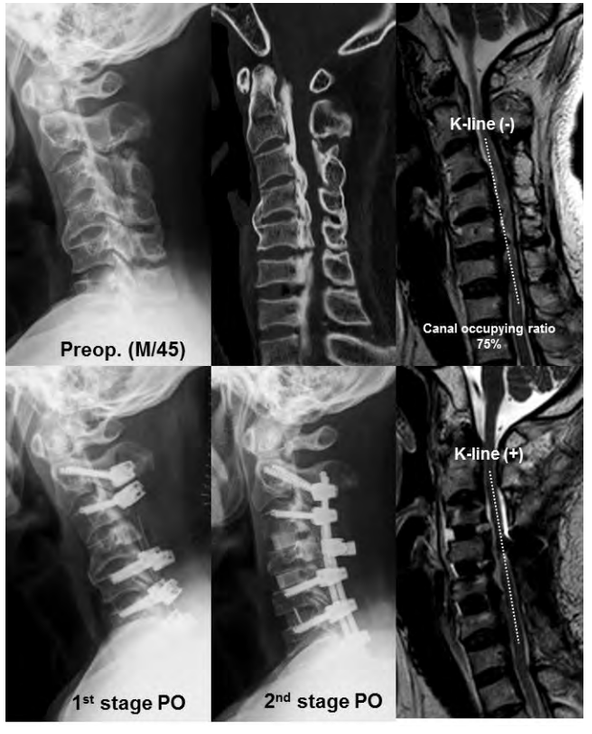
Results: A total of 16 patients (M:F = 12:4, mean age 64.9 years) were enrolled. Mean follow-up was 27 (range 9–71) months. Mean extent of the cervical OPLL was 3.8 vertebral body levels. Posterior fusion was performed on mean 4.4 segments and anterior fusion was on 2.3 segments. Mean hospitalization period was 19.1 days. EBL was averaged 75mL at the first stage and 55mL at the second stage surgery. The mean C2-7 Cobb angle was improved from 10.5° into -12.2° at the follow-up.

Presentation #81 P

The K-line distance to the maximal compression and canal occupying ratio were improved from -3.3mm, 73.5% to 3.8mm, 38.4%, respectively. Neck and arm pain VAS were improved from 3.7 and 4.7 to 1.7 and 1.6. Preoperative NDI and JOA scores (23.5 and 8.2) were significantly improved (9.4 and 14.8) at the last follow-up. There was one case of postoperative CSF leakage and one asymptomatic C7 screw fracture as the complications.

Conclusions: The 540° procedure could provide safe decompression, cervical realignment and favorable outcomes for extensive cervical OPLL with kyphotic deformity. Although there may be disadvantages of the staged surgeries, this procedure could avoid shortcomings of the conventional anterior and/or posterior surgery for extensive OPLL.

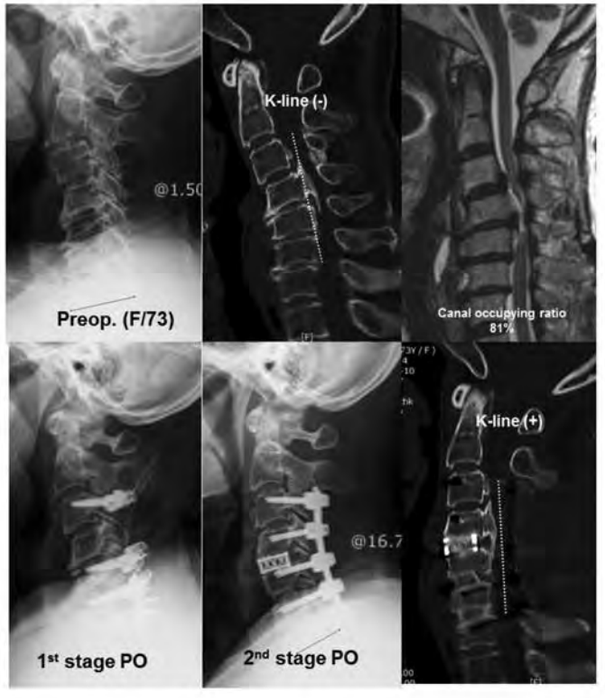
Figure 1.



See Disclosure Index pages 40–88.

Presentation #81 P (cont.)

Figure 2.



Presentation #82 P

Regional Thoracic and Lumbar Sagittal Cobb Angle Changes and UIV Determine Evolution of Cervical Alignment after ASD Surgery: Series of 171 Patients with Two-Year Follow-up

Brian J. Neuman, MD*, Baltimore, MD*
Amit Jain, MD, Baltimore, MD
Daniel M. Sciubba, MD, Baltimore, MD
Eric O. Klineberg, MD, Sacramento, CA
Han-Jo Kim, MD, New York, NY
Luke P. Zebala, MD, St. Louis, MO
Gregory M. Mundis, MD, San Diego, CA
Virginie C. Lafage, PhD, New York, NY
Peter G. Passias, MD, New York, NY
Renaud Lafage, MS, New York, NY
Themistocles S. Protopsaltis, MD, New York, NY
D. Kojo Hamilton, Portland, OR
Justin K. Scheer, BS, Chicago, IL
Christopher P. Ames, MD, San Francisco, CA
International Spine Study Group, Brighton, CO

Introduction: The aim of our study was to assess the influence of postoperative changes in spinopelvic parameters on cervical alignment in adult spinal deformity patients

Methods: This was a retrospective review of prospectively collected multicenter database. 171 ASD patients ≥ 18 years were assessed for changes from baseline to the 2-year follow-up (base-2yr) in the: C2-C7 sagittal vertical axis (C2-C7 SVA), T1-slope (T1S), and C2-C7 lordosis (C2-C7Lord). Multivariate models were constructed to analyze the influence of: UIV selection (T9 and below vs. above T9), and operative changes from baseline to 6 weeks (base-6wk) in the following spinopelvic parameters: thoracic kyphosis (TK), lumbar lordosis (LL), C7-S1 SVA, pelvic incidence, pelvic tilt and sacral slope.

Presentation #82 P (cont.)

Results: The base-2year changes in C2-C7 SVA and in T1S were both significantly associated with the surgical changes from base-6-week in TK, LL and with the UIV selection (Figure 1). Interestingly, the operative correction of C7-S1 SVA from base-6week was not significantly associated with either changes in C2-C7 SVA or T1S over the 2-year follow-up. Multivariate model revealed that changes from base-2year in the C2-C7Lord were associated with the base-6week changes in the C7-S1 SVA (P = 0.004). The majority of changes in the C2-C7 SVA over the 2-year follow-up occurred in the first 6 weeks after surgery (base-2yr 95% CI: -0.1mm to +4.6mm, and base-6wk 95% CI: +0.7mm to +4.7mm). Over the 2-year follow-up, on average, there was loss of C2-C7Lord, majority of which was lost in the first 6 weeks after surgery (base-2yr 95% CI: -3.2 to +0.5deg, and base-6wk 95% CI: -4.8 to -1.2deg).

Conclusions: Reciprocal changes in cervical alignment occur in response to operative changes in TK, LL and C7-S1 SVA. Cervical alignment is also influenced by UIV selection. Majority of changes occur in the first 6 weeks and persist over 2 years.

Figure 1: Multivariate Regression Model Analyzing the Effect of Spinopelvic Parameters on Cervical Alignment

Parameters	Change from baseline to 2 yrs in C2C7 SVA	Change from baseline to 2 yrs in T1 Slope	Changes from baseline to 2 yrs in C2C7 Lordosis
Change from Baseline to 6 weeks in:			
- Thoracic Kyphosis	P<0.001*	P<0.001*	P=0.100
- Lumbar Lordosis	P=0.027*	P<0.001*	P=0.234
- C7-S1 SVA	P=0.499	P=0.936	P=0.004*
- Pelvic Incidence	P=0.757	P=0.247	P=0.715
- Pelvic Tilt	P=0.768	P=0.239	P=0.726
- Pelvic Slope	P=0.784	P=0.232	P=0.753
Selection of UIV	P=0.009*	P=0.009*	P=0.072

Presentation #83 P

- **Are Collapsed Cervical Discs Amenable to Total Disc Arthroplasty? Analysis of Prospective Clinical Study Results with Two-Year Follow-up**

** Cervical Disc Arthroplasty (M6 cervical disc prosthesis)*

***Avinash G. Patwardhan, PhD**, Maywood, IL*
Gerard Carandang, MS, Hines, IL
Leonard I. Voronov, PhD, Hines, IL
Robert M. Havey, BS, Hines, IL
Gary Paul, San Jose, CA
Carl Lauryssen, MD, Beverly Hills, CA
Domagoj Coric, MD, Charlotte, NC
Thomas A. Dimmig, MD, Durham, NC
David B. Musante, MD, Durham, NC

Background: There is limited clinical data on the relationship between preoperative disc height and quantity and quality of postoperative motion after cervical total disc replacement (TDR). We investigated this relationship by analyzing the radiographic and clinical results of a prospective, FDA-regulated feasibility study of a compressible cervical disc prosthesis.

Methods: The study included 30 patients: 12 single-level and 18 two-level implantations (C4-C5:7; C5-C6:27, C6-C7:14). All patients received a 6mm-height compressible prosthesis (M6-C, Spinal Kinetics). An independent core facility performed measurements on preoperative and 2-year postoperative radiographs. Anterior, posterior, and average disc heights were measured at the operated and adjacent segments. Segmental and total (C2-C7) range of motion (ROM) was measured on flexion-extension films. We analyzed the influence of preoperative disc height on the postoperative ROM, location of flexion-extension center of rotation (COR), and clinical outcomes (VAS neck and arm pain, NDI) 2-years following TDR.

Results: The preoperative disc height at the TDR level was 3.7 ± 0.8mm (median: 3.7; range: 2.0–5.7). Group#1 with disc height below the median height (3.0 ± 0.4mm, range: 2.0–3.6) had significantly narrower discs than Group#2 with above median disc heights (4.4 ± 0.5mm, range:3.8–5.7mm) ($p < 0.05$) (Figure 1). Postoperatively the disc height increased to 5.8 ± 1.0mm at 2 years (range: 3.8–7.5mm), with no significant group difference. Narrow discs were less mobile preoperatively than taller discs (7.4 ± 3.7 vs. 11.1 ± 5.3 degrees, $p < 0.05$). Both groups achieved the same motion postoperatively (6.3 ± 2.8 vs. 6.4 ± 4.6 degrees, $p = 0.922$); thus, narrower discs had greater retention of motion than taller discs ($p = 0.054$).

See Disclosure Index pages 40–88.

Presentation #83 P (cont.)

We further examined the response of a subset of narrow discs, so-called "collapsed discs"; those with preoperative disc height < 3.0mm (range: 2.0–2.9mm) (Figure 2). The 2-year postoperative disc height was not different compared to the overall group (5.7 ± 0.7 vs. 5.8 ± 0.9mm, p = 0.908). The index-level preoperative ROM (5.1 ± 1.9degrees, range: 2.4–8.1) was smaller than the overall group (9.1 ± 4.8degrees, range: 2.4–21.6) (p < 0.05). The postoperative index-level ROM in this subset of discs (7.6 ± 2.4degrees, range: 3.3–10.6) was greater than the overall group mean ROM (6.3 ± 3.7degrees, range: 2.0–20.6) (p = 0.04).

The index level COR for the cohort of 48 implanted levels was maintained posterior to disc midline two years after TDR surgery. The VAS neck and arm pain scores and NDI scores all significantly improved at 2-years postoperatively for the cohort of 30 patients (p < 0.05). The preoperative disc height did not influence the postoperative index level COR location, pain scores, or NDI scores (p > 0.05).

Conclusions: Narrower discs had larger height increase and greater retention of motion without compromising the quality of motion when compared to taller discs. This is contrary to previous biomechanical studies which showed the immediate postoperative ROM and motion quality decreased with increasing disc-space distraction. Postoperative quantity and quality of motion in narrow and collapsed discs observed in this cohort may be due to intra-operative segmental mobilization, seating of the metal endplates in the bones and viscoelastic soft-tissue relaxation over time.

The results suggest that disc-space distraction up to 2X preoperative height in a collapsed segment may not degrade the postoperative motion or clinical outcomes two years after TDR with compressible disc prosthesis; and thus, collapsed discs may be amenable to disc arthroplasty.

Presentation #83 P

Figure 1.

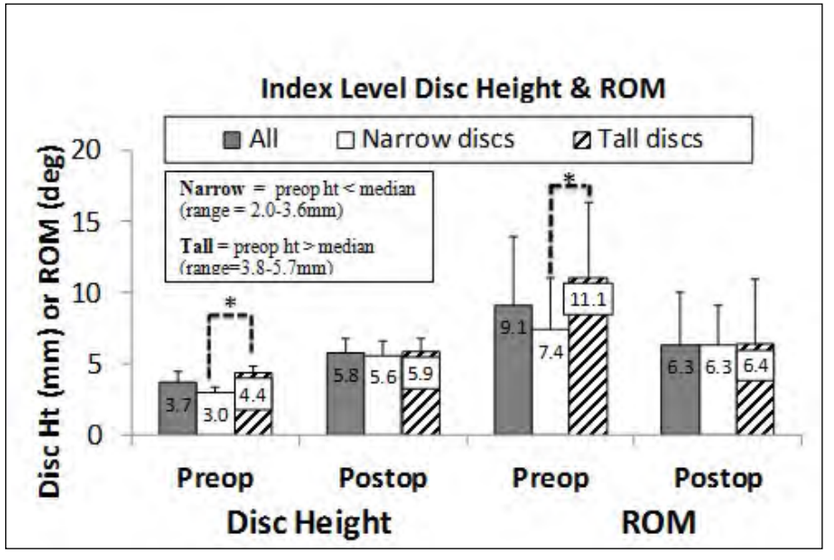
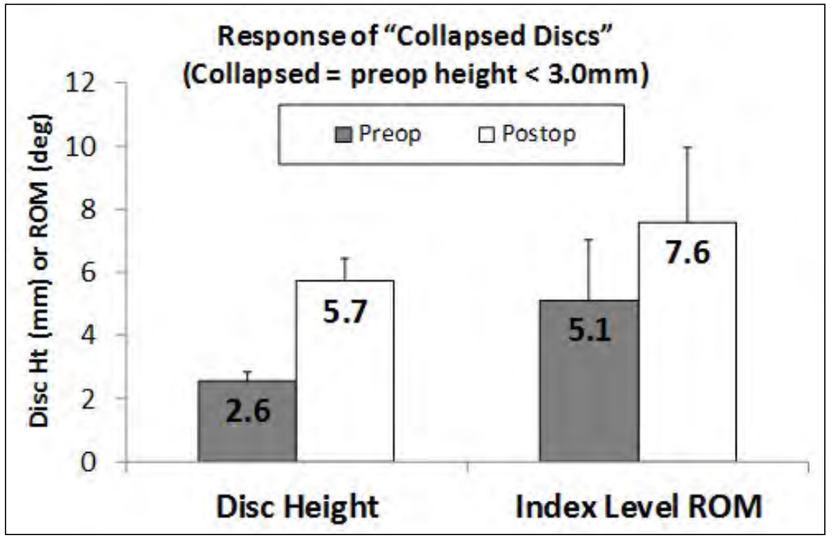


Figure 2.



See Disclosure Index pages 40–88.

Presentation #84 P

Can C3 Laminectomy Reduce Interlaminar Bony Fusion and Preserve Cervical Range of Motion after Cervical Laminoplasty?

Dong-Ho Lee, MD, PhD, Seoul, Republic of Korea
***Jung-Ki Ha, MD**, Seoul, Republic of Korea*
Jae Hwan Cho, MD, Seoul, Republic of Korea
Choon Sung Lee, MD, PhD, Seoul, Republic of Korea
Chang Ju Hwang, MD, Seoul, Republic of Korea
Sunghun Choi, MD, Seoul, Republic of Korea
Chul Gie Hong, MD, Seoul, Republic of Korea
Youn-Suk Joo, MD, Seoul, Republic of Korea

Introduction: Interlaminar bony fusion after cervical laminoplasty is one of causes to decrease postoperative cervical range of motion (ROM). It was reported to occur in 53% of patients, with marked frequency at C2-3. In a previous report, C3 laminectomy, instead of laminoplasty, could minimize muscle detachment at C2 and decrease the postoperative neck pain. Our hypothesis in this study is if C3 lamina is resected rather than opened during multi-level laminoplasty, the bony fusion between C2-3-4 laminae could be prevented and postoperative motion would be preserved more.

Methods: Fifty-nine patients with cervical spondylotic myelopathy involving 3 or more levels including C3 were consecutively treated with laminoplasty and followed more than 2 years after surgery. The first 45 patients underwent open-door laminoplasty at C3 with same technique as other levels (Lp group) and the next 14 patients underwent laminectomy at C3 instead of laminoplasty (Lm group). Lp group was divided into two subgroups according to the development of interlaminar bony fusion at C2-3 and/or C3-4 until postoperative 2 years: Lp-NF (no fusion, 26 patients) and Lp-F (fusion, 19 patients). The clinical outcomes such as Neck Disability Index (NDI), Japanese Orthopedic Association (JOA) scores, JOA recovery rate, and Visual Analogue Scale (VAS) of neck pain were investigated. Radiographic parameters including cervical ROM, C2-7 lordosis and segmental instability were assessed pre- and post-operatively and compared between the groups.

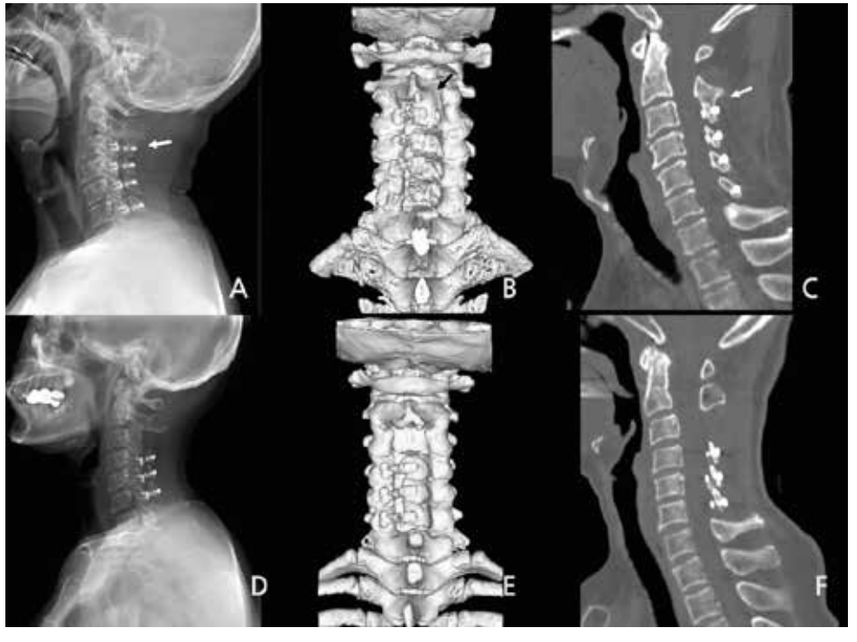
Results: No interlaminar bony fusion of C2-3 and/or C3-4 was detected in Lm group, but only in Lp group. Nineteen out of 45 patients (42.2%) who underwent laminoplasty showed fusion at postoperative 2 years: 13 patients at C2-3, 5 at C3-4 and 1 at C2-3-4. Fusion developed more commonly in the patients who had smaller preoperative cervical ROM, especially with smaller ROM at C2-3-4 segments (Lp-F 14.3 ± 6.9° vs Lp-NF 21.4 ± 5.3°, P = 0.013).

Presentation #84 P

Both Lm and Lp groups showed significant improvements in NDI, JOA scores, JOA recovery rates and VAS of neck pain after surgery; however, there was no significant difference in those clinical outcomes between both groups. Cervical ROM significantly decreased in both Lm and Lp groups postoperatively; however the degree of decrease was significantly smaller in Lm group (10.5°, from 44.2 ± 9.1° to 33.7 ± 6.0°) than that in Lp-NF (15.1°, from 45.4 ± 8.5° to 30.3 ± 7.4°) and Lp-F groups (18.2°, from 39.6 ± 9.3° to 21.4 ± 10.3°)($P < 0.05$). Postoperative segmental instability at C2-3 and C3-4 was not detected even after C3 laminectomy.

Conclusion: C3 laminectomy could prevent interlaminar bony fusion of C2-3-4 and finally result in more preservation of cervical ROM than C3 laminoplasty after multi-level laminoplasty. Furthermore, it assured similar neurologic and functional outcomes compared to C3 laminoplasty in this study.

Figure 1. Interlaminar bony fusion at C2-3 after C3 laminoplasty (A, B, C). This could be prevented by C3 laminectomy (D, E, F).



See Disclosure Index pages 40–88.

Presentation #84 P (cont.)

Table 1. Degree of decrease – Cervical ROM

	Lp-NF (°)	Lp-F (°)	Lm (°)
Preoperative ROM	45.4±8.5	39.6±9.3	44.2±9.1
Postoperative ROM	30.3±7.4	21.4±10.3	33.7±6.0
Degree of ROM Decrease	18.2±3.9	15.1±4.7	10.5±3.5*†

* Significant difference between Lm and Lp-NF, p<0.05
† Significant difference between Lm and Lp-F, p<0.05

Presentation #85 P

Is it "In" or "Out"? The Optimal Fluoroscopic Views for Intraoperative Determination of Proper Lateral Mass Screw Placement

Sangbum Kim, MD, PhD, Atlanta, GA
***John M. Rhee, MD,** Atlanta, GA*
Kun Young Park, MD, Atlanta, GA
Chulmin Kim, PhD, Atlanta, GA

Introduction: Potential complications of cervical lateral mass screws (LMS) include subjacent facet joint and exiting nerve root violation. Single plane (eg, AP/lateral) intraoperative xrays are commonly used but are frequently inadequate for determining screw malposition due to the complex trajectory of LMS. Fluoroscopy can be taken in multiple planes and provides intraoperative feedback to allow for screw repositioning, but the ideal fluoroscopic view to assess malposition is not known: depending on the view, any given screw may look "in" or "out". The purpose of this study was to determine the optimal fluoroscopic views for detecting LMS violations involving the facet and nerve root.

Methods: LMS were inserted from C3-6 bilaterally using the Magerl technique in 3 cadavers. In order to evaluate potential nerve root violation, LMS were inserted in the direction of the exiting nerve root with the tip penetrating the anterior cortex by 0 mm (ie, not penetrated), then 2 mm, and then 4 mm. In order to assess facet joint violation, LMS were inserted toward the subjacent facet joint with the tip penetrating the anterior cortex by 0 mm and then by 2 mm. Fluoroscopic views were taken at 0^o (ie, neutral lateral), 10^o, 20^o, 30^o, and 40^o to the lateral plane. Views were then evaluated for screw violation by three fellowship trained spine surgeons (Figure 1).

Results: With screws directed toward the nerve root (TABLE 1), the 20^o oblique view correctly identified a 2mm penetration of the anterior cortex in 79%, and a 4 mm penetration in 86%, for a sensitivity of 83% and a specificity of 90%. The 30^o view had a lower sensitivity (76%) but a slightly higher specificity (93%). The 20^o and 30^o views were significantly more sensitive than the 0^o, 10^o, and 40^o views, with no difference between the 20^o and 30^o views.

With respect to facet violation (Table 2), the 0^o neutral lateral view correctly identified a 2 mm penetration into the facet joint 93% of the time, for a sensitivity of 93% and specificity of 92%. The 10^o view had a lower sensitivity (72%) but a higher specificity (100%). The neutral lateral view was significantly more sensitive than the 10^o, 20^o, 30^o, and 40^o views.

See Disclosure Index pages 40–88.

Presentation #85 P (cont.)

Conclusion: The 20° and 30° oblique views significantly provided the most sensitive assessment of LMS potentially violating the nerve root, whereas the 0° neutral lateral view significantly provided the most sensitive assessment of facet violations. The specificities were also high (in the 90% range) for all of these views, suggesting that they provide useful, though not perfect, assessment of potential screw malposition. Therefore, we recommend the use of these views intraoperatively when assessing proper placement of LMS.

Figure 1. 2 mm violation (upper screws in each panel) directed toward the nerve root assessed on 0°, 20°, and 40° views. Violation is impossible to determine on the 0° view. On the 40° view, there do not appear to be any violations. However, the 20° view accurately demonstrates a violation of every screw tip into its respective foramen.

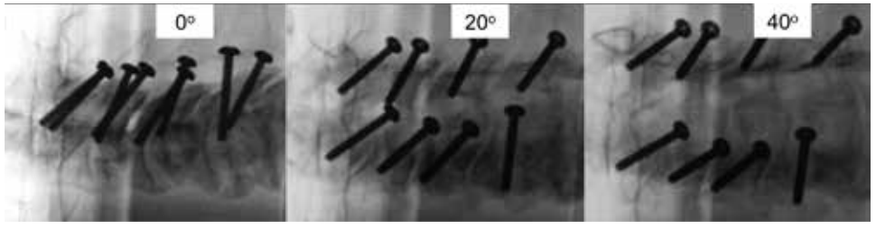


Table 1. Screws directed toward nerve root:

	% Deemed violated		
View	0 mm penetrated	2 mm penetrated	4 mm penetrated
0° (neutral)	*1%*	*0%*	*8%*
10°	*3%*	*17%*	*26%*
20°	*10%*	*79%**	*86%**
30°	*7%*	*68%**	*85%**
40°	*0%*	*17%*	*47%*

*p < 0.001 compared to 0°, 10°, and 40° views, Chi squared analysis

Presentation #86 P

An Approach to Primary Tumors of the Upper Cervical Spine with Total Spondylectomy using a Combined Approach: Our Experience with 19 Cases

Feng Wei, MD, Beijing, China
Zhongjun Liu, MD, PhD, Beijing, China
Xiaoguang Liu, MD, PhD, Beijing, China
Liang Jiang, Beijing, China
Genting Dang, Beijing, China
***Peter G. Passias, MD**, New York, NY*
Miao Yu, Beijing, China
Fengliang Wu, Beijing, China
Lei Dang, Beijing, China

Introduction: Spondylectomy has been demonstrated to prolong cancer-free survival in many patients with locally aggressive spinal tumors. However, the challenging nature of this surgical procedure and associated severe complications often limit its application in the upper cervical spine. This study examines the link between major complications, surgical techniques, and peri-operative care in the intralesional spondylectomy of the upper cervical spine.

Methods: This study was a retrospective review of nineteen patients with primary upper cervical tumors were treated surgically with spondylectomy from March 2005 to August 2009 at a single institution, using either the anterior-posterior or posterior-anterior approach. Anterior procedures were transmandibular, transoral, or high retropharyngeal. Anterior reconstructions were performed in plates with iliac crest strut grafts, plates with mesh cages, and Harms mesh cages alone. Occipito-cervical fixations were performed with the use of Halo-vests for post-operative immobilization. Demographic and pre-operative data were collected, and follow-up was performed every 3-6 months during the first and second post-operative years, and then annually thereafter.

Results: Vertebral artery injuries occurred unilaterally in 5 cases intra-operatively: 4 occurred in the anterior approach of the anterior-posterior procedures. Fusion was achieved in 9 patients with intact internal instrumentation. Fusion with the anterior construct in a tilting position was performed in 3 patients, all of whom underwent anterior-posterior procedures with Halo-vest immobilization for less than 1 month. Non-union occurred in 3 cases after the posterior-anterior procedure due to anterior bone graft absorption. Prolonged Halo-vest immobilization maintained post-operative stability. Failure of internal instrumentation occurred in 3 cases. Anterior construct dislocation and severe tilting occurred in 2 cases after the anterior-posterior procedure. 5 patients had a local recurrence. All recurrent lesions were malignant tumors and occurred in regions where surgical exposure was inadequate.

See Disclosure Index pages 40–88.

Presentation #86 P (cont.)

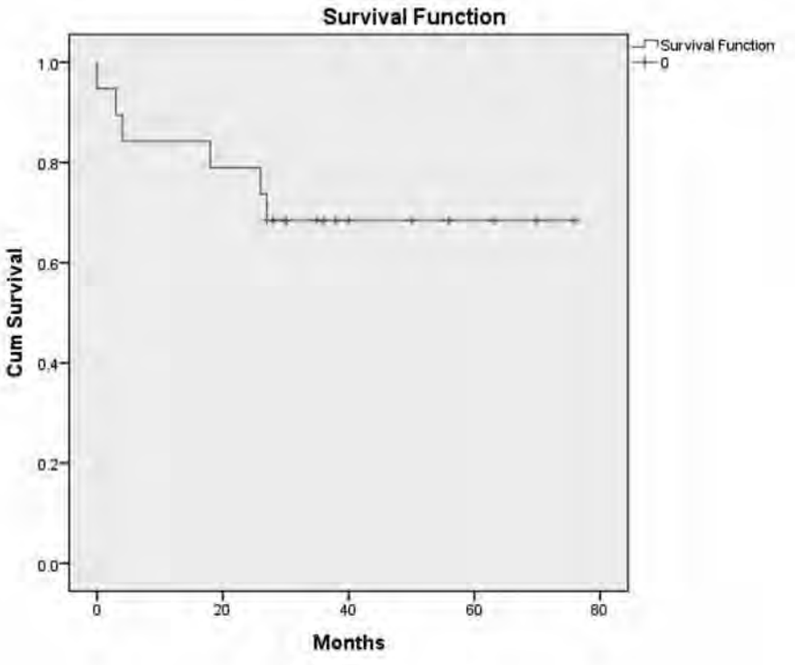
Conclusion: The order of the surgical approach is a critical determinant of complications, fusion rates, choice of surgical technique, and reconstruction methods. The post-operative use of a Halo-vest is recommended. Local recurrence is associated with tumor malignancy and inadequate excision margin.

Table 1. Treatment related data. *excluding one patient who died perioperatively

Variable	N
Types of anterior approach	
High retropharyngeal	9
Transoral	7
Transmandibular	3
Order of the approaches	
Anterior-posterior	10
High retropharyngeal	7
Transoral	1
Transmandibular	2
Posterior-anterior	9
High retropharyngeal	2
Transoral	6
Transmandibular	1
Types of anterior reconstruction	
Plate with autologous iliac strut graft	4
Plate with mesh cage	4
Harms mesh cage alone	11
Types of posterior reconstruction	
Occiput plate and cervical screw plate system	11
Occiput plate and cervical screw rod system	8
Duration of posterior Halo-vest immobilization*	
＜3months	8
＝3months	8
＞3months	2
Range	14 days~38months
Perioperative radiation therapy	
Preoperative	4
Postoperative	11

Presentation #86 P

Figure 1. Kaplan-Meier survival curve.



See Disclosure Index pages 40–88.

Presentation #87 P

Collar Fixation is not Mandatory after Cervical Laminoplasty – A Randomized Controlled Study

***Tetsuro Hida, MD**, Nagoya, Aichi, Japan*
Yoshito Sakai, PhD, Ahbu, Aichi, Japan
Kenyu Ito, Nagoya, Aichi, Japan
Shiro Imagama, MD, Nagoya, Aichi, Japan

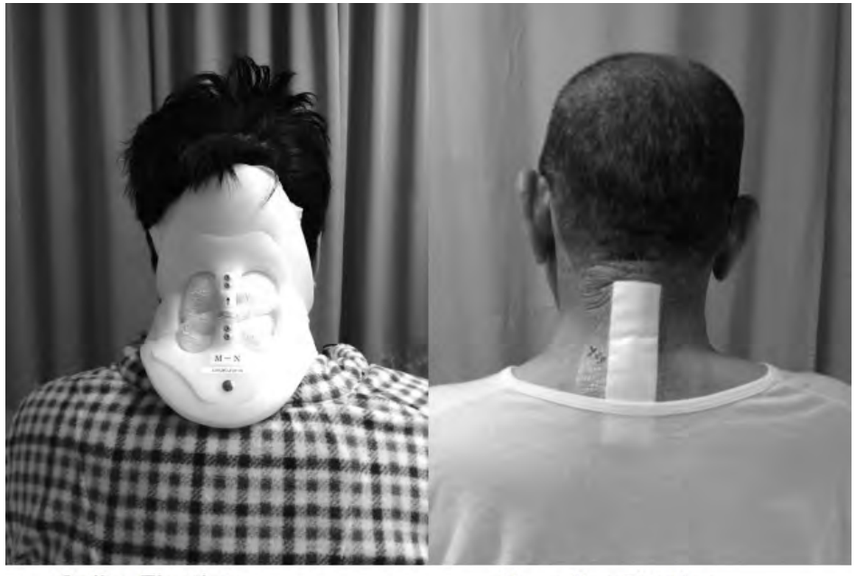
Background: Traditionally, it has been common to apply external fixation using a collar after cervical laminoplasty for the purpose of resting the wound. However, some reports have been made claiming that use of a collar for a long period may induce such problems as muscle atrophy and joint contracture, and increase risks of malalignment and axial pain, and that, therefore, postoperative fixation may be omitted. However, these reports were all based on retrospective studies, and controversy remains as to the benefit of postoperative use of a collar. We investigated the effect of collar-aided fixation on prognosis following laminoplasty for cervical myelopathy in this randomized controlled study.

Methods: This trial involved 90 patients (mean age, 72.7years; 62 males and 28 females) with cervical compressive myelopathy who had undergone double-door laminoplasty from June, 2009 to July, 2012. Patients with rheumatoid arthritis, trauma or sever local kyphosis were excluded. The study protocol was approved by the Institutional Review Board and written informed consent was obtained from each patient before research participation. Prior to their operations, we randomly assigned 45 patients to the collar-fixation (CF) group where each of them underwent external fixation using a Philadelphia collar for 2 weeks following their operations, and 45 to the no-collar (NC) group where they wore no collar (Figure). Finally, we successfully completed one-year follow-up for 74 patients (39 patients in the CF group and 35 patients in the NC group) and we assessed them using the JOA score, SF-36, a visual analog scale (VAS) of cervical pain, lordotic angle of C2 to 7, prior to the operations and one year after the operations, and perioperative complications (infection, epidural hematoma, C5 palsy). We used Student's t test and chi-squared test for statistical analysis and a P value of less than 0.05 considered to be significant.

Results: JOA scores significantly improved in both groups ($P = 0.002$, $P < 0.001$). There was no significant difference between the two groups with regard to the recovery rate of JOA scores ($P = 0.80$). The loss of lordotic angle of the cervical spine after operation was 6.5degrees and 7.1degrees in the CF goup and the NC group, respectively ($P = 0.82$). VAS scores after operation were 2.9cm and 3.5cm, respectively ($P = 0.68$). SF-36 BP-domain was similar in both groups ($P = 0.58$). The Incidences of complication were not significantly different between the groups.

Presentation #87 P

Conclusion: Previous retrospective studies showed better cervical range of motion for no-collar or shortened collar term after laminoplasty. However, there was no randomized controlled study before. Here we showed that patients exhibited good neurological symptoms and recovery of ADL with or without collar fixation. Furthermore, there might be potential disadvantages for collar fixation such as higher cost or skin discomfort. Omitting collar-aided fixation was demonstrated to be a beneficial option after laminoplasty of cervical spine.



See Disclosure Index pages 40–88.

Presentation #88 P

Missing Data May Invalidate Spine Surgery Database Studies

Bryce A. Basques, MD, Chicago, IL
***Nathaniel T. Ondeck, BS,** New Haven, CT*
Andre M. Samuel, BBA, New Haven, CT
Matthew L. Webb, AB, New Haven, CT
Adam M. Lukasiewicz, MSc, New Haven, CT
Daniel D. Bohl, MD, MPH, Chicago, IL
Junyoung Ahn, BS, Chicago, IL
Kern Singh, MD, Chicago, IL
Jonathan N. Grauer, MD, New Haven, CT

Introduction: National databases are increasingly being used for research in spine surgery, as they offer significant power for analyses. However, these databases have significant limitations. One limitation that has received sparse mention in the literature is the prevalence of missing data. Studies using these databases often do not mention the percent of missing data for each variable used, and do not make note of how patients with missing data are incorporated into analyses. This study uses the American College of Surgeons National Quality Improvement Program (ACS-NSQIP) database to illustrate how different treatments of missing data can significantly skew the results of spine studies.

Materials/Methods: Patients who underwent spine surgery between 2005 and 2013 were identified from the ACS-NSQIP database using Current Procedural Terminology codes. Demographics, comorbidities, and perioperative lab values were tabulated for each patient and the percent of missing data was noted for each variable. These variables were tested for association with “any adverse event” using two separate multivariate regressions that used the two most common treatments for missing data. In the first regression, patients with any missing data were simply excluded. In the second regression, missing data was treated as a negative, or “reference” value. The results of these regressions were compared in order to determine how the different treatments of missing data could affect the results of spine studies using the ACS-NSQIP database.

Results: A total of 88,471 spine surgery patients were identified. The average patient age was 56.56 ± 14.4 years (mean ± standard deviation). Rates of missing data by each variable are reported in Table 1. The following rates of missing data were found for each demographic category: 0.00% for age, 0.07% for sex, 0.78% for body mass index (BMI), and 5.02% for race. The rate of missing data was 65.54% for many comorbidities, including alcohol use, pneumonia, history of myocardial infarction, previous cardiac surgery, impaired sensorium, coma, and quadriplegia, among others. For lab values, rates of missing data ranged from 8.85% for hematocrit to 80.13% for prothrombin time.

Presentation #88 P

Multivariate logistic regressions for the association of demographics, comorbidities, procedure type, and lab values with any adverse event within 30 days of surgery were performed with the two most common techniques for handling missing data: excluding patients with missing data, and treating missing data as the negative, or “reference” value. As seen in Table 2, these different techniques lead to finding vastly different significant risk factors for adverse events on multivariate analysis. Out of 33 risk factors found to be significantly associated with adverse events in either analysis, only 16 (48.4%) of these risk factors were common between the two regressions.

Conclusion: This study illustrates that a significant amount of missing data can be found in a spine surgery sample drawn from the ACS-NSQIP and extreme caution needs to be taken when selecting variables for inclusion in analyses. Specifically, 19 comorbidity variables have 65.54% missing data, as they are now only collected at certain ACS-NSQIP participating sites. This is not made clear in the basic participant user manual distributed with the dataset and researchers must be diligent when using data from more recent years.

In addition, as shown in this sample, the treatment of missing data can significantly affect the results of spine studies performed with this dataset. There are multiple studies in the literature that have used this cohort of spine patients in the ACS-NSQIP, and the majority of these studies fail to comment on the amount of missing data or how it was treated in analyses. This study raises significant questions about the validity of these studies and it is important for researchers to be aware of the limitations of databases when designing, performing, and evaluating such investigations. It is critical that studies using these data sources report how missing data are handled.

Table 1. Missing data by variable in spine surgery patients from ACS-NSQIP 2005-2013

Variable	% Missing
Demographics	
Age	0.00%
Sex	0.07%
BMI	0.78%
Race	5.02%
Ethnicity	3.61%
Diabetes	0.00%
Smoking	0.00%
Functional status	0.61%
Comorbidities	
Alcohol	65.54%
Current pneumonia	65.54%
Esophageal varices	65.54%
History of MI	65.54%

See Disclosure Index pages 40–88.

Presentation #88 P (cont.)

Previous PCI	65.54%
Previous cardiac surgery	65.54%
Angina	65.54%
Peripheral vascular disease	65.54%
Rest pain	65.54%
Impaired sensorium	65.54%
Coma >24 hrs	65.54%
Hemiplegia	65.54%
History of TIA	65.54%
Stroke w/ neuro deficit	65.54%
Stroke w/o neuro deficit	65.54%
CNS tumor	65.54%
Paraplegia	65.54%
Quadraplegia	65.54%
Chemotherapy	65.54%
Radiotherapy	65.54%
Pregnancy	65.54%
Prior operation within 30 days	65.33%
Lab values	
Na	13.86%
BUN	16.32%
Cr	14.25%
Albumin	62.02%
Bilirubin	63.32%
SGOT	62.34%
AlkPhos	63.60%
WBC	9.78%
HCT	8.85%
Plt	9.83%
PTT	44.28%
INR	37.95%
PT	80.13%

Table 2. Significant results of multivariate logistic regressions for any adverse event with differing treatments of missing data.

Risk Factor	Patients with missing data excluded		Missing data treated as negative	
	OR	P-value	OR	P-value
Paraplegia	1.6	0.002	1.6	<0.001
Quadriplegia	2.9	<0.001	3	<0.001
Hemiplegia			1.6	0.008
Cerebrovascular accident			1.5	0.010
Preoperative pneumonia			9.3	<0.001
Impaired Sensorium			1.8	0.042
Age 60-69 vs age < 40			1.3	<0.001
Age 70-79 vs age < 40			1.5	<0.002
Age 80+ vs age < 40	1.7	<0.001	1.7	<0.003
BMI 35+ vs BMI <25			1.2	<0.001
Black race vs white race			1.2	0.015
Male sex			0.9	0.003
ASA 3 vs ASA 1-2	1.5	0.001	1.7	<0.001
ASA 4+ vs ASA 1-2	2.5	<0.001	3.7	<0.001
Procedure type (vs lumbar laminotomy)				
Anterior cervical discectomy and fusion			0.8	<0.001
Anterior lumbar fusion	5.6	<0.001	2.0	<0.001
Cervical laminectomy	2.3	0.001	1.7	<0.001
Cervical laminotomy	2.4	0.009		
Corpectomy	3.6	<0.001	2.0	<0.001
Lumbar laminectomy	1.6	0.005	1.3	<0.001
Posterior lumbar fusion	2.1	<0.001	1.6	<0.001
Posterior cervical fusion	2.7	0.002	2.1	<0.001
Thoracic fusion	3.5	<0.001	2.9	<0.001
Thoracic laminectomy	2.3	0.013	2.9	<0.001
Lab values*				
Albumin	0.72	<0.001		
Bilirubin			0.90	<0.001
AlkPhos	1.01	<0.001	1.00	<0.001
WBC	1.05	0.001	1.01	<0.001
HCT	1.01	0.009	0.99	<0.001
PTT			0.99	<0.001
INR			1.00	<0.001
PT	1.11	0.013		

OR = odds ratio, BMI = body mass index, ASA = American Society of Anesthesiologists.

*Odds ratios per one-unit increase in each lab value

Saturday, December 5, 2015, 11:28–11:30 am CSRS–2015

Presentation #88 P

See Disclosure Index pages 40–88.

Presentation #89 P

Iatrogenic Instability at the Supra-Adjacent Level of Posterior Cervical Instrumentation Constructs for Cervical Laminectomies: A Biomechanical Analysis

Sina Pourtaheri, MD, *Cleveland, OH*
Andrew T. Healy, MD, Cleveland, OH
Daniel Lubelski, MD, Cleveland, OH

Introduction: Currently, it is acceptable to designate the cranial instrumented level to the most proximal laminectomy level. However, to date, there are no biomechanical studies proving the validity of this construct design. With 2-year follow-up, 6% of posterior cervical instrumented fusions have worsening kyphosis and hardware pullout. With a complete laminectomy of the proximal level, the dorsal ligamentous complex is compromised above the most cranial instrumented level. To determine if long-cervical, instrumented constructs extending up to C3, result in instability at C2-3 after a C3 laminectomy.

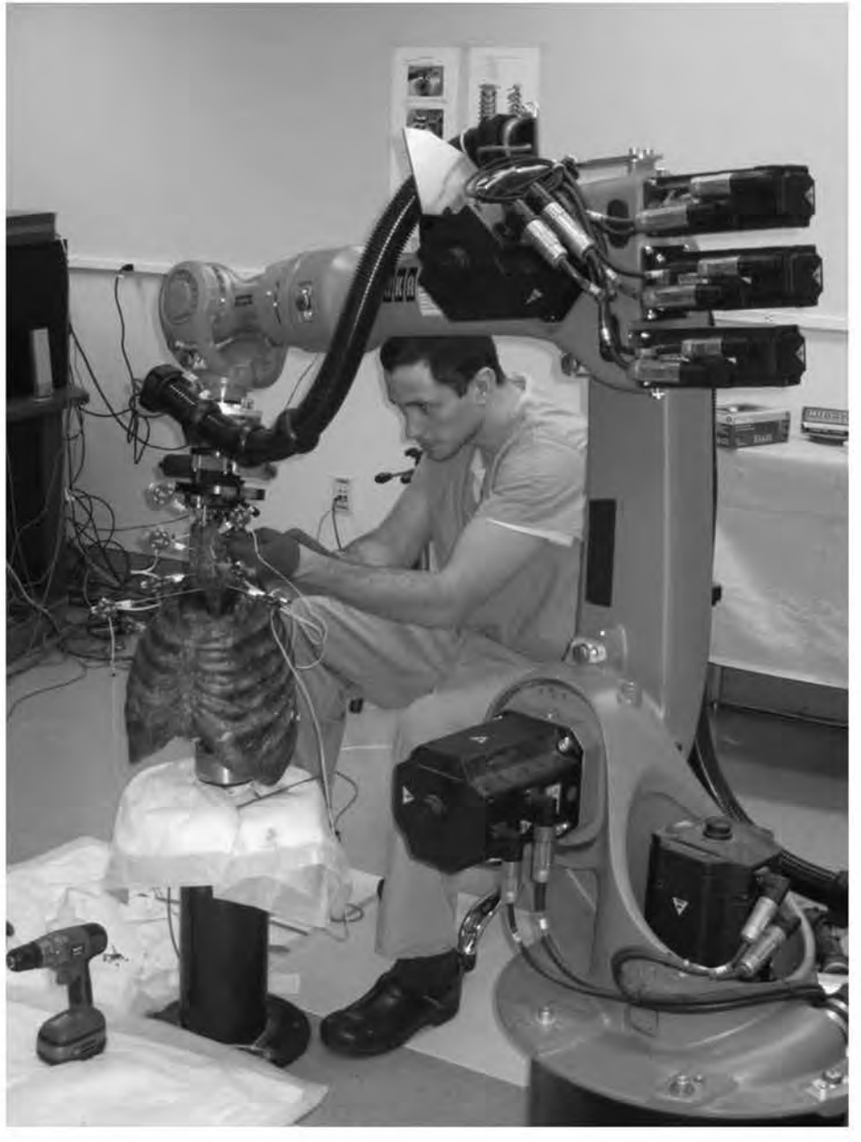
Methods: *In vitro* biomechanical testing of six human cadaveric specimens with the osseous and ligamentous integrity intact. An industrial robot was utilized to apply moments while measuring the segmental motion at each level. The intact state was tested, followed by nine post-surgical permutations of laminectomy and lateral mass fixation spanning C2-C7. Tukey-Kramer analysis was utilized for multiple comparisons.

Results: Constructs spanning a single level exerted no significant effects on the proximal adjacent segment motion. However, with each additional level instrumented, there was linear increase in the range of motion of the supra-adjacent level. A laminectomy of the uppermost instrumented level had no effect on the ROM of the supra-adjacent level in a single-level construct. However, with a three-level construct a laminectomy of the uppermost level had a significant effect on the supra-adjacent level ROM (316%, $p = 0.02$).

Conclusions: With increasing length of the construct, a laminectomy of the uppermost instrumented level significantly affected the stability of the supra-adjacent segment. The current data supports maintaining a portion of the uppermost instrumented level's lamina with long constructs. When a complete laminectomy of the uppermost instrumented level is necessary with a long construct, consider the possibility of extending the instrumentation proximally.

Saturday, December 5, 2015, 11:31 – 11:33 am CSRS – 2015

Presentation #89 P



See Disclosure Index pages 40–88.

Presentation #90 P

Characteristics of Residual Symptoms following Laminoplasty in Diabetic Patients with Cervical Spondylotic Myelopathy: A Prospective Cohort Study in 505 Patients with Cervical Spondylotic Myelopathy

***Masaaki Machino, MD**, Nagoya, Japan*
Yasutsugu Yukawa, MD, PhD, Nagoya, Japan
Shiro Imagama, MD, PhD, Nagoya, Japan

Introduction: Diabetes is one of the most frequent coexisting diseases; therefore, surgical options have been increasing for diabetic patients. However, there has been no study to assess the postoperative residual symptom after cervical laminoplasty in a large series of patients with cervical spondylotic myelopathy (CSM). This study aimed to compare the outcome of cervical laminoplasty in diabetic patients and non-diabetic patients with CSM and to characterize the residual symptoms following laminoplasty in diabetic patients with CSM.

Materials and Methods: A total of 505 consecutive patients with CSM (331 males; 189 females) who were followed up for more than one year after surgery were enrolled. All patients underwent double-door laminoplasty. Exclusion criteria included the following: 1) ossification of the posterior longitudinal ligament; 2) history of rheumatoid arthritis, cerebral palsy, or tumors; 3) injuries; 4) destructive spondyloarthritis caused by hemodialysis; 5) previous cervical surgery; 6) spinal fusion with instrumentation; 7) thoracic spondylotic myelopathy; and 8) lumbar spinal canal stenosis. The patients were divided on the basis of diabetic criteria for glucose intolerance into two groups: the diabetic group (n = 105) and non-diabetic group (n = 400). We consulted diabetes specialists at our hospital for these patients, and all patients had well-controlled blood glucose levels during the perioperative period. We evaluated differences in pre- and post-operative Japanese Orthopedic Association (JOA) scores, recovery rate (RR) between both groups.

Results: There was no significant difference in age, gender, symptom duration of CSM, body mass index (BMI), smoking history, preoperative cervical alignment and range of motion (ROM), occurrence of increased signal intensities (ISI) on magnetic resonance T2-weighted imaging (MRT2WI) between both groups. There was also no statistically significant difference in the follow-up period, operation time, blood loss, postoperative cervical alignment and ROM, change of alignment and ROM between two groups. The mean RRs of motor function of the upper extremities in the diabetic and non-diabetic groups were 59.2% and 60.5% with no significant difference. The diabetic group showed significantly low RR of motor function of the lower extremities compared with the non-diabetic group (36.1% vs. 43.4%, $p < 0.05$). There was significant difference in RR of sensory function of the upper extremity (36.8% vs. 49.6%, $p < 0.05$).

Presentation #90 P

However, the mean RRs of sensory function of the lower extremity and trunk were 59.7 and 59.2 %, 69.3 and 74.1 %, respectively. The Mean RRs of urinary bladder function were 42.1 and 53.7 % with significant difference ($p < 0.05$).

Conclusion: In the diabetic patients, motor function impairments of the lower extremities, sensory function impairments of the upper extremities and urinary bladder function impairments are persist more than other symptoms after surgery compared with the non-diabetic group. These findings provide baseline data that may allow clinicians to accurately assess preoperative impairment and postoperative outcomes in diabetic patients with CSM.

See Disclosure Index pages 40–88.

Presentation #91 P

Number of Operative Levels Minimally Impacts Risk for Adverse Events following an Anterior Cervical Decompression and Fusion

Daniel D. Bohl, MD, MPH, Chicago, IL
Junyoung Ahn, BS, Chicago, IL
Dustin H. Massel, BS, Chicago, IL
Benjamin C. Mayo, BA, Chicago, IL
Bryce A. Basques, MD, Chicago, IL
***Nathaniel T. Ondeck, BS**, New Haven, CT*
Jonathan N. Grauer, MD, New Haven, CT
Kern Singh, MD, Chicago, IL

Introduction: Little is known regarding the impact of the number of operative levels on the risk for adverse events following spinal procedures. The present study tests for associations between the number of operative levels and occurrence of adverse events following an anterior cervical decompression and fusion (ACDF).

Materials/Methods: Patients undergoing one-, two-, or three-level ACDF were identified in the American College of Surgeons National Surgical Quality Improvement Program database. Cases were identified based on current procedural terminology coding and excluded for traumatic, oncologic, or infectious indications. Number of operative levels was tested for association with occurrence of adverse events using multivariate regression. Post-hoc pairwise comparisons were made between one- and two-level procedures and between two- and three-level procedures. All analyses were adjusted for differences in patient age, sex, body mass index, and the presence of diabetes, congestive heart failure, dyspnea, hypertension, end-stage renal disease, chronic obstructive pulmonary disease, smoking status, and anemia.

Results: 8,994 patients met inclusion criteria, of which 5,159 underwent one-level, 3,439 underwent two-level, and 396 underwent three-level ACDFs. Following adjustment for all demographics and comorbidities, there were no differences in the rates of occurrence of "any adverse events" or "serious adverse events" between one- and two-level procedures, or between two- and three-level procedures (Table 1). Following adjustment for all demographics and comorbidities, there were no differences in the rates of occurrence of any of the specific adverse events between one- and two-level procedures, or between two- and three-level procedures.

Saturday, December 5, 2015, 11:37–11:39 am CSRS–2015

Presentation #91 P

Conclusion: The present study suggests that increasing the number of operative levels by one level has minimal impact on the rates of postoperative adverse events. This is true both for an increase from one to two levels and for an increase from two to three levels. Hence, the risk for adverse events should play minimal role in the decision making process regarding the number of operative levels.

Table 1. Impact of number of operative levels on risk for adverse outcomes

	Risk for adverse event			P-values from pairwise comparisons adjusted for baseline characteristics	
	1-level	2-level	3-level	1 versus 2*	2 versus 3†
Composite adverse event outcomes					
Serious adverse event‡	0.54%	0.70%	0.76%	0.511	0.758
Any adverse event	1.63%	1.95%	3.28%	0.400	0.234
Specific adverse events					
Mortality‡	0.04%	0.09%	0.25%	0.392	0.277
Wound dehiscence	0.06%	0.06%	0.00%	0.965	-
Pulmonary embolism‡	0.10%	0.17%	0.00%	0.492	-
Myocardial infarction‡	0.10%	0.09%	0.25%	0.841	0.475
Anemia requiring transfusion	0.14%	0.35%	0.76%	0.038	0.545
Deep vein thrombosis	0.17%	0.15%	0.25%	0.643	0.741
Urinary tract infection	0.33%	0.32%	0.76%	0.667	0.298
Pneumonia	0.35%	0.41%	1.01%	9.773	0.214
Unplanned intubation‡	0.37%	0.41%	0.51%	0.850	0.795
Surgical site infection	0.37%	0.26%	0.25%	0.453	0.982
Unplanned hospital readmission	2.25%	2.51%	2.33%	0.672	0.458

RR = relative risk; CI = confidence interval.
* Bonferroni adjustment for 9 repeated tests lowered the p-value required for statistical significance of the specific adverse events to $p<0.006$.
† Bonferroni adjustment for 7 repeated tests lowered the p-value required for statistical significance of the specific adverse events to $p<0.007$.
‡ Serious adverse events included mortality, pulmonary embolism, myocardial infarction, and unplanned intubation.

See Disclosure Index pages 40–88.

Presentation #92 P

Most 30-Day Readmissions after Anterior Cervical Discectomy and Fusion are not due to Surgical Site-related Issues: An Analysis of 10,006 Patients

Andre M. Samuel, BBA, New Haven, CT
Jason O. Toy, MD, New Haven, CT
***Michael C. Fu, MD**, New York, NY*
Adam M. Lukasiewicz, MSc, New Haven, CT
Matthew L. Webb, AB, New Haven, CT
Daniel D. Bohl, MD, MPH, New Haven, CT
Bryce A. Basques, BS, New Haven, CT
Todd J. Albert, MD, New York, NY
Jonathan N. Grauer, MD, New Haven, CT

Introduction: The anterior cervical discectomy and fusion (ACDF) is a relatively safe and effective surgical procedure. However, as hospital quality-based reimbursements begin to be tied to readmissions within the 30 days after discharge, understanding the reasons that patients are readmitted after surgery is important for both practitioners and administrators.

Methods and Materials: All patients undergoing ACDF were identified in the 2012 and 2013 American College of Surgeons National Surgical Quality Improvement Program (NSQIP). Reasons for readmission in the 30 days after surgery were assessed. Multivariate logistic regression was then used to identify risk factors for readmission.

Results: A total of 10,006 patients undergoing ACDF were identified in the 2012 and 2013 NSQIP. Of those patients, 3.32% (332 patients) were readmitted in the 30 days after surgery (Table 1). Of these readmitted patients, 159 (1.59% of total study population) were readmitted for non-surgical site related reasons (Table 1). The most common non-surgical site related reasons were cardiovascular reasons (n = 30), neuro/psychiatric reason (n = 21), other infections (n = 21), and pneumonia (n = 20). A total of 114 patients (1.14% of total study population), were readmitted for surgical-site related reasons. The most common surgical site related reasons were hematoma/hemorrhage (n = 25), surgical site infection (n = 23), and dysphagia (n = 21).

In multivariate analysis (Table 2), the only frisk factors found to be predictive of readmission within 30 days were older age (70 – 79 years, compared to 50 – 59 years; odds ratio [95% confidence interval]: 1.73 [1.23 – 2.42]) and higher American Society of Anesthesiologists (ASA) class (ASA III: 1.89 [1.48 – 2.41]; ASA IV+: 5.23 [3.23 – 8.41]). Factors that were not found to be predictive of readmission included inpatient versus outpatient surgery, number of levels fused, and nature of the index cervical spine pathology.

Presentation #92 P

Conclusions: Readmissions are relatively uncommon after ACDF. However, as hospital reimbursements are tied to readmissions in the 30 days after discharge, it is important to understand which patients are being readmitted and for what reasons.

Most readmissions after ACDF were due to non-surgical site related reasons, indicating the importance of careful patient selection, aggressive preoperative medical optimization, and adequate postoperative monitoring. The most common surgical site related reasons were, unsurprisingly, due to bleeding, infection, and dysphagia, each occurring in only around 0.25% of all patients. Factors such as inpatient versus outpatient surgery, number of levels fused, primary diagnosis were not found to play independent significant roles.

See Disclosure Index pages 40 – 88.

Presentation #92 P (cont.)

Table 1. Reasons for readmission after ACDF

	(N)	(% of all patients)	(% of readmitted patients)
All ACDF patients	10,006		
Readmitted within 30 days	332	3.32%	-
Non-surgical site related	159	1.59%	47.89%
Cardiovascular	30	0.30%	9.04%
Neuro/ psychiatric	21	0.21%	6.33%
Other infections	21	0.21%	6.33%
Pneumonia	20	0.20%	6.02%
Other	19	0.19%	5.72%
Gastrointestinal	16	0.16%	4.82%
Thromboembolism	15	0.15%	4.52%
Renal	5	0.05%	1.51%
Fluids/ electrolytes/ nutrition	4	0.04%	1.20%
Lumbar spine pathology	3	0.03%	0.90%
Respiratory	3	0.03%	0.90%
Fall/ injury	2	0.02%	0.60%
Surgical site related	114	1.14%	34.34%
Hematoma/hemorrhage	25	0.25%	7.53%
Surgical site infection	23	0.23%	6.93%
Dysphagia	21	0.21%	6.33%
Neck pain	15	0.15%	4.52%
Cervical myelopathy	11	0.11%	3.31%
Dyspnea	6	0.06%	1.81%
Mechanical failure	6	0.06%	1.81%
Wound disruption	5	0.05%	1.51%
Cervical radiculopathy	1	0.01%	0.30%
Dural tear	1	0.01%	0.30%
Unknown reason	59	0.59%	17.77%

Presentation #92 P

Table 2. Multivariate analysis of risk factors for readmission after ACDF

Risk factor	Odds ratio (95% confidence interval)	P-value
Age		
18 - 29	1.55 (0.55 - 4.36)	0.409
30 - 39	0.59 (0.34 - 1.04)	0.070
40 - 49	**0.67 (0.48 - 0.95)**	**0.023***
50 - 59	Reference	-
60 - 69	1.03 (0.76 - 1.38)	0.856
70 - 79	**1.73 (1.23 - 2.42)**	**0.001**
80 +	1.57 (0.85 - 2.92)	0.149
ASA class		
I	0.37 (0.12 - 1.18)	0.094
II	Reference	-
III	**1.89 (1.48 - 2.41)**	**< 0.001***
IV +	**5.23 (3.25 - 8.41)**	**< 0.001***
Inpatient status		
Inpatients	Reference	-
Outpatients	0.66 (0.37 - 1.20)	0.173
Levels fused		
One-level	Reference	-
Two-level	0.95 (0.75 - 1.20)	0.666
Three-level (or more)	1.31 (0.85 - 2.03)	0.226
Diagnosis		
Disc herniation	0.89 (0.70 - 1.14)	0.373
Cervical stenosis	1.09 (0.72 - 1.64)	0.692
Myelopathy	1.24 (0.96 - 1.58)	0.097
Fracture	1.41 (0.64 - 3.10)	0.387

See Disclosure Index pages 40–88.

Presentation #93 P

The Efficacy and Safety of Additional Posterior Foraminotomy Performed with Laminoplasty for Cervical Spondylotic Myeloradiculopathy

Jung-Ki Ha, MD, Seoul, Republic of Korea
Jae Hwan Cho, MD, Seoul, Republic of Korea
Choon Sung Lee, MD, PhD, Seoul, Republic of Korea
Chang Ju Hwang, MD, Seoul, Republic of Korea
***Sung Hoon Choi, MD**, Seoul, Republic of Korea*
Chul Gie Hong, MD, Seoul, Republic of Korea
Youn-Suk Joo, MD, Seoul, Republic of Korea
Dong-Ho Lee, MD, PhD, Seoul, Republic of Korea

Introduction: Cervical spondylotic myeloradiculopathy (CSMR) is a disabling condition caused by the compression of cervical nerve roots as well as the spinal cord. The conventional laminoplasty is known to be useful to expand stenotic spinal canal; however it is still of limited use for the decompression of accompanying neural foraminal stenosis. To compensate this limitation, additional posterior foraminotomy could be applied simultaneously, although this procedure implies the risk of segmental instability and kyphotic deformity because it impairs part of the posterior facet joint. The purpose of this study is to elucidate the long-term surgical outcomes of posterior foraminotomy additionally performed with laminoplasty for the CSMR patients.

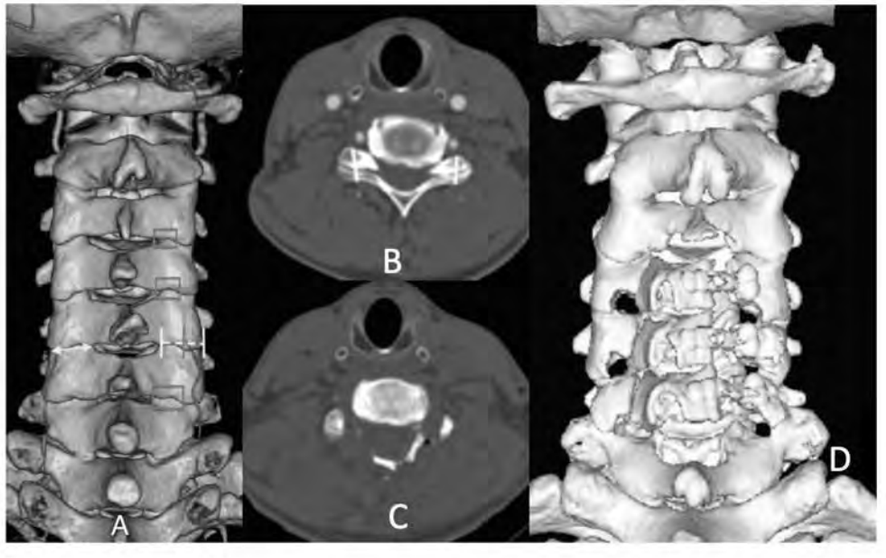
Methods: Sixty-six patients suffering from CSMR involving 3 or more segments were consecutively treated with laminoplasty and followed more than 2 years after surgery. The first 26 patients underwent laminoplasty alone (LA group) and the next 40 patients underwent additional foraminotomies at all the stenotic neural foramens as well as laminoplasty (LF group). In the LF group patients, foraminotomies were performed at 78 segments (unilateral : bilateral = 57 : 21). Neck disability index (NDI), Japanese Orthopedic Association (JOA) score, JOA recovery rate and Visual Analogue Scale (VAS) of arm/neck pain were assessed pre- and post-operatively and then compared between both groups. Radiographic data as follows was also analyzed: 1) C2-C7 sagittal vertical axis (SVA); 2) C2-C7 lordosis; 3) flexion-extension angle; 4) range of motion (ROM); 5) segmental angulation; and 6) vertebral slippage more than 3mm at the foraminotomy levels.

Presentation #93 P

Results: NDI scores, JOA scores, JOA recovery rates and VAS of neck/arm pain improved significantly in both groups after surgery. Nineteen patients in the LF group (47.5%) and 4 patients in the LA group (15.4%) showed complete resolution of their preoperative arm pain at final follow-up. The improvement in VAS of arm pain was significantly greater in the LF group (from 5.55 ± 2.52 to 1.85 ± 2.39) than in the LA group (from 5.48 ± 2.42 to 3.40 ± 2.68)($P < 0.001$). Although, cervical lordosis and ROM decreased postoperatively in both LF and LA groups, there was no significant difference between both groups. Other radiographic parameters were not significantly changed after surgery in both groups. In the LF group, segmental instability such as a slippage more than 3mm or an angular motion more than 10° was not observed even at the level where the foraminotomy was performed bilaterally.

Conclusions: Additional foraminotomy performed with laminoplasty for CSMR is likely to improve arm pain more significantly than laminoplasty alone by decompressing nerve roots as well as the spinal cord. In spite that it impairs part of the facet joint, it would not increase global or segmental kyphosis following laminoplasty more and would not induce segmental instability even if it performed bilaterally at the same segment. Therefore, when laminoplasty is performed for the CSMR patients, additional foraminotomy should be considered for more improvement of arm pain without any concerns about the aggravation of kyphosis, neck pain and segmental instability.

Figure 1. A) Arrow line indicates the medial and lateral margin of the cervical facet joint. The medial edge of the interior and superior facet resections was kept at less than 50% (red line and red square line). B, C, D) Additional foraminotomies performed with laminoplasty for bilaterally stenotic C4-5-6-7 neural foramens.



See Disclosure Index pages 40–88.

Presentation #93 P (cont.)

Table 1. Clinical Outcomes of Laminoplasty with Additional Foraminotomy vs. Laminoplasty Alone

		Laminoplasty with Additional Foraminotomy		Laminoplasty Alone		p value
		Mean	p value	Mean	p value	
NDI	Pre-op	12.85 ± 7.41	<0.001	11.46 ± 7.07	0.001	0.236
	Postop	5.58 ± 5.35		6.35 ± 6.05		
JOA	Pre-op	14.25 ± 1.81	<0.001	14.69 ± 2.07	<0.001	0.330
	Postop	16.18 ± 1.13		16.35 ± 1.02		
JOA recovery rate (%)		70.22 ± 21.34		71.19 ± 25.63		0.437
VAS of neck pain	Pre-op	2.30 ± 2.28	0.002	2.08 ± 2.31	0.032	0.386
	Postop	0.90 ± 1.55		1.19 ± 1.70		
VAS of arm pain	Pre-op	5.55 ± 2.52	<0.001	5.48 ± 2.42	0.021	<0.001
	Postop	1.85 ± 2.39		3.40 ± 2.68		

Mean ± standard deviation
JOA recovery rate (%) = {(Postop. JOA score – pre-op. JOA score)/(17 – pre-op. JOA score)} × 100

Presentation #94 P

Quality of Life and Functional Outcomes after Surgical Decompression in Patients with Cervical Ossification of the Posterior Longitudinal Ligament: Results from the Prospective, Multicenter AOSpine International Study on 479 Patients

***Hiroaki Nakashima, MD**, Toronto, ON, Canada*
Lindsay Tetreault, HBSc, Toronto, ON, Canada
Narihito Nagoshi, MD, PhD, Toronto, ON, Canada
Aria Nouri, MD, Toronto, ON, Canada
Michael G. Fehlings, MD, PhD, Toronto, ON, Canada

Introduction: Degenerative cervical myelopathy (DCM) is an umbrella term that includes cervical spondylotic myelopathy, ossification of the posterior longitudinal ligament (OPLL) and other forms of degenerative changes to the spinal axis. The surgical management of OPLL can be technically challenging for spine surgeons and may result in a higher incidence of perioperative complications than surgery for other forms of DCM. It is unclear whether surgery is equally effective and safe in patients with OPLL as it is in other forms of DCM. This study aims to compare the impact of cervical decompressive surgery on functional status and Quality of Life (QOL) outcomes in patients with OPLL and those with other forms of DCM.

Materials/Methods: 479 surgical patients with symptomatic DCM were prospectively enrolled in the CSM-International study at global 16 sites. Patients' functional and neurological status were evaluated using the modified Japanese Orthopedic Assessment scale (mJOA) and the Nurick score. QOL was assessed using patient-reported outcome measures, including the Neck Disability Index (NDI) and the Short- Form 36 (SF-36) Health Survey. Improvements in functional status and QOL were assessed between baseline and 1- and 2-year follow-ups, and relative gains were compared between patients with and without OPLL. A sub-analysis was conducted in patients with "severe" myelopathy (a preoperative mJOA<12) to determine whether surgical outcomes differed between patients with severe OPLL and those with other forms of severe DCM. Improvements in preoperative functional status and QOL at 2-years follow-up were compared between the two diagnosis groups, while controlling for relevant confounding variables.

Results: Of 479 patients, 135 (28.2%) exhibited evidence of OPLL and 344 (71.8%) displayed other forms of degenerative changes. There were no significant differences in demographics, surgical approach, or baseline severity scores between patients with OPLL and those with other forms of DCM. Patients with OPLL achieved similar functional outcomes at 1- and 2-years following surgery when compared to patients with other forms of DCM (Table 1). With respect to QOL, the NDI and most subscales of the SF-36, there were no differences between the two diagnosis groups (Table 1).

See Disclosure Index pages 40–88.

Presentation #94 P

However, the SF-36 Role Limitation Physical subscale (p = 0.0091) at 1-year and the SF-36 Social Functioning subscale at 1- and 2-years (p = 0.014, p = 0.018) were significantly lower in OPLL patients. In patients with severe myelopathy (preoperative mJOA < 12), 49 (28.65%) presented with OPLL and 122 (71.35%) with other forms of DCM. There were comparable improvements between preoperative and 2-year postoperative scores across all outcome measures (mJOA, Nurick, NDI, and SF-36) in patients with severe myelopathy due to OPLL and other forms of DCM (Table 2). Finally, there was a significantly higher rate of perioperative complications in the OPLL group (p = 0.054). This significant difference was mainly due to a higher incidence of superficial infection (p = 0.0067), new neck pain (p = 0.079) and dural tear (p = 0.076) in the OPLL group. However, rates of neurological complication did not significantly differ (p = 0.73).

Conclusion: Surgical decompression for the treatment of OPLL results in significant improvements in functional status and QOL, comparable to gains seen in other forms of DCM.

Table 1. Functional Status and Quality of Life at 2-year following surgery (N=389)

	OPLL	Other forms of DCM	Significance
Functional Status at 2-years			
mJOA	14.74±2.74	15.25±2.66	0.064
Nurick	2.01±1.64	1.78±1.68	0.15
Quality of Life at 2-years			
Neck Disability Index	24.48±15.93	23.52±19.42	0.30
SF36v2 Physical Functioning	38.24±11.79	40.26±12.58	0.10
SF36v2 Role Limitation Physical	38.67±11.54	39.91±12.67	0.30
SF36v2 Bodily Pain	45.02±11.30	44.23±11.49	0.71
SF36v2 General Health	43.50±11.60	45.38±11.25	0.14
SF36v2 Emotional Well-being	45.90±12.64	47.19±11.84	0.38
SF36v2 Role Limitation Emotional	39.20±13.70	41.68±13.98	0.078
SF36v2 Social Functioning	41.61±12.79	44.92±12.36	0.018
SF36v2 Energy/Fatigue	50.13±11.64	49.55±12.06	0.74
SF36v2 Physical Component Score	40.72±10.11	41.50±11.19	0.41
SF36v2 Mental Component Score	45.81±13.06	47.80±12.64	0.15

OPLL: Ossification of posterior longitudinal ligament. Other forms of DCM: Degenerative cervical myelopathy, including myelopathy secondary to spondylosis, disc herniation, subluxation and hypertrophied ligamentum flavum. mJOA: modified Japanese Orthopaedic Association scale. Means were compared using the appropriate t-test.

Presentation #94 P

Table 2. Improvements in Preoperative Functional Status and Quality of Life at 2-years following surgery in patients with severe myelopathy (mJOA<12)

	OPLL (n=40)	Other forms of DCM (n=94)	Signifi-cance*
Functional Status at 2-years			
Δ mJOA	3.90 (2.95, 4.85)	4.13 (3.51, 4.74)	0.69
Δ Nurick	1.78 (1.25, 2.31)	1.47 (1.12, 1.81)	0.34
Quality of Life at 2-years			
Δ Neck Disability Index	16.62 (9.10, 24.15)	16.50 (11.67, 21.33)	0.98
Δ SF36v2 Physical Component Score	10.86 (7.47, 14.25)	7.39 (5.21, 9.57)	0.093
Δ SF36v2 Mental Component Score	7.90 (2.83, 12.98)	8.90 (5.63, 12.16)	0.75

OPLL: Ossification of posterior longitudinal ligament. Other forms of DCM: Degenerative cervical myelopathy, including myelopathy secondary to spondylosis, disc herniation, subluxation and hypertrophied ligamentum flavum.
mJOA: modified Japanese Orthopaedic Association scale.
Δ: difference in scores between preoperative and 2-years postoperative visit.

*All analyses controlled for age as patients with severe OPLL were significantly younger than those with other forms of severe DCM.

See Disclosure Index pages 40–88.

Presentation #95 P

The Modified Japanese Orthopaedic Association Scale: Establishing Criteria for Mild, Moderate and Severe Disease in Patients with Degenerative Cervical Myelopathy

Lindsay Tetreault, HBSc, Toronto, ON, Canada
***Aria Nouri, MD,** Toronto, ON, Canada*
Anoushka Singh, PhD, Toronto, ON, Canada
Ronald HMA Bartels, MD, PhD, Nijmegen, Netherlands
Branko Kopjar, MD, PhD, Seattle, WA
Paul M. Arnold, MD, Kansas City, MO
Michael Fehlings, MD, PhD, Toronto, ON, Canada

Introduction: The modified Japanese Orthopaedic Association (mJOA) score is a validated, investigator-administered tool used to evaluate functional status in patients with degenerative cervical myelopathy (DCM). This scale is increasingly used in this population to measure baseline myelopathy severity, postoperative improvements and social independence. There is, however, no study that determines what scores on the mJOA constitute mild, moderate and severe disease. Patients in different severity categories are managed differently both intraoperatively and postoperatively; therefore, establishing this criteria has clinical value across the whole spectrum of care.

Objective: This study aims to determine appropriate cut-offs between mild, moderate and severe myelopathy and to examine the construct validity of these definitions.

Methods: Between December 2005 and January 2011, 757 patients with clinically-diagnosed and imaging-confirmed CSM were enrolled in either the prospective, multicenter CSM-North America (n = 278) or CSM-International (n = 479) study at 26 global sites. Functional status and quality of life were evaluated in these patients at baseline and at 6-, 12- and 24-months postoperative using a wide variety of outcome measures, including the mJOA, Nurick score, Neck Disability Index (NDI) and Short-form-36 (SF-36). Using the Nurick grade as an anchor, ROC analysis was conducted to determine the cut-offs between mild and moderate myelopathy and between moderate and severe disease. These cut-offs were validated by developing and testing various constructs. Specifically, we examined whether patients in different severity groups had significantly different functional impairment, disability, symptomatology, imaging findings and post-treatment improvements. Finally, members of AOSpine International were surveyed to see what professionals viewed as appropriate cut-offs between severity categories.

Results: In ROC analysis, a mJOA of 14 was determined to be the cut-off between mild and moderate myelopathy and a score of 11 as the score between moderate and severe disease (Figure 1).

Presentation #95 P

Patients in the severe myelopathy group (n = 254) had significantly reduced quality of life and functional status and a greater number of signs and symptoms than patients classified as mild (n = 193) or moderate (n = 296) (Table 1). Furthermore, severe patients required greater improvements on the mJOA to achieve a minimum clinically important difference. From our survey, a score of 15 (n = 143, 34.38%) was the most commonly selected cut-off between mild and moderate myelopathy (mean 14.38). The majority of respondents selected 10 (n = 178, 42.79%) as the mJOA cut-off between moderate and severe myelopathy (mean 11.26).

Conclusions: Based on our results, mild myelopathy can be defined as a mJOA = 15-17, moderate as mJOA = 12-14 and severe as mJOA < 12. These categories are the same as those established by the AOSpine study group for the purpose of the CSM-North America study.

Table 1. Construct Validity of Severity Criteria for the modified Japanese Orthopaedic Association Score

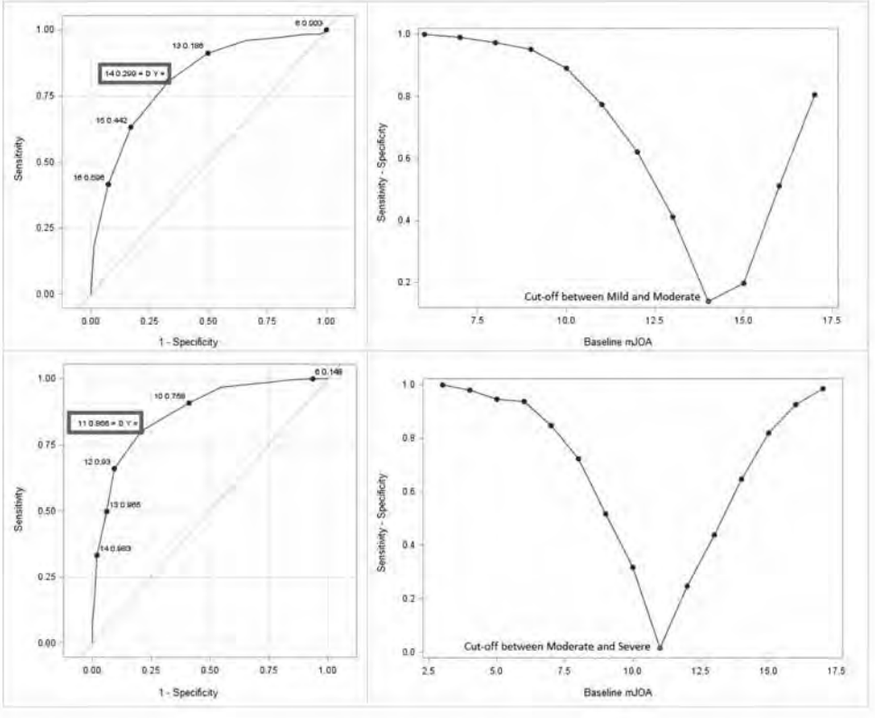
	mJOA=15-17	mJOA=12-14	mJOA<12	p-value
Nurick Score	2.31±0.81	3.11±0.80	4.17±1.03	<0.0001
mJOA Upper Extremity Function	4.47±0.57	3.78±0.80	2.45±0.96	<0.0001
mJOA Lower Extremity Function	6.22±0.75	4.65±0.98	3.26±0.91	<0.0001
mJOA Sensory Function	2.16±0.52	1.97±0.44	1.55±0.63	<0.0001
mJOA Bladder Function	2.91±0.28	2.66±0.51	2.14±0.87	<0.0001
Neck Disability Index	31.34±17.32	37.56±19.30	47.87±21.01	<0.0001
SF-36 Physical Component Score	39.74±8.89	34.11±8.86	30.19±7.80	<0.0001
SF-36 Mental Component Score	42.72±13.16†	41.53±13.10†	36.54±13.62	<0.0001
Number of symptoms	3.07±1.28	4.20±1.26	4.69±1.02	<0.0001
Number of signs	2.85±1.55	3.73±1.75	4.68±1.61	<0.0001
Combined T1/T2 signal change (n=114)*	7 (25.93%) 16 (59.26%) 4 (14.81%)	16 (39.02%) 15 (36.59%) 10 (24.39%)	7 (21.21%) 15 (45.45%) 11 (33.33%)	0.20

* Imaging data was extracted from patients enrolled in the CSM-North America study who had available MRIs. Combined T1/T2 signal change: first row, no signal change on T1- or T2-weighted images; second row, high signal change on T2-weighted image and no signal change on T1-weighted image; third row, combined high signal change on T2-weighted image and low signal change on T1-weighted image.
† The difference in SF-36 Mental Component Score between mild and moderate patients was not statistically significant
mJOA: modified Japanese Orthopaedic Association; SF: short-form

See Disclosure Index pages 40–88.

Presentation #95 P (cont.)

Figure 1. ROC Analysis to determine an appropriate mJOA cut-off between Mild and Moderate Myelopathy (Top) and between Moderate and Severe Disease (Bottom)



Each point on the ROC curve (left) indicates a unique value for the mJOA. The cut-off mJOA between mild and moderate disease (mJOA=14) and between moderate and severe myelopathy (mJOA=11) is the point that yields the smallest difference between sensitivity and specificity. Score of 11 and 14 were also the closest point to (x=0, y=1) (D) and the furthest from the diagonal line. The graphs on the right plot the baseline mJOA by the difference between sensitivity and specificity.

Presentation #96 P

What Happens to the Disc Bulge after Posterior Laminectomy and Fusion in Patients with Cervical Myelopathy?

***Saankritya Ayan, MD**, Bronx, NY*
Jonathan Morris, MD, Bronx, NY
Manal Abouelrigal, MD, Bronx, NY
Woojin Cho, MD, PhD, Bronx, NY
Alok D. Sharan, MD, Bronx, NY

Introduction: Cervical myelopathy is a disabling condition that often presents with a loss of fine motor skills in the hand with lower limb ataxia. The most common cause of myelopathy is degeneration of the cervical discs with resulting compression of the spinal cord. Treatment often consists of surgical decompression and fixation, performed through ugh an anterior, posterior, or combined approach. Posterior laminectomy and fusion is recommended for patients with multilevel compression with preserved cervical lordosis. This approach affords an indirect decompression of the spinal cord by allowing it to drift away posteriorly from the anteriorly bulging discs. Although this approach effectively decompresses the spinal cord there has been no study that critically analyzes the degree of remaining stenosis due to the anterior bulging discs. The purpose of this study is to determine the fate of the anterior disc bulges after completion of a posterior cervical laminectomy and fusion.

Materials and Methods: We retrospectively evaluated the charts and imaging of 43 patients who underwent posterior laminectomy and fusion from C3-T1. Patients who had a minimum follow up of 52 weeks (1 year) along with a post-op MRI after one year were included in the study. 15 patients met our inclusion criteria and were further evaluated for this study. Significant compression was defined as the segment which had a ventral or dorsal block to the flow of CSF (CSF cut off sign). 49 segments with significant compression were further evaluated. We measured the disc bulge with reference to a straight line connecting the posterior- inferior and superior corner of the vertebral body on the pre-op and postop surgery MRI films. We also measured the disc bulge using the same technique at the C2-3 segment to look for evidence of post-operative disc bulge (adjacent segment degeneration). The results were tabulated and paired T test was used as a test of significance.

See Disclosure Index pages 40 – 88.

Presentation #96 P (cont.)

Results: 15 patients with 49 significant compression levels were evaluated. The mean age was 61.2 years (39–76). The mean difference in Pre- and post-operative MRI was 103.7± 56.3 (range 61–257) weeks. There were 7 males and 8 females in the study group. The common presenting complaints were loss of fine motor skills in the hand (15/15), hand numbness (12/15), and ataxia with loss of balance (13/15). The mean number of levels with significant compression was 3.46 ± 1 (range 2–6). C3-4 was the most common segment to have significant compression, seen in 14/15 patients. The mean disc bulge in the pre-op MRI was 4.02 ± .99 mm which improved to 2.90 ± 1.35 mm in the follow up MRI accounting for a 28.1% improvement ($P < 0.001$). Table 1 summarizes these overall results. No significant worsening was seen at the C2-3 segments. (Pre-operatively 2.91 ± 1.5 vs. 3.17 ± 1.58 mm post-operatively p-value = 0.41)

Discussion: To the best of our knowledge no study has been completed that documents the changes in the anterior disc bulges after surgery. Our study shows a significant reduction of disc bulges at levels with significant spinal cord compression at one year after a C3-T1 posterior laminectomy and fusion surgery alone. In addition there was no worsening at the unfused C2-3 level. This study might not address the clinical consequences of performing an isolated posterior surgery as a means for effective decompression in multilevel cervical spondylotic myelopathy. A comparison of pre and post-operative functional outcome scores using the index surgery would be a better indicator of adequacy of decompression, yet this study might serve as good starting point to investigate it further.

Table 1. Cervical segment wise tabulation of improvement/worsening of disc bulge

Stenotic segments	Pre-operative	Post-operative	Difference	Percent improvement/ worsening	P-value
Overall n=49	4.02±0.99 mm	2.90±1.35 mm	1.13±1.25 mm	28.1% improvement	0.001
C2-3 n= 15	2.91±1.5 mm	3.17±1.58 mm	0.26±1.15 mm	8.9% worsening	0.41
C3-4 n=14	4.06±1.1 mm	3.37±1.73 mm	0.69±1.73 mm	36.4 % improvement	0.01
C4-5 n= 12	4.12±0.90 mm	2.62±.87 mm	1.5±0.99 mm	42.7% improvement	<0.001
C5-6 n=13	3.69±0.87 mm	2.35±0.96 mm	1.35±0.81 mm	36.58% improvement	<0.001
C6-7 n= 8	4.04±0.67 mm	2.86±0.84 mm	1.19±0.65 mm	29.4% improvement	0.002
C7-T1 n=2	5.13±1.35 mm	5.02± 1.42 mm	0.12±2.76 mm	2% improvement	0.97

Presentation #96 P

Figure 1.

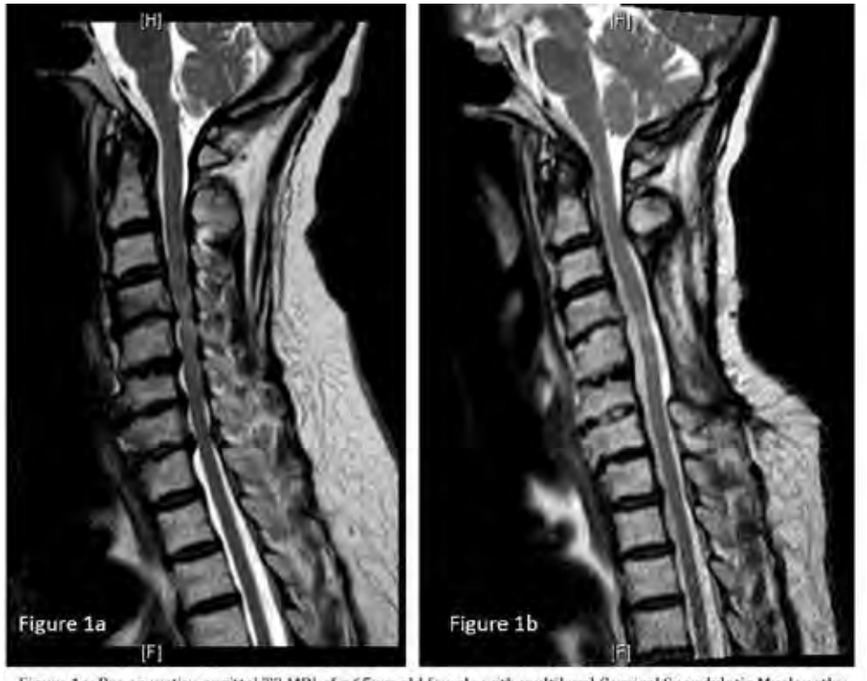


Figure 1a: Pre operative sagittal T2 MRI of a 65yrs old female with multilevel Cervical Spondylotic Myelopathy
Figure 1b: 2 yrs follow up MRI of the same patient after C3-7 laminectomy and C3-T1 fusion. Marked reduction in disc bulge at C4-T1 level noted.

See Disclosure Index pages 40–88.

Presentation #97 P

Anterior Decompression with Fusion vs. Posterior Decompression with Fusion for Massive Cervical Ossification of Posterior Longitudinal Ligament with 50% Canal Occupying Ratio or More: Retrospective Multicenter Study

***Toshitaka Yoshii, MD, PhD**, Tokyo, Japan*
Takashi Hirai MD, PhD, Tokyo, Japan
Satoshi Sumiya MD, Tokyo, Japan
Tsuyoshi Kato, MD, PhD, Tokyo, Japan
Shigenori Kawabata, MD, PhD, Tokyo, Japan
Atsushi Okawa, MD, PhD, Tokyo, Japan
Kenichi Shinomiya, MD, PhD, Tokyo, Japan

Introduction: Surgical approach for cervical ossification of longitudinal ligament (OPLL) is still a matter of debate. Posterior decompression is a relatively safe method; however, the effect of indirect decompression of the spinal cord is limited for patients with massive OPLL. It has been previously reported that posterior laminoplasty for patients, who have massive OPLL with 50% canal-occupying ratio or more, can result in poor outcomes. Therefore, we usually choose anterior decompression with fusion (ADF) or posterior decompression with fusion (PDF) to treat such patients. However, it is unclear which procedure is more favorable for postoperative neurological improvement for massive OPLL. In this study, we retrospectively evaluated the surgical outcomes of these two procedures for the treatment of OPLL with ≥ 50% occupying ratio with a minimum of 2-year follow-up.

Methods: From 2006 to 2013, 61 OPLL patients with ≥ 50% occupying ratio, who received ADF (n = 39) or PDF (n = 22) in our multi-center research group, were included in this study. The ADF group and PDF group were matched on the basis of patient's age, gender, preoperative neurological status evaluated by Japanese Orthopaedic Association score (JOA) score, occupying ratio of OPLL (Table 1). In the ADF group, averaged 3.1 levels were fused after decompression using autologous fibula graft or hydroxyapatite graft with plating. In the PDF group, the cervical spine was generally fused from C2 to C7 after laminectomy or laminoplasty. When OPLL existed from cervical to upper thoracic spine, we extended the fusion levels as needed. We evaluated prospectively collected surgical data including JOA score for neurological recovery, visual analogue scale (VAS) for neck pain, cervical sagittal alignment at C2-7, operating time, intraoperative blood loss, and perioperative complications.

Results: No significant differences were found in the postoperative neurological recovery rate between the two groups (Table 2). However, in patients with kyphotic alignment (C2-7 angle < 0 degree), the recovery rate was significantly higher in the ADF group ($p < 0.05$). Postoperative cervical pain was greater in PDF group ($p < 0.05$).

Presentation #97 P

The improvement in cervical alignment at C2-7 was greater in the ADF group ($p < 0.05$). There was a trend of longer operating time in the ADF group ($p = 0.06$), whereas no difference was found in intraopeartive blood loss. Surgery-related complications was more frequently observed in the ADF group (30.8%: 4 dysphasia, 1 upper respiratory disturbance, 5 graft dislodgement/subsidence, 2 C5 palsy) than in the PDF group (18.2%: 2 C5 palsy, 1 nonunion, 1 infection).

Conclusion: The present study demonstrated that the postoperative recovery rate was more favorable in ADF in patients, who have massive OPLL with kyphotic alignment. Additionally, postoperative neck pain was less in the ADF group. However, the occurrence of perioperative complications was more frequent in the ADF group. From these results, ADF can be considered first for the treatment of massive OPLL especially in cases with kyphotic alignment. For the treatment of high-risk patients, PDF can be alternatively considered.

Table 1. Demographics

	ADF (n=39)	PDF (n=22)	*P*
Age	61.1±8.5	60.6±12.8	0.87
Gender (M/F)	31/8	18/4	0.56
Pre JOA score	11. 5±1.2	11.0±1.9	0.27
Canal occupying ratio	58.8±8.3	57.1±7.2	0.42
Pre-op C2-7 angle	5.0±9.6	9.6±10.6	0.09
Levels of fusion	3.1± 0.9	5.3±2.0**	P<0.01
Follow-up (mo)	44.5±18.8	36.9±16.5	0.12

Mean ± standard deviation, **: p<0.01

Table 2. Comparison between ADF vs PDF

	ADF (n=39)	PDF (n=22)	*P*
Operating time	345.4±132.1	281.5±112.4	0.06
Intra-op blood loss	317.8±687.4	374.6±401.8	0.73
Post-op JOA score	14.7±1.9	14.2±1.6	0.30
IR in JOA score	61.6±28.2	55.8±18.2	0.40
IR (kyphotic patients)	65.1±23.0*	47.2±7.8	P<0.05
Post-op neck pain	2.7± 2.3	4.8±3.0*	P<0.05
Post-op C2-7 angle	9.1±7.1	9.8±8.0	0.74
Change in C2-7 angle	4.1±7.1*	0.2±6.2	<0.05

Mean ± standard deviation, IR: improvement rate in JOA score, *: p<0.05

See Disclosure Index pages 40–88.

Presentation #98 P

Is it Necessary to Extend a Multilevel Posterior Cervical Decompression and Fusion to the Upper Thoracic Spine?

***Gregory D. Schroeder, MD**, Philadelphia, PA*
Christopher K. Kepler, MD, MBA, Philadelphia, PA
Mark F. Kurd, MD, Philadelphia, PA
Loren B. Mead, BS, Philadelphia, PA
Kristen Nicholson, PhD, Philadelphia, PA
Christie E. Stawicki, BS, Philadelphia, PA
Priyanka Kumar, BS, Philadelphia, PA
Paul W. Millhouse, MD, Philadelphia, PA
Kristen E. Radcliff, MD, Philadelphia, PA
Jeffery A. Rihn, MD, Philadelphia, PA
D. Greg Anderson, MD, Philadelphia, PA
Alan S. Hilibrand, MD, Philadelphia, PA
Alexander R. Vaccaro, III, MD, PhD, Philadelphia, PA

Introduction: Multilevel posterior cervical decompression and fusions are common procedures for patients with cervical spondylotic myelopathy. While often the neural elements can be decompressed adequately with a decompression and fusion ending at C7, many surgeons elect to extend the fusion into the upper thoracic spine rather than stopping a long construct at the cervicothoracic junction. The purpose of this study is to determine if there is a difference in either the revision rate or the cervical alignment in patients who undergo a multilevel posterior cervical fusions ending at C7 or the upper thoracic spine.

Methods: A retrospective review of all patients who underwent a three or more level posterior cervical decompression and fusion at a single institution between 1/2008 and 9/2013 was performed. All patients with at least one year of clinical follow-up were included in the study. Additionally the C2-C7 lordosis and the C2-C7 sagittal vertical axis (SVA) was recorded for patients with radiographic follow-up of at least one year. Patients were excluded if the surgery was performed for a tumor, trauma or an infection. Student's T-test was used to evaluate continuous variables, and a Fisher's exact test was used to evaluate categorical variables. Significance was set at p = 0.05.

Results: A total of 70 multilevel posterior cervical fusions were identified that terminated at C7, and 98 cases were identified that terminated in the upper thoracic spine (T1–T3). The average follow up was 28.2 +/- 17.9 months. No difference in age, gender, diagnosis, preoperative cervical alignment or the presence of concomitant anterior surgery was identified (Table 1).

Presentation #98 P

The total revision rate was similar between surgeries ending at C7 and those that ended in the upper thoracic spine (8.6% (6 cases) vs. 13.3% (13 cases), p = 0.46). Similarly, when revisions for wound complications were excluded, there was again no difference in the revision rate (5.7% vs. 7.1%, p = 0.76). Adequate postoperative radio-graphs were available for 56 patients whose surgery terminated at C7 and 88 patients whose surgery extended into the upper thoracic spine. No difference in either the post-operative cervical lordosis or the C2-C7 SVA was identified between the groups (Table 2).

Conclusion: When performing a routine multilevel posterior cervical fusion, stopping the construct at the C7 does not lead to an increase risk of early revision, and it does not affect the ability to restore sagittal alignment.

Table 1. Comparison of pre-operative variables between patients who had a multilevel posterior cervical decompression and fusion that ended at C7 or the upper thoracic spine

	C7	T1-3	P-value
Cases	70	98	
Age	61.31 +/- 11.72	57.59 +/- 15.48	0.07
Number of males	33 (47/1%)	56 (57.1%)	0.21
Months of follow up	29.82 +/- 19.61	32.24 +/- 14.44	0.71
Diagnosis			
Myelopathy	59 (84.3%)	83 (84.7%)	0.99
Radiculopathy	1 (1.4%)	1 (1.0%)	0.99
Combination	7 (10.0%)	10 (10.2%)	0.99
Had anterior support	27 (38.6%)	23 (23.5%)	0.12
+/- = standard deviation			

Table 2. Comparison of the cervical lordosis and C2-C7 SVA between patients who had a multilevel posterior cervical decompression and fusion that ended at C7 or the upper thoracic spine.

	C7	T1-3	P-value
Cases	56	88	
Preoperative lordosis in degrees	6.12 +/- 13.96	7.56 +/- 20.26	0.71
Preoperative SVA in cm	2.84 +/- 1.32	2.95 +/- 1.40	0.65
Postoperative lordosis in degrees	6.56 +/- 13.24	8.82 +/- 11.26	0.29
Postoperative SVA in cm	3.39 +/- 1.49	3.76 +/- 1.70	0.17
+/- = standard deviation			

See Disclosure Index pages 40–88.

E-Poster Abstracts

Efficacy of Posterior Segmental Decompression Surgery for Pincer Mechanism in Cervical Spondylotic Myelopathy – A Retrospective Case-Control Study using Propensity Score Matching

***Akihito Minamide, MD, PhD**, Wakayama, Japan*
Munehito Yoshida, MD, PhD, Wakayama, Japan
Hiroshi Yamada, MD, PhD, Wakayama, Japan
Hiroshi Hashizume, MD, PhD, Wakayama, Japan
Yukihiro Nakagawa, MD, PhD, Wakayama, Japan
Hiroshi Iwasaki, MD, PhD, Wakayama, Japan
Shunji Tsutsui, MD, PhD, Wakayama, Japan
Hiroyuki Oka, MD, PhD, Tokyo, Japan

Introduction: Compression of the cervical spinal cord in cervical spondylotic myelopathy (CSM) consists of a pincer mechanism due to bulging discs and hypertrophied ligamentum flavum. Posterior decompression of the cervical spinal cord in CSM is sufficient to remove the elements of the articular segment, such as the ligamentum flavum and the superior or inferior edge of the lamina. The surgical procedures of this concept for posterior decompression include the segmental partial laminectomy or laminotomy. The authors have performed cervical microendoscopic laminotomy (CMEL) as a minimally invasive strategy for cervical posterior decompression surgery of the articular segment with a pincer mechanism in CSM patients. The purpose of this study was to evaluate the efficacy of CMEL for the articular segment with pincer mechanism in CSM patients by comparing the clinical results of CMEL with conventional expansive laminoplasty (ELAP) for patients with CSM.

Surgical Technique: The MEL surgery has been developing to the bilateral decompression surgery by the unilateral approach though 16mm skin incision. On the microendoscopic system, the cervical laminotomy in the inter-lamina portion was performed until attachment of ligamentum flavum using a high-speed air drill (Fig1, 2). As the spinal cord was decompressed, the ligamentum flavum was floated. With removing the ligamentum flavum, the dural pulsation was observed. This procedure is also a spinal cord decompression procedure that maintains the posterior structures.

See Disclosure Index pages 40–88.

Methods: This retrospective case–control study of the clinical outcomes of CMEL and ELAP for the treatment of CSM used the propensity score matching method. A one-to-one matching analysis was performed between patients who underwent CMEL and ELAP on the basis of the estimated propensity scores of each patient. To estimate the propensity score, we fitted a logistic regression model for the receipt of ELAP as a function of patient demographic factors including age, sex, and preoperative JOA score. All patients were followed postoperatively for >2 years. The preoperative and 2-year follow-up evaluations included neurological assessment (Japanese Orthopaedic Association [JOA] score), recovery rates, the JOA Cervical Myelopathy Evaluation Questionnaire (JOACMEQ), axial pain (visual analog scale), and the Short Form 36 questionnaire (SF-36). All parameter were analyzed statistically ($p < 0.05$).

Results: There were 71 patients in each group (47 males and 24 females each). The mean ages of the CMEL and ELAP groups were 63.8 and 62.8 years, respectively. There was no significant difference in the preoperative JOA score between groups. The mean numbers of surgically affected levels in the ELAP and CMEL groups were 3.8 and 1.7 discs, respectively ($p < 0.05$). The groups exhibited similar recoveries of JOA, JOACMEQ, and SF-36 scores postoperatively. Sagittal alignment was maintained in both groups. However, postoperative neck axial complaints were significantly reduced in the CMEL group.

Conclusions: CMEL may be a useful and effective surgical procedure for CSM, providing similar results as ELAP. Posterior decompression of the articular segment with a pincer mechanism in CMEL can be indicated for patients with CSM. This minimally invasive technique solves some problems caused by ELAP-induced soft-tissue damage, providing an alternative surgical method for CSM patients.

Figure 1.

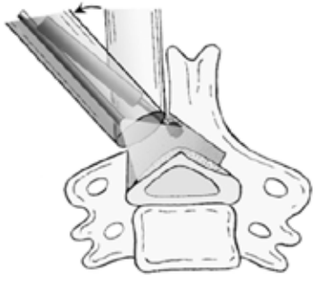
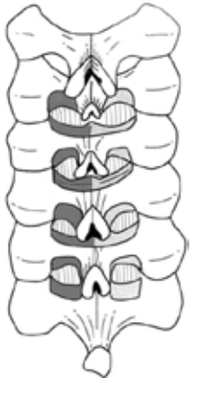


Figure 2.



Efficacy of a Short Plate with an Oblique Screw Trajectory for Anterior Cervical Plating: A Comparative Study with a Two-Year Minimum Follow-up

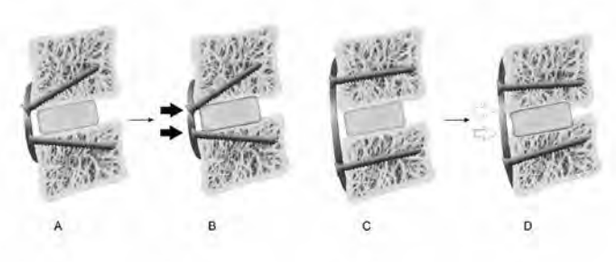
Jong-Hwa Park, MD, Uijeongbu-Si, Republic of Korea
Seung-Jae Hyun, MD, PhD, Seongnam, Republic of Korea
Chang-Hyun Lee, MD, Daejeon, Republic of Korea
***Ki-Jeong Kim, MD, PhD**, Seongnam, Republic of Korea*
Jin S. Yeom, MD, PhD, Seongnam, Republic of Korea

Introduction: It has been reported that adjacent segment ossification development (ASOD) commonly occurs after anterior cervical arthrodesis. This study was conducted to compare the efficacy of the short plate and oblique screw trajectory with the traditional long plate and parallel screw trajectory by investigating the incidence of ASOD and graft subsidence.

Materials/Methods: We retrospectively reviewed the patients who underwent single level anterior cervical discectomy and fusion (ACDF) with plate augmentation in our institute between June 2003 and August 2011. The patients were divided into two groups according to the plating technique, which was determined by the distances between the tips of the plate and the cranial and caudal adjacent endplates (plate-to-endplate distance, PED). Group L included the patients with a long plate (PED shorter than 5mm) and Group S contained the patients with a short plate (PED longer than 5mm). Vertebral body height, distribution of ACDF level, incidence of cranial and caudal ASOD, ASOD grade, screw-to-end plate angle, vertebral body diameter, screw length, screw-to-body ratio, disc space height, subsidence, and cervical range of motion (ROM) were measured and compared between the two groups.

Results: The incidences of both cranial and caudal ASOD at least 2 years after surgery in Group S were significantly lower than in Group L (17.6% vs. 53.8%, $p = 0.001$ and 31.4% vs. 65.4%, $p = 0.004$, respectively). The incidence of severe ASOD at the caudal adjacent disc space in Group S was significantly lower in Group S (2.0% vs. 23.0%, $p = 0.002$). The incidence of the subsidence was significantly lower in Group S (2.0% vs. 25.9, $p = 0.001$). Changes in the cervical ROM showed no significant differences regardless of group, ASOD and graft subsidence.

Conclusions: Techniques using a short plate with an oblique screw trajectory resulted in significantly reduced incidence and severity of ASOD and prevented graft subsidence.



See Disclosure Index pages 40–88.

Prolonged Weakness affects Recovery of Motor Function following Anterior Cervical Discectomy and Fusion

***Ronald Huang, MD**, Philadelphia, PA*
David Beck MD, Merchantville, NJ
Andrew G. Park, MD, Philadelphia, PA
Alan S. Hilibrand, MD, Philadelphia, PA

Introduction: Patients with cervical radiculopathy and myelopathy may have significant upper extremity weakness. Although anterior cervical discectomy and fusion (ACDF) has been shown to effectively relieve pain and prevent progressive worsening of myelopathy, it is unclear what factors influence recovery of motor function following ACDF. The purpose of our study is to identify factors that significantly affect the postoperative recovery of motor function in patients with significant upper extremity weakness undergoing ACDF.

Methods: From our prospectively maintained institutional database, we identified 603 patients undergoing one, two, three, or four level ACDFs for radiculopathy and/or myelopathy between January 2011 and December 2012. 138 Patients operated on for fracture, tumor, and infection were excluded. Demographics, comorbidities, preoperative physical exam, operative details, and follow-up data were obtained for each patient. Patients with significant weakness, defined as preoperative grade 3/5 or less strength in at least one upper extremity muscle group, were identified. Postoperative recovery of motor function was defined as an improvement of 1 grade of strength in at least two muscle groups or improvement of 2 grades in one muscle group. Logistic regression analysis was utilized to identify risk factors associated with a lack a recovery of motor function in patients with significant preoperative weakness.

Results: Incidence of significant weakness in our patient population was 6.2% (29 of 465 patients). 24 of 29 patients with weakness had recovery of their motor function at two years postoperatively, whereas five patients had persistent weakness. Median duration of preoperative weakness was 34 months in patients with persistent postoperative weakness vs. 4 months in patients with motor recovery ($p = 0.006$). Prolonged duration of preoperative weakness was found to be an independent risk factor for persistent weakness following ACDF ($p = 0.021$).

Discussion and Conclusion: Weakness in patients with cervical radiculopathy is relatively uncommon. However, our study demonstrates a strong association between prolonged preoperative weakness and decreased recovery of motor function. Further studies with larger cohorts of patients are needed to more precisely identify which patients with significant upper extremity weakness are likely to recover motor function following ACDF.

Factors Associated with Morbidity and Mortality in Adults Undergoing Cervical Corpectomy

***Dante M. Leven, DO, PT**, Brooklyn, NY*
Branko Skovrlj, MD, New York, NY
Parth Kothari, BS, New York, NY
Jeremy Steinberger, MD, New York, NY
Javier Z. Guzman Tejero, BS, MD, New York, NY
Nathaniel J. Lee, BS, New York, NY
John I. Shin, MD, New York, NY
John M. Caridi, MD, New York, NY
Samuel K. Cho, MD, New York, NY

Introduction: Cervical corpectomy is a common surgical technique and several studies have shown favorable outcomes for patient being treated for cervical myelopathy, radiculopathy, and other forms of spinal cord or nerve root compression. However, postoperative complications are reportedly high and few studies have identified consistent risk factors for morbidity and mortality in this patient cohort using a large database. Our study objective was to analyze predictors of morality and morbidity in adults following cervical corpectomy.

Materials/Methods: Adult patients (> 18 years) who underwent cervical corpectomy (CPT code: 6301 ad 63082) between 2005 and 2012 were identified in the NSQIP database. Patients were divided into 1) no morbidity and 2) morbidity cohorts and 3) no mortality and 4) mortality cohorts and the groups were compared. Patient demographics, comorbidities, operative variables and postoperative courses were analyzed. Outcomes assessed included any complications, reoperation, unplanned readmission or mortality. Univariate analysis was performed on demographics, comorbidities and operative variables. Only variables with $p < 0.2$ were evaluated for inclusion in the final step-wise multivariate logistic regression model. Statistical significance was maintained at $p < 0.05$.

Results: A total of 1609 patients met inclusion criteria with 150/1609 (9.3%) in the morbidity cohort and 16/1609 (0.9%) in the mortality cohort. Predictors of morbidity were increasing age, diabetes, dependent functional status prior to surgery, pulmonary comorbidity, cardiac comorbidity, renal comorbidity, prior neuromuscular injury, history of stroke, steroid use, preoperative blood transfusion, disseminated cancer, prolonged operative time (> 4 hours) and ASA >/= 3 ($p < 0.05$). Predictors of mortality were increasing age, smoking, dependent functional status, pulmonary comorbidity, peripheral vascular disease, renal comorbidity, recent weight loss, bleeding disorder, preoperative blood transfusion, chemotherapy within 30 days, radiotherapy within 90 days, disseminated cancer and ASA >/= 3 ($p < 0.05$) (Table 1). Independent predictors of morbidity were dependent functional status (OR 2.9, 1.6-5.3 95% CI), history of stroke (OR 3.1, 1.3–7.1 95% CI), ASA >/= 3 (OR 2.3, 1.3–3.9 95% CI) and operative time > 4 hours (OR 3.3, 2.0–5.4 95% CI) (Table 2).

See Disclosure Index pages 40–88.

Conclusions: This study highlights risk factors for morbidity and mortality following cervical corpectomy in the adult population. These findings can be utilized during risk stratification, patient counseling and perioperative care to minimize complications and mortality.

Table 1.

Univariate Analysis of Patent Factors and Clinical Conditions for Cervical Corpectomy

	Total		No Morbidity		Morbidity		P value	No Mortality		Mortality		P value
	1609		1459		150			1593		16		
Demographics	N	%	N	%	N	%		N	%	N	%	
Sex												
Female	798	49.60%	716	49.07%	82	54.67%	0.192	792	49.72%	6	37.50%	0.331
Male	811	50.40%	743	50.93%	68	45.33%		801	50.28%	10	62.50%	
Age									0.00%		0.00%	
< 51	517	32.13%	494	33.86%	23	15.33%		517	32.45%	0	0.00%	
51 to 60	491	30.52%	446	30.57%	45	30.00%		487	30.57%	4	25.00%	
61 to 70	385	23.93%	337	23.10%	48	32.00%	**<0.0001**	380	23.85%	5	31.25%	**0.001**
71 to 80	176	10.94%	148	10.14%	28	18.67%		171	10.73%	5	31.25%	
> 80	40	2.49%	34	2.33%	6	4.00%		38	2.39%	2	12.50%	
Race									0.00%		0.00%	
White	1161	72.16%	1057	72.45%	104	69.33%		1148	72.07%	13	81.25%	
Black	235	14.61%	209	14.32%	26	17.33%	0.457	232	14.56%	3	18.75%	0.473
Other	121	7.52%	107	7.33%	14	9.33%		121	7.60%	0	0.00%	
Unknown	92	5.72%	86	5.89%	6	4.00%		92	5.78%	0	0.00%	
BMI Class >= 30	611	37.97%	560	38.38%	51	34.00%	0.292	607	38.10%	4	25.00%	0.283
Diabetes	278	17.28%	243	16.66%	35	23.33%	**0.039**	273	17.14%	5	31.25%	0.137
Smoke	493	30.64%	448	30.71%	45	30.00%	0.858	484	30.38%	9	56.25%	**0.026**
Alcohol	42	2.61%	38	2.60%	4	2.67%	0.907	41	2.57%	1	6.25%	0.230
Dyspnea	112	6.96%	100	6.85%	12	8.00%	0.560	109	6.84%	3	18.75%	0.063
Dependent Functional Status Prior to Surgery	119	7.40%	85	5.83%	34	22.67%	**<0.0001**	111	6.97%	8	50.00%	**<0.0001**
Comorbidites												
Pulmonary Comorbidity	86	5.34%	66	4.52%	20	13.33%	**<0.0001**	83	5.21%	3	18.75%	**0.017**
Cardiac Comorbidity	788	48.97%	698	47.84%	90	60.00%	**0.005**	777	48.78%	11	68.75%	0.112
Peripheral Vascular Disease	9	0.56%	8	0.55%	1	0.67%	0.853	8	0.50%	1	6.25%	**0.002**
Renal Comorbidity	21	1.31%	16	1.10%	5	3.33%	**0.022**	19	1.19%	2	12.50%	**<0.0001**
Neuromuscular Injury	122	7.58%	103	7.06%	19	12.67%	**0.014**	120	7.53%	2	12.50%	0.455
History of Stroke	37	2.30%	26	1.78%	11	7.33%	**<0.0001**	36	2.26%	1	6.25%	0.289
Steroid Use	63	3.92%	53	3.63%	10	6.67%	**0.068**	62	3.89%	1	6.25%	0.629
Recent Weight Loss	17	1.06%	14	0.96%	3	2.00%	0.235	15	0.94%	2	12.50%	**<0.0001**
Bleeding Disorder	43	2.67%	36	2.47%	7	4.67%	0.112	39	2.45%	4	25.00%	**<0.0001**
Preoperative Blood Transfusion	9	0.56%	5	0.34%	4	2.67%	**0.0003**	7	0.44%	2	12.50%	**<0.0001**
Chemotherapy in last 30 days (preop)	10	0.62%	7	0.48%	3	2.00%	0.075	9	0.56%	1	6.25%	**0.006**
Radiotherapy in last 90 days	6	0.37%	4	0.27%	2	1.33%	0.126	4	0.25%	2	12.50%	**<0.0001**
Prior Operation in last 30 days	12	0.75%	7	0.48%	5	3.33%	**0.001**	12	0.75%	0	0.00%	0.223
Disceminated Cancer	37	2.30%	28	1.92%	9	6.00%	**0.002**	30	1.88%	7	43.75%	**<0.0001**
Tumor CNS	9	0.56%	6	0.41%	3	2.00%	**0.015**	7	0.44%	2	12.50%	**<0.0001**
Operative Conditions												
Total RVU, mean (SD)	65.59 (28.04)		64.92 (27.05)		72.12 (35.76)		**0.018**	65.49 (27.95)		75.16 (35.49)		0.170
Operative Time > 4 Hours	354	22.00%	283	19.40%	71	47.33%	**<0.0001**	348	21.85%	6	37.50%	0.133
Inpatient vs. Outpatient	1394	86.64%	1245	85.33%	149	99.33%	**<0.0001**	1378	86.50%	16	100.00%	0.114
ASA >= 3	805	50.03%	693	47.50%	112	74.67%	**<0.0001**	790	54.15%	15	10.00%	**0.0004**

Table 2.

Risk Factors	Adjusted OR	95 CI		P Value
Female vs. Male	1.406	0.865	2.287	0.169
Dependent Functional Health Status Prior to Surgery	2.908	1.591	5.314	**0.001**
History of Stroke	3.065	1.332	7.054	**0.008**
Chemotherapy in last 30 days (preop)	3.253	0.753	14.049	0.1141
Inpatient vs. Outpatient	9.035	1.228	66.482	**0.031**
ASA >= 3	2.251	1.298	3.902	**0.004**
Operative Time > 4 Hours	3.293	2.014	5.385	**<0.0001**

- **Clinical Outcomes following Anterior Cervical Hybrid Surgery using Total Disc Replacement Combined with Anterior Cervical Fusion at the Adjacent Segment**

Roger W. Rogers, DO, Plano, TX
Scott L. Blumenthal, MD, Plano, TX
Richard D. Guyer, MD, Plano, TX
Jack E. Zigler, MD, Plano, TX
Donna D. Ohnmeiss, DrMed, Plano, TX

** ProDisc-C, DePuy Synthes Spine; approved for single-level TDR, but not hybrid*

Introduction: During the past decade, cervical total disc replacement (TDR) has become an option to anterior cervical fusion (ACF) for patients failing to respond to non-operative care for radiculopathy or myelopathy. Concerns of accelerated adjacent segment degeneration after ACF may be greater for patients with multi-level pathology. Biomechanical studies found hybrid surgery, using TDR at one level and ACF at the adjacent level, may offer some adjacent level benefit over two-level ACF. To date, there is little literature available on the clinical use of this treatment option. The purpose of this study was to evaluate the clinical results cervical hybrid surgery.

Materials/Methods: The study included the consecutive series of 71 patients undergoing cervical hybrid surgery beginning with the first case experience. The primary indication was symptoms related to cervical disc degeneration unresponsive to non-operative treatment. Outcome was based on comparing pre- to post-operative scores on the Neck Disability Index (NDI), and visual analog scales (VAS) separately assessing neck and arm pain. Re-operations were also recorded. The mean follow-up was 13.6 months with a maximum of 44 months. All patients were treated with a cervical hybrid procedure, using the same TDR type (ProDisc-C) combined with ACF performed at the adjacent segment. The ACFs involved the use of an anterior plate or a stand-alone interbody implant. Two levels were operated in 61 patients, and three levels were operated in the remaining 10 patients. The mean patient age was 46.4 years (range 28-63 years). For patients who had not been seen recently in the clinic, outcome data were collected via a mailed questionnaire.

Results: The mean blood loss was 52.0 cc. The mean NDI score improved significantly from 43.4 pre-operatively to 22.7 post-operative ($p < 0.05$; paired t-test). Improvement of at least 15 points was achieved on the NDI in 73% of patients. When comparing pre- to post-operative values, the mean VAS neck and arm pain scores improved significantly (Figure 1; $p < 0.05$). There were two re-operations. One was for TDR subsidence and the other for TDR migration. In both cases, the TDR was removed, and ACF performed at that level.

See Disclosure Index pages 40–88.

Discussion: This study found that hybrid surgery using cervical TDR combined with fusion at the adjacent segment produced statistically significant improvement in NDI and VAS scores in patients undergoing treatment at two or three cervical disc levels. These results are in line with those reported by other authors and support that hybrid surgery may be a viable alternative to two-level ACF in patients meeting the selection criteria for TDR.

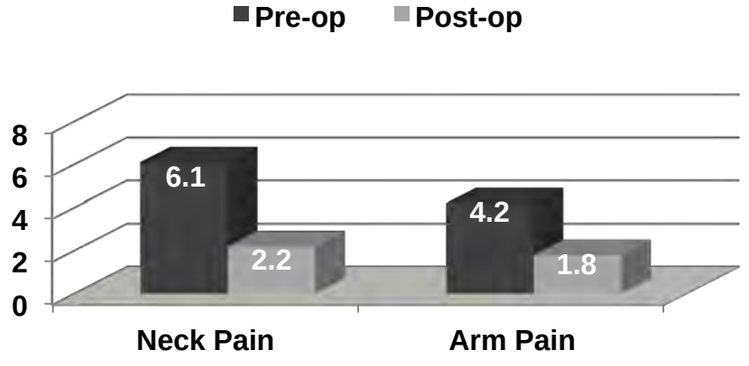


Figure 1. Mean VAS scores assessing neck and arm pain improved significantly ($p < 0.05$).

Safety Assessment of NSCS Induced from Human PBMC-Derived IPS Cells for Transplantation Therapy for Spinal Cord Injury

***Keiko Sugai1, MD**, Tokyo, Japan*
Tomoko Shofuda, Osaka, Japan
Ryuji Fukuzawa, Tokyo, Japan
Hayato Fukusumi, Osaka, Japan
Miho Isoda, Tokyo, Japan
Shigeki Ohta, Tokyo, Japan
Jun Kohyama, Tokyo, Japan
Akio Iwanami, MD, PhD, Tokyo, Japan
Morio Matsumoto, MD, PhD, Tokyo, Japan
Yonehiro Kanemura, Osaka, Japan
Hideyuki Okano, Tokyo, Japan
Masaya Nakamura, MD, Tokyo, Japan

Purpose: Transplantation of human neural stem cells (NSCs) is now considered to be a promising treatment for various central nervous system disorders including spinal cord injury, amyotrophic lateral sclerosis (ALS), Parkinson's disease, and brain infarction. In countries where fetal NSCs are not allowed to use due to ethical issues, iPS cells are a potential cell source of NSCs for cell therapy. Especially in Japan, an iPS cell bank is planned to be established from peripheral blood mononuclear cells (PBMCs) of immunologically preferable donors. To apply these cells to clinic, we developed three Good Manufacturing Practice (GMP) grade protocols to induce PBMC-derived iPSCs into NSCs. The purpose of this study was to compare the characteristics of differently-induced GMP-grade NSCs in vitro and in vivo, and to investigate useful markers to distinguish safe NSCs for clinical use.

Result: In vitro, karyotype analysis revealed that the frequency of CNV was higher in 1231A3-iPSCs than in 1210B2-iPSCs. All three neural induction protocols had the potential to induce PBMC-derived iPS cells into NSCs. FACS analysis revealed that there were more subtypes of neural crest stem cells (NCSCs) in ProC-NSCs. Microarray clustering analysis also showed that ProA-NSCs and ProB-NSCs were more similar to fetal derived NSCs than ProC-NSCs. In vivo, 1210B2-ProA-NSCs had the best integration to the host brain and also to the spinal cord. 1210B2-ProB-NSCs had a tendency to leak to the subdural space when transplanted into the spinal cord. 1231A3-ProA-NSCs revealed massive growth both in the brain and spinal cord. Bone formation was observed in 1210B2-ProC-NSCs 6 months after transplantation to the spinal cord.

Conclusion: 1210B2-ProA-NSCs had the best quality in vitro and in vivo. All of the analyses performed in this study are critical in terms of tumorigenicity of iPS cell derived NSCs. Further study should be performed to determine in vitro markers to certify safe human iPSC-derived NSCs for clinical application.

See Disclosure Index pages 40–88.

Programmed Freeze/Thaw Method Dramatically Improved Cell Viability of IPS Cell-derived Neural Stem Cells for Clinical Application in Spinal Cord Injury

Yuichiro Nishiyama, *Tokyo, Japan*
Akio Iwanami, MD, PhD, Tokyo, Japan
Jun Kohyama, Tokyo, Japan
Go Itakura, ATC, BA, BOC, BOCO, BOCP, Tokyo, Japan
Yoshiomi Kobayashi, MD, PhD, Tokyo, Japan
Soraya Nishimura, MD, PhD, Tokyo, Japan
Hiroki Iwai, MD, PhD, Tokyo, Japan
Morio Matsumoto, MD, PhD, Tokyo, Japan
Hideyuki Okano, Tokyo, Japan
Masaya Nakamura, MD, Tokyo, Japan

Background: Recently, we have reported the effectiveness of transplanting human iPS cell-derived neural stem cells (iPS-NSCs) for subacute spinal cord injury (SCI) in mice as well as common marmosets. Because it takes about 6 months to establish iPS-NSCs derived from SCI patient's own somatic cells, at present, it is impossible to perform autograft of iPS-NSCs within an optimal therapeutic time window for subacute SCI. To extend our results into clinical application, allogeneic transplantation of iPS-NSCs is a realizable goal. However, there are still some concerns to overcome, such as iPS-NSCs storage and supply. It is especially critical to determine whether freezing and thawing affects the viability and characters of iPS-NSCs since cell viability was extremely low when iPS-NSCs were cryopreserved in freezing container.

Purpose: The purpose of this study is to improve the viability and assess the effects of cryopreservation on the characters of iPS-NSCs.

Materials and Methods: 201B7 iPS-NSCs, which are considered safe and non-tumorigenic as reported previously (Nori et al, PNAS 2011), were used in the present study. The iPS-NSCs were cryopreserved in STEM-CELLBANKER® by slow-freezing method. First, we evaluated the cell viability to determine the timing of freezing (3 or 6 culture days after the last passage), the number of frozen cells (2 or 5 million/ml) and freezing method (programmed freezer or freezing container). Then proliferation, differentiation assays and microarray were performed under appropriate conditions in the cell viability.

Results: The cell viability was highest when the iPS-NSCs were frozen on 6 days after the last passage at the concentration of 2 million cells/ml. Compared to the freezing container; the programmed freezer significantly increased the cell survival after thawing. In addition, differentiation assay revealed that frozen-thawed cells dominantly differentiated into Tuj-1-positive neurons as same as non-frozen cells. There were no significant differences in proliferation and differentiation ability between frozen-thawed cells and non-frozen cells. Furthermore, principal component analysis and hierarchical clustering revealed that the gene expression profile of frozen-thawed cells was similar to that of non-frozen cells. This finding indicated that freezing and thawing process did not significantly affect the gene expression of cells.

Conclusion: Towards clinical application of cell transplantation for subacute SCI, cryopreservation of iPS-NSCs is essential in terms of cell viability after thawing. In this study, we succeeded in improving the viability of the iPS-NSCs by means of the programmed freezer. Furthermore, frozen-thawed cells showed similar proliferation, differentiation ability as well as gene expression profile to non-frozen cells, suggesting that our programmed freeze/thaw method would be useful for clinical application of cell therapy in SCI. Further study of transplanting these frozen-thawed iPS-NSCs into the injured spinal cord of mice would help determine their effectiveness and safety.

See Disclosure Index pages 40–88.

Cervical Spinal Cord Injury Modifies Distal Lumbar Locomotor Central Pattern Generator (CPG)

***Spyridon K. Karadimas**, **MD, PhD**, Toronto ON, Canada*
Kajana Satkunendrarajah, PhD, Toronto ON, Canada
Mohamad Khazaei, PhD, Toronto ON, Canada
Simon Gosgnach, PhD, Edmonton, AB, Canada
Michael G. Fehlings, MD, PhD, Toronto ON, Canada

Introduction: Cervical spinal cord injury (SCI) has a devastating impact on quality of life and presently there are no effective treatment options for the motor dysfunctions that ensue. The neural network responsible for the generation of walking (locomotor CPG) is located within the lumbar enlargement. It is presumed that this neural network remains intact but dormant after trauma, making the locomotor CPG the main target for restoring walking in SCI patients. However, to date, studies aimed at restoring walking by either coaxing axons across the lesion to the locomotor CPG, or directly activating it using electrical stimulation has only resulted in very modest results. Here, for the first time, we present data showing that chronic cervical SCI (cSCI) induces anatomical and physiological modifications of the locomotor CPG that prompts a major shift in the way the preclinical and clinical researchers approach restoring walking in SCI patients.

Methods: A novel mouse model of chronic cSCI was used. Analysis of spatiotemporal and kinematic parameters was performed during walking in mice and human cSCI patients. The number of excitatory and inhibitory interneurons as well as the number motoneurons within the lumbar enlargement was assessed in transgenic cSCI and sham mice. The mono-synaptic connectivity between different neuronal components within the locomotor CPG as well as between locomotor CPG and supraspinal centers after cSCI was evaluated using modified rabies virus. The intrinsic physiological properties of the locomotor CPG after cSCI were evaluated using *in vivo* electrophysiological recordings.

Results: Human and mouse cSCI subjects displayed altered hindlimb flexor/extensor coordination and hindlimb right/left alteration. Early after cSCI induction, at 5 weeks, there was no change in the number of interneurons and motoneurons within the locomotor neural network in lumbar spinal cord. However, at the same time point inhibitory interneurons within the locomotor CPG lose a significant proportion of their input from cervical propriospinal neurons. While at the same time, monosynaptic connectivity between the inhibitory interneurons within the lumbar CPG and the motoneurons controlling the extensor hindlimb muscles was decreased. Subsequently, at 10 weeks post-induction of cSCI, the number of inhibitory interneurons and motoneurons within the lumbar enlargement was significantly reduced compared to sham. Interestingly, the preserved neurons had significantly altered morphology of their soma and reduced dendritic arborisation. Finally, selective ablation of the cervical propriospinal neurons projecting to lumbar CPG in naïve C57bl mice resulted in recapitulating the gait deficits seen in CSM.

Conclusion: Here, for the first time, we provide fundamental insights into the transformations experienced by the intrinsic components of the distal lumbar locomotor network in response to chronic cervical SCI. Importantly, we have identified an initiating event that triggers the anatomical changes in the locomotor CPG and ensuing gait deficits. As such, findings of this study will dramatically alter the way in which we approach the development of treatment strategies, giving us a tangible target to restore walking in cervical SCI patients.

See Disclosure Index pages 40–88.

- **An *In Vitro* Evaluation of Sagittal Alignment in the Cervical Spine after Insertion of Supraphysiologic Lordotic Implants**

***Donald J. Blaskiewicz, MD**, San Diego, CA*
Patrick Han, MD, Tulsa, OK
Jeffrey E. Harris, MS, San Diego, CA
Alexander W. Turner, PhD, San Diego, CA
Gregory M. Mundis, MD, San Diego, CA

** NuVasive CoRoent Small Interbody system device only cleared for use at one level with anterior cervical plating.*

Introduction: Abnormal changes in cervical spine alignment can result in fatigue and neck pain as a result of extensor muscle recruitment to maintain horizontal gaze. When surgery is used to treat a degenerative and sagittal plane deformity, it is important to understand the compensatory mechanisms that influence this reconstructive effort which may result in unintended postoperative malalignment. The use of implants with supraphysiologic lordosis (SL) has become of increasing interest to treat sagittal plane deformities of the cervical spine. The purpose of this study was to evaluate the ability of SL implants to restore lordosis and sagittal alignment, and to understand the reciprocal changes that may occur in the cervical spine as a result of SL implants.

Materials/Methods: Eight cadaveric occiput-T1 segments were placed in testing apparatus with T1 tilt fixed at 23°. The occiput was free to translate but restricted from rotation to ensure horizontal gaze. SL implants with angles of 7°, 10°, 15°, and 20° were implanted in different combinations starting with single level constructs (C5-C6), followed by two (C5-C6-C7), and three-level (C4-C5-C6-C7) constructs. Radiographs were taken pre-implantation and after each stage of implantation. Radiographic measurements included the instrumented segmental lordosis, C2-C7 SVA, and Occ-C2 angle.

Results: With a single implant instrumental segmental lordosis increased by 4.1°–8.4° (Figure 1). With two implants the instrumental segmental lordosis increased 10.3°–20.5°, and with three implants the instrumental segmental lordosis increased 16.0°–25.0°. Increased cage lordosis corresponded with larger changes in SVA. The change in SVA was 7.8–9.4 mm for the single level construct, 12.0–17.5 mm for the two level construct, and 11.5–17.7 mm for the three level construct. The two level constructs resulted in larger changes in SVA than their 3 level counterparts with similar amounts of cage lordosis. As implanted lordosis increased the horizontal distance required to maintain balance was decreased. As instrumented segmental lordosis increased, the Occ-C2 segment compensated by decreasing in lordosis to maintain horizontal gaze. With a single implant, Occ-C2 decreased by 6.0°–8.8°, C2-5 decreased 1.0°–1.5°, while C6-7 increased by 0.6°–2.6°. With two implants, Occ-C2 decreased 9.9°–12.4° and C2-5 decreased 0.1°–5.0°.

With three implants, Occ-C2 decreased 13.0°–19.6° and C2-C4 decreased 2.1°–4.5°. While the change in instrumented segmental lordosis differed between the constructs, the inverse relationship between cervical lordosis and Occ-C2 remained consistent.

Conclusions: This is the first biomechanical study investigating the biomechanical effects of SL implants and their effect on the sagittal alignment of the cervical spine. The SL implants were able to increase lordosis and correct SVA. Adding more implant lordosis led to larger changes in lordosis and SVA. Reciprocal compensation was observed in the cervical spine, with the Occ-C2 segment undergoing the largest compensation. When comparing two and three level constructs with similar amounts of implanted lordosis, the two level constructs created similar increases in cervical lordosis and subsequent Occ-C2 compensation. The two level constructs also created larger changes in SVA. Implants with SL may allow for increased capabilities in correcting cervical sagittal plane deformity.

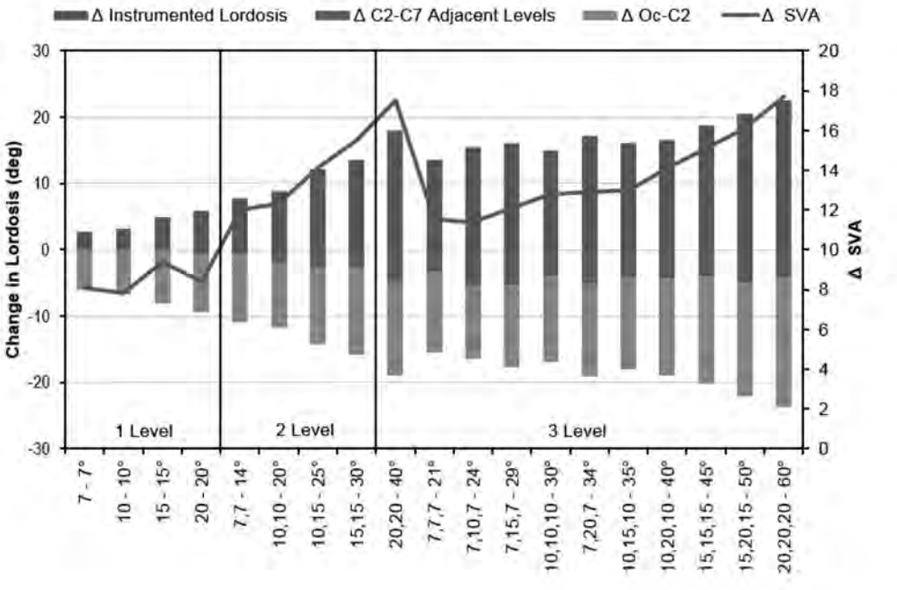


Figure 1. Change in lordosis at the instrumented and adjacent levels for one, two, and three level constructs with different cage configurations.

See Disclosure Index pages 40–88.

The Location of Instant Center of Rotation in the Cervical Spine during In Vivo Dynamic Flexion-Extension

***Kwang Sup Song, MD, PhD**, Seoul, Republic of Korea*
Seong Hwan Kim, MD, Seoul, Republic of Korea
Jae Jun Yang, MD, Goyang, Republic of Korea
Seung Bum Koo, PhD, Seoul, Republic of Korea

Introduction: The locations of the instant center of rotation (ICR) in cervical spine at each segment were conventionally measured using plain lateral radiographs collected at the ends of the range of motion (ROM). This study is to find and to compare the location of the ICR at each cervical segment in vivo dynamic flexion-extension in voluntary subjects.

Material and Methods: Three asymptomatic controls were performed cervical flexion-extension while biplane fluoroscopy was evaluated. Dynamic flexion/extension images were collected from two oblique views aligned horizontally and angled approximately 55°. The minimum change of degree to detect the significant movement in calculating helical axis model was set 2°. The anterior-posterior (AP) and superior-inferior (SI) location of each ICR was defined with respect to the inferior bone anatomic coordinate system, and zero setting was center of the upper end plate of lower cervical vertebra. The ROM was started neutral position, then to the flexion, to the full extension, and finally neutral position. The mean AP and SI coordination of ICR was defined as the center of ICR. To evaluate the possible distribution area of the ICR, the distance between each AP and SI coordination of ICR and the center of ICR was calculated. The circle with the radius of calculated distance was drawn with the mean AP and SI locations of ICR as its center.

Results: The mean ROM curves were shown in Figure 1. The mean AP and SI locations of the ICR are -5.81 mm(SD : 5.9) and -8.31mm(SD : 4.5) in C2/3, -4.47mm(SD : 8.7) and -8.03mm(SD : 7.5) in C3/4, -2.61mm (SD : 8.1) and -4.24mm(SD : 8.8) in C4/5, -2.19mm (SD : 5.3) and -6.34mm(SD : 4.0) in C5/6, -1.76mm (SD : 10.5) and -3.15mm(SD : 6.9) in C6/7. The mean distance for radius of circle was 6.3mm(SD : 3.7) in C2/3 segment, 9.7mm(SD : 5.7) in C3/4 segment, 11.2mm(SD : 3.8) in C4/5 segment, 5.7mm(SD : 3.3) in C5/6 segment 10.8mm(SD : 6.2) in C6/7 segment. The circle was made using the radius of calculated distance with the mean AP and SI coordination of ICR as its center (Figure 2).

Conclusion: The mean AP and SI location of the ICR became progressively more superior and anterior from the C2/C3 motion segment to the C6/C7 motion segment. The statistical difference was found in the mean SI location of the ICR ($p = 0.015$) and significant difference was found between the ICR in C2/3 and C6/7. However, the mean AP locations of the ICR were not significantly different. Moreover, to evaluate the distribution border, the circle was made by calculated distance of AP and SI coordination. By the distribution area, the ICR would be located more closely to center of lower vertebral body at corresponding cervical segment, and overlapped with disc space.

If the goal of cervical arthroplasty is to replicate in vivo motion, they should be designed to account for level-specific differences although further study needed.

Figure 1.

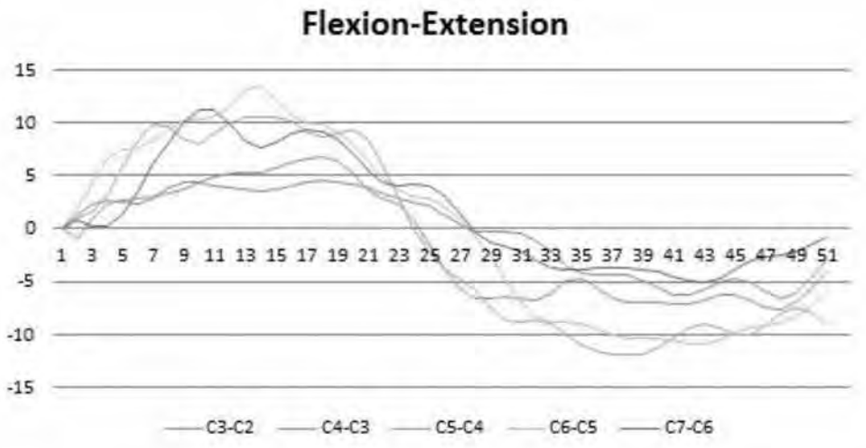
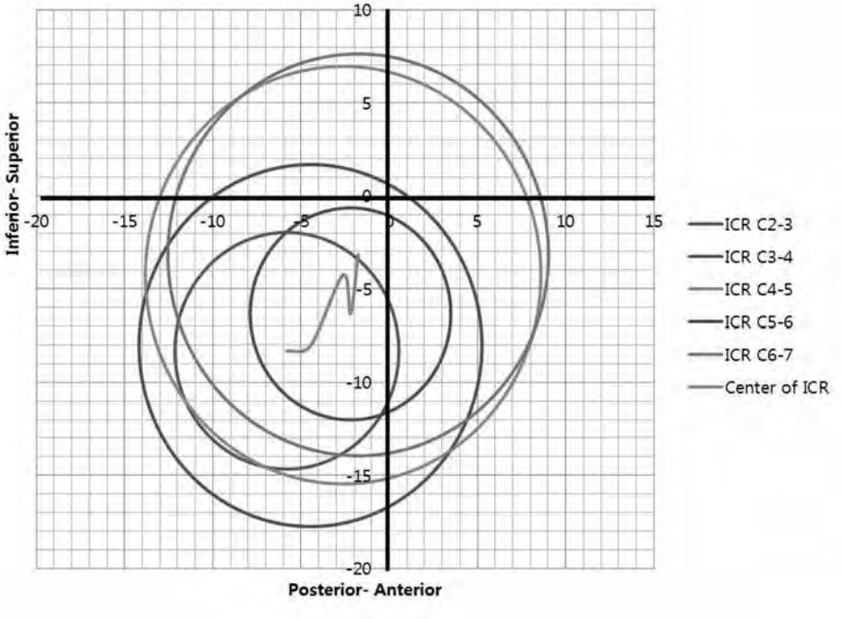


Figure 2.



See Disclosure Index pages 40–88.

Arthroplasty and ACDF Compared to ACDF Alone for Two- and Three-Level Cervical Disc Disease

***Jin Young Kim, MD**, St. Louis, MO*
K. Daniel Riew, MD, New York, NY

Study Design: Retrospective comparative study

Objective: We compared the clinical and radiologic outcomes of cervical disc arthroplasty (CDA) combined with anterior cervical discectomy and fusion (ACDF) versus ACDF alone for two and three-level cervical disc disease as there are few such reports in the literature.

Methods: We identified a consecutive series of patients who had undergone either an ACDF or an ACDF combined with CDA for 2-3 level disease by the senior author from 2007 to 2014. They had to have minimum 2-year follow-up. The patients were evaluated with VAS for neck and arm pain, NDI, SF-36 PCS, SF-36 MCS, angular ROM for C2-C7, ROM for the superior and inferior segments (S-ROM and I-ROM), and the level of the CDA (CDA ROM). They were followed-up at regular postoperative intervals of 1.5, 6, 12, and 24 months. The CDA was utilized only in patients whose insurance approved its use. Otherwise, all patients were candidates for a CDA for at least 1 level. Inclusion criteria to the present study comprises patients with radiculopathy or myelopathy due to cervical degenerative disc disease such as cervical spondylosis or disc herniation. All included patients should be followed up at least for 2 years. Exclusion criteria were acute infection, acute trauma, instability, previous cervical spine surgery, osteoporosis, significant cervical deformity, malignancy, and autoimmune disorder.

Results: Fifty patients met the inclusion criteria. Of these, twenty-two received a hybrid procedure (14 had a one-level CDA plus one-level ACDF; 8 had a 1-level CDA plus two-level ACDF). In the controls, 28 patients were treated with only ACDFs (14 with two-level ACDFs; 14 with three-level ACDFs). For two-levels, there were no statistically significant differences in the VAS Arm and Neck, NDI, and SF-36 PCS and MCS, C2-7 ROM and S-ROM between a hybrid two-level (CDA+ACDF) and two-level ACDF (ACDFx2) preoperatively, as well as postoperatively. However, I-ROM was greater in the ACDFx2 patients than in the CDA+ACDF patients at 6 and 24 months postoperatively ($P = 0.019$ and $P = 0.001$). In the three-level group, there were also no significant differences between the ACDFx3 patients and the CDA+ACDFx2 patients for VAS Arm and Neck, NDI, SF-36 PCS and MCS, S-ROM and I-ROM. C2-7 ROM for the CDA+ACDFx2 group were 48.5 ± 21.4 preoperatively, 24.5 ± 11.8 at 6 weeks, 36.4 ± 10.9 at 6 months, 34.2 ± 12.2 at 12 months, and 31.4 ± 16.3 at 24 months postoperatively. C2-7 ROM for the ACDFx3 were 37.1 ± 12.5 preoperatively, 15.6 ± 7.2 at 6 weeks, 23.0 ± 6.3 at 6 months, 21.3 ± 6.5 at 12 months, and 21.1 ± 7.1 at 24 months postoperatively.

C2-7 ROM was significantly greater at 1.5, 6, 12, and 24 months postoperatively ($P = 0.044$, 0.009, 0.025, and 0.048, respectively) in the CDA + ACDFx2 than ACDFx3. C2-7 ROM of the CDA+ACDFx2 were statistically similar to that of CDA+ACDF patients, but the C2-7 ROM of ACDFx3 was less than that of the ACDFx2 at the 12 and 24 month follow-up ($P = 0.016$ and 0.001).

Conclusion: It appears that there is no clinical difference between patients who have all ACDFs versus those who have a hybrid procedure with a 1-level CDA along with a 1 or 2-level ACDF. Although the CDA+ACDF patients had similar C2-7 ROM as the ACDFx2 patients, the CDA+ACDFx2 had significantly better C2-7 ROM than the ACDFx3 patients at 1.5, 6, 12, and 24 months postoperatively ($P = 0.044$, 0.009, 0.025, and 0.048).

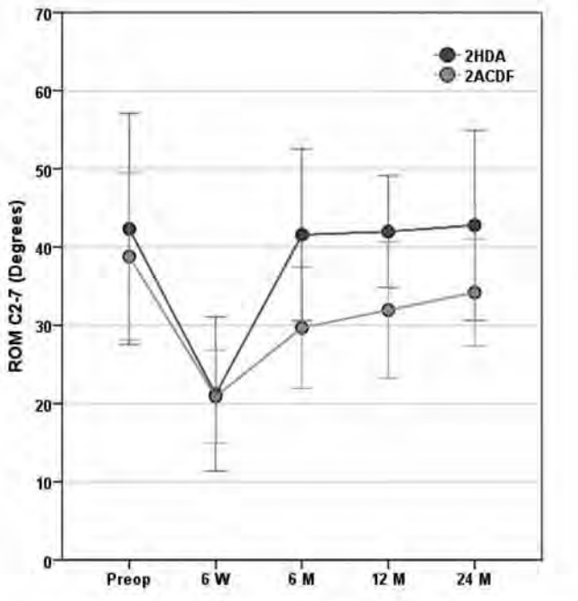
Key words: hybrid surgery, cervical arthroplasty, cervical artificial disc replacement, anterior cervical discectomy and fusion, cervical disc disease, cervical spine, ACDF

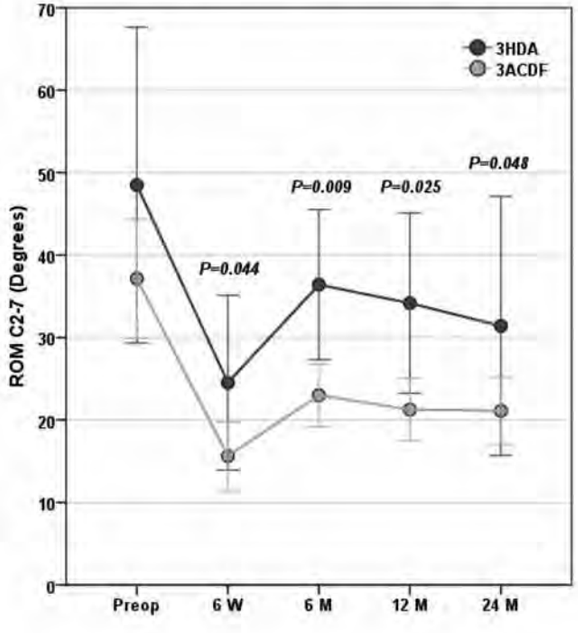
Table 1. Demographic Data

	2 level surgery			3 level surgery		
	CDA + ACDF	ACDFx2	*P*	CDA + ACDFx2	ACDFx3	*P*
Patients number(M/F)	14(7/7)	14(6/8)	0.705*	8(4/4)	14(6/8)	1.000‡
Age at surgery (range) years	49.9±9.2 (39-74)	53.8±9.9 (34-68)	0.107†	51.0±7.8 (41-62)	56.2±8.7 (42-72)	0.206†
Surgery levels						
C4/5/6(U:L)	3(3:0)	4	1.000‡	NA	NA	
C5/6/7(U:L)	11(5:6)	10		NA	NA	
C4/5/6/7(U:L)	NA	NA		8(5:3)	14	1.000‡
Symptom						
Radiculopathy	14	13	1.000‡	8	9	0.115‡
Myeloradiculopathy	0	1		0	5	

**P* values calculated by Chi-square test
†*P* values calculated by Wilcoxon rank sum test
‡*P* values calculated by Fisher's Exact test
M, Male; F, Female; U, Upper level; L, Lower level; CDA, Cervical Disc Arthroplasty; ACDF, Anterior Cervical Discectomy and Fusion; NA, Not Available.

See Disclosure Index pages 40–88.





Intraoperative Correction of the O-C2 Angle can Prevent Dysphagia and/or Dyspnea after Occipitocervical Fusion Surgery

***Keita Nakayama, MD**, Tsukuba-city, Ibararaki, Japan*
Tetsuya Abe, MD, PhD, Tsukuba-city, Ibararaki, Japan
Kengo Fujii, MD, Tsukuba-city, Ibararaki, Japan
Kosei Miura, MD, Tsukuba-city, Ibararaki, Japan
Masaki Tatsumura, MD, PhD, Tsukuba-city, Ibararaki, Japan
Masashi Yamazaki, MD, Tsukuba-city, Ibararaki, Japan

Background: Dysphagia and/or dyspnea have been recognized as serious complications after posterior occipitocervical (O-C) fusion surgery. Previous reports showed that postoperative dysphagia/dyspnea occasionally occurred when patients' O-C2 angle decreased after surgery. To avoid these complications, we performed intraoperative correction of the O-C2 angle.

Objective: We measured the amount of the intraoperative correction of the O-C2 angle, and evaluated the efficacy of intraoperative correction of the O-C2 angle to prevent postoperative dysphagia/dyspnea.

Methods: We analyzed 14 consecutive patients who underwent O-C fusion between January 2012 and May 2015. The sample population consisted of 1 male and 13 female patients with a mean age of 65.8 years (range, 28–78 years). The O-C2 angles at the neutral, flexion, and extension positions were evaluated by using preoperative lateral radiographs. We decided the ideal postoperative O-C2 angle individually to be larger than that at the preoperative neutral position. During surgery, we checked the O-C2 angle by using fluoroscopic lateral radiography immediately after the placement of occipital and spinal anchors such as occipital plate and cervical pedicle/lateral mass screws. We then rotated the head posteriorly and corrected the O-C2 angle. When the corrected O-C2 angle exceeded the preoperative neutral O-C2 angle, we placed the rods and performed final tightening of the instruments. We analyzed the association of the amount of the correction of the O-C2 angle with the development of dysphagia/dyspnea after surgery.

Results: The mean preoperative O-C2 angle at neutral position was 9.4° (range, -2° to 27°). After anchor placement, the angle was 3.1° (range, -16° to 21°). After the correction, the angle increased to 17.4° (range, 3° to 32°). Postoperative O-C2 angles were increased without any neurological deficits in all 10 patients. Dysphagia/dyspnea did not develop in any patients.

Discussion: Considering the results of our study, our method of intraoperative correction of the O-C2 angle could ensure the establishment of O-C fusion surgery.

See Disclosure Index pages 40–88.

Conclusions: Intraoperative correction of the O-C2 angle is an effective and safe technique to prevent postoperative dysphagia/dyspnea. The O-C2 angle at the preoperative neutral position could be a practical index individually in O-C fusion surgery to prevent postoperative dysphagia/dyspnea.

Does Cervical Sagittal Alignment Correlate with Outcomes following Anterior Cervical Surgery?

***J. Alex Sielatycki, MD**, Nashville, TN*
Sheyan Armaghani, MD, Nashville, TN
Arnold Silverberg, BS, Nashville, TN
Matthew J. McGirt, MD, Charlotte, NC
Clinton J. Devin, MD, Nashville, TN
Kevin R. O'Neill, MD, MS, Nashville, TN

Introduction: There is increasing interest the impact of cervical sagittal alignment (CSA) on surgical outcomes, with a recent study showing the impact of C2-7 sagittal vertical axis (SVA) in patients undergoing posterior cervical fusion. In addition, studies have found T1 slope to be an important predictor of adjacent segment disease following anterior fusion. However, it remains unclear whether associations between CSA and patient reported outcomes (PROs) exist following anterior cervical fusion procedures. The purpose of this study was to investigate the relationship between CSA and PROs in patients undergoing anterior cervical fusion.

Methods:

Patient Sample

We analyzed all adult patients who underwent primary anterior cervical fusion for degenerative conditions during a 3-year period at a single academic institution. Patients with post-operative radiographs and a minimum 1-year follow up were included.

Outcome Measures

PROs included Short-Form 12 (SF-12) physical component (PCS) and mental component (MCS) scales, Neck Disability Index (NDI), modified Japanese Orthopaedic Association (mJOA) score, and EuroQol-5D (EQ-5D). CSA parameters measured were C1-C2 Cobb, C2-C7 Cobb, C1-C7 Cobb, C2-C7 SVA, C1-C7 SVA, and T1 slope. PROs were recorded at baseline and at 3- and 12-months postoperatively in a prospective database, along with patient demographics, treatment variables, and complications. CSA parameters were measured on standing radiographs in the neutral position at baseline and a minimum of 3-months postoperatively. Wilcoxon rank test was used to test for changes in PROs and CSA parameters, and Pearson correlation coefficients were calculated for CSA parameters and PROs preoperatively and at 12 months postoperatively.

See Disclosure Index pages 40–88.

Results: There were 143 patients included with an average age of 52 years who underwent anterior cervical arthrodesis. There were 134 (93.7%) ACDFs and 9 (6.3%) ACCFs included with mean fusion of 1.8 ± 0.77 levels. Significant improvement was seen in all PROs at 12 months postoperatively. No significant changes in alignment parameters were observed from baseline to 12 months. Preoperatively, increased T1 slope correlated with worse mJOAS score ($r = -0.52$, $p = 0.02$); no other correlations were found at baseline. At 12 months postoperatively, T1 slope was significantly correlated ($p < 0.05$) with worse scores on EQ-5D ($r = -0.24$), SF-12 PCS ($r = -0.25$), and mJOA ($r = -0.29$), as well as increased disability on NDI ($r = 0.23$). No correlations were seen between the other CSA parameters and PROs postoperatively.

Conclusions: The results of this study indicate T1 slope may be an important consideration in patients undergoing anterior cervical fusion. Previous studies have also shown that T1 slope is an important factor in the development of adjacent segment disease. Further studies are necessary to investigate potential strategies of improving PROs and reducing the risk of adjacent segment disease in patients with high T1 slope undergoing anterior cervical fusion.

Outcome of Correction Surgery using Pedicle Screw for Cervical Kyphosis Exclusive of Ankylosing Spondylitis

***Hiroshi Miyamoto, MD**, Kobe, Japan*
***Terumasa Ikeda, MD**, Kobe, Japan*
***Kazuki Hashimoto, MD**, Osaka-Sayama, Japan*
***Masao Akagi, MD**, Osaka-Sayama, Japan*

Introduction: Severe cervical kyphosis exclusive of ankylosing spondylitis (AS) is rare. Decompensation of the alignment due to multilevel disc degeneration, loss of disc height, anterior slip of the vertebra, and/or denervation of paravertebral muscles can cause severe kyphotic deformity, and canal stenosis, osteoarthritis of the facet, and/or foraminal stenosis may coexist. Correction surgery for those has a risk to cause neural complications such as spinal cord injury and C5 nerve palsy. The purpose of the present study was to examine the outcome of correction surgery using pedicle screw for severe cervical kyphosis exclusive of AS.

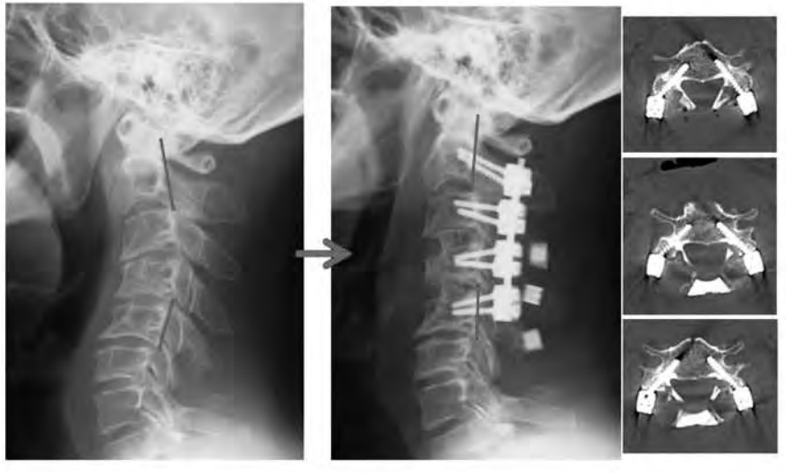
Methods: Twenty-seven patients who underwent correction surgery of cervical kyphosis exclusive of AS were involved. Male were 16, and female 11, and mean age was 63.5 years old. Infection, tumor, trauma were also excluded. Preoperative cervical kyphosis angle was a mean of 32 degree (from 20 to 74). For 16 cases in which kyphosis were reducible in extension position, posterior correction surgery using pedicle screw was performed (group P). On the other hand, for 11 cases in which kyphosis were irreducible, anterior release of the discs and facetectomy at kyphotic lesions was necessitated. Consequently, two-staged (anterior-posterior, AP) or three-staged (posterior-anterior-posterior, PAP) procedures were carried out (Figure 1). The extent of fusion was a mean of 4.9 vertebra. Since 2013, prophylactic foraminotomy at C4/5 was performed for prevention of C5 palsy. Recovery rate of the JOA score, incidence of complications, correction angle, and fusion rate were examined.

Results: Recovery rate of the JOA score was 40%. Preoperative kyphotic angle and correction angle were; 25.0° and 27.1°in group P, 42.0° and 43.8° in group AP, and 44.0° and 47.7° in group PAP respectively, and postoperative cervical curvature was straight or a bit lordosis as we intended to obtain. Neither spinal cord injury nor vertebral artery injury were found. Five C5 nerve palsy in group P, and one in group AP were found. Whereas, Five C5 palsy out of six patients in group PAP occurred although prophylactic foraminotomy was performed. All C5 palsy fully recovered at follow-up. Bony fusion was achieved in all patients.

See Disclosure Index pages 40–88.

Discussion: The present study showed that correction surgery using pedicle screw fixation provided acceptable realignment of the cervical curvature from 31.2 degree kyphosis to 2.1 degree lordosis. Although we did not have excessive postoperative lordosis, we still had several incidence of C5 nerve palsy. Especially, we have to be aware of the incidence in group PAP which required massive range of realignment. The incidence occurred even after we introduced prophylactic foraminotomy, however, this procedure may lessen the severity of the complication because those all were transient.

Figure 1.



Cervical Spine Fusion: 16-Year Trends in Epidemiology, Indications, and Bone Morphogenetic Protein Utilization by Surgical Approach

***Lukas P. Lampe, MD**, New York, NY*
Alexander P. Hughes, MD, New York, NY
Peter Derman, MD, MBA, New York, NY
Janina Kueper, New York, NY
Ting Jung Pan, MPH, New York, NY
Federico P. Girardi, MD, New York, NY
Todd J. Albert, MD, New York, NY
Stephen Lyman, PhD, New York, NY

Introduction: Studies analyzing nationwide databases have demonstrated progressive growth in the annual volume of cervical spine fusions. The explanation for increased adoption may be multi-factorial: advances in operative techniques, improvements in instrumentation systems, expanded indications, and improved peri-operative medical management have improved outcomes. The Food and Drug Administration's (FDA) mid-2008 warning against the use of bone morphogenetic protein (BMP) in cervical spine fusion was another notable event. Prior studies, however, have been limited by looking only at trends in cervical fusion volume based on statistical sampling with incomplete information regarding diagnosis and demographics. We are reporting 16 years of significant perioperative trend changes in a primary cervical fusion cohort with 99% of all-payer data by surgical approach with diagnosis.

Materials/Methods: The New York *Statewide Planning and Research Cooperative System* (SPARCS) database was queried to identify a cohort of patients who underwent primary cervical or cevicothoracic fusion between the years 1997 and 2012 using *International Classification of Disease-9th Revision-Clinical Modification* (ICD-9-CM) codes. Data on patient age and surgical approach were collected. BMP use was also recorded (since FDA approval in 2002). Data were analyzed with respect to surgical approach – anterior (A), posterior (P), and circumferential (C). All surgical rates were population adjusted based on US Census data for the state of New York.

Results: 87,106 primary cervical fusion cases met inclusion criteria. The vast majority of fusions were anterior (85.2%), followed by posterior (12.3%), and finally circumferential (2.5%). BMP was utilized in a total of 2863 (4.3%) cases since 2002. The annual utilization rates of each of the three approaches increased over the study period (Figure 1). The rate of anterior fusion utilization increased an average of 107% from 1997 to 2012 for age groups 36–50, 51–60, 61–70, and >70. Only the 18–35 year age group remained stable. The top indications for anterior surgery were degenerative disc disease (DDD), spondylosis, spinal stenosis, and fracture, which increased by 83%, 162%, 208%, and 57%, respectively between 1997 and 2012. BMP use in anterior surgery reached its peak in 2009 with a rate of 59 per 1,000 cases (Figure 2).

See Disclosure Index pages 40–88.

Similar to anterior fusion, the most common posterior cervical fusions indications were DDD, spondylosis, spinal stenosis, and fracture, which increased by 164%, 625%, 439%, and 135%, respectively over the study period. Additionally, the rate of posterior fusion remained stable in the 18–35 age group, while increasing an average of 270% for patients 36 and older. BMP was applied more often in posterior than anterior surgery, reaching maximal utilization in 2008 with use in 125 of every 1,000 cases. Circumferential fusion same trends mirrored those found in anterior and posterior cervical fusion surgeries.

Conclusions: This study indicates relatively stable utilization of cervical fusion for traumatic conditions but significantly expanded utilization for degenerative conditions (particularly in older patients). Furthermore this database comprehensively includes critical details such as BMP utilization and reflects declining utilization. Further research is needed to more comprehensively understand the drivers behind the expanded utilization of cervical fusion and the outcomes of these surgeries.

Figure 1.

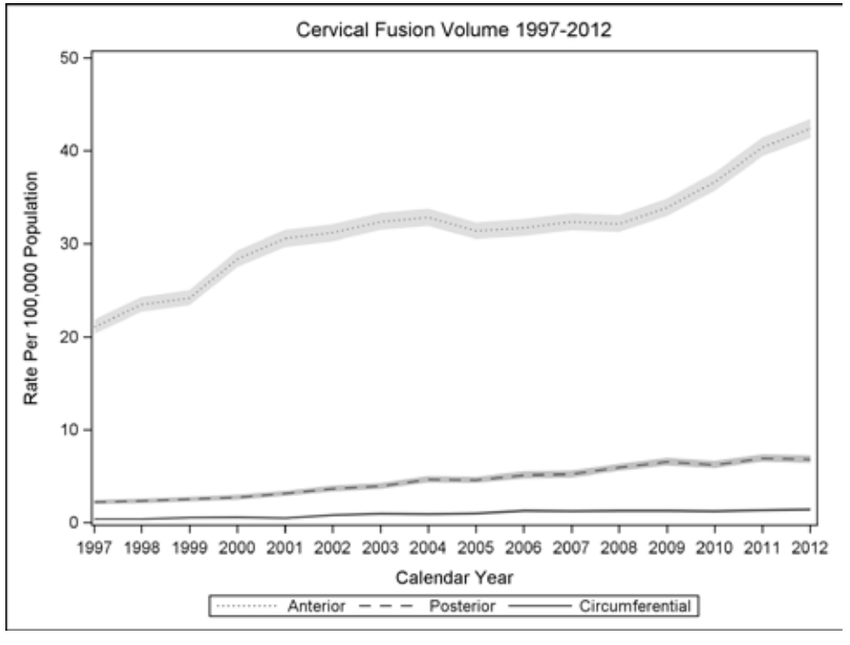
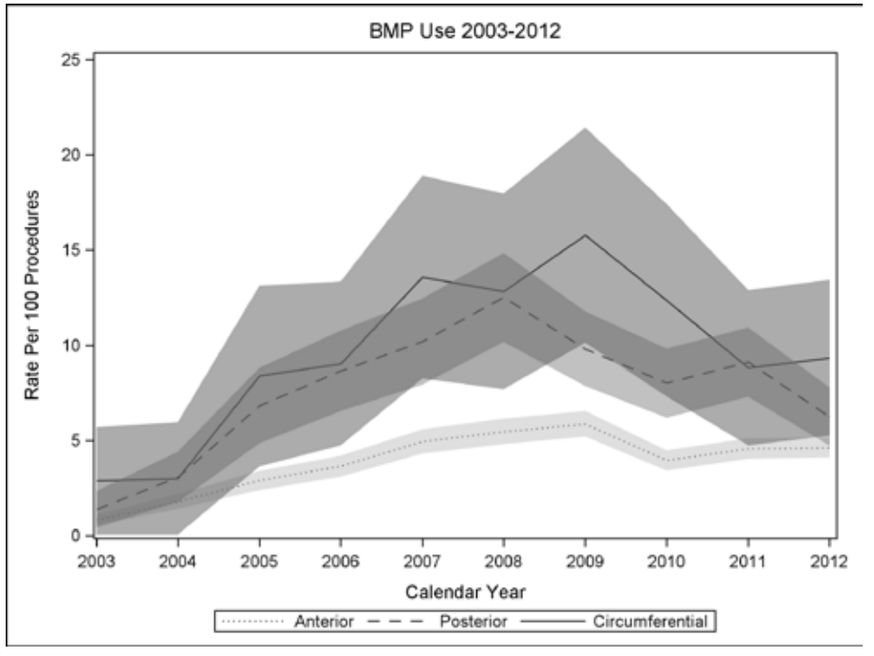


Figure 2.



See Disclosure Index pages 40–88.

Preoperative Nomograms Predicting Patient-Specific Cervical Spine Surgery Clinical and Quality of Life Outcomes

Daniel Lubelski, MD, Cleveland, OH
Vincent Alentado, BS, Cleveland, OH
Michael Shriver, BS, Cleveland, OH
Amy Nowacki, PhD, Cleveland, OH
Kalil G. Abdullah, MD, Philadelphia, PA
Michael P. Steinmetz, MD, Cleveland, OH
Edward C. Benzel, MD, Cleveland, OH
***Thomas E. Mroz, MD**, Cleveland, OH*

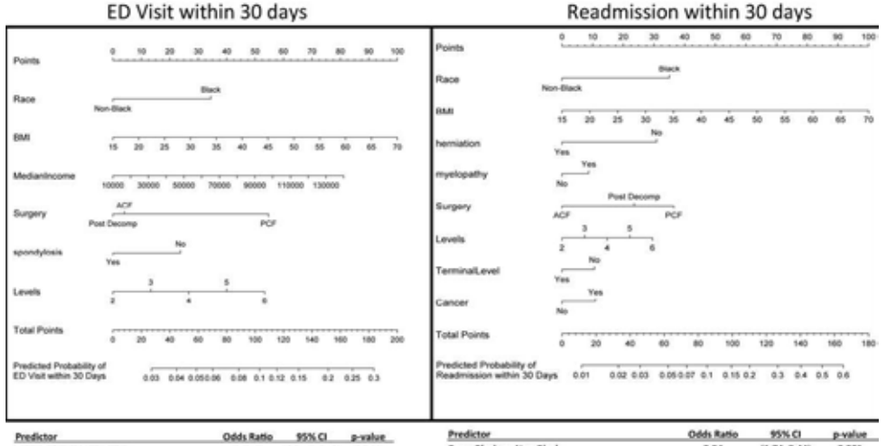
Introduction: Substantial clinical equipoise exists among surgeons regarding the optimal approach used to treat various cervical spine pathologies. Moreover, clinical and quality of life outcomes vary depending on the patient's demographic characteristics, cov morbidities, combination of presenting symptoms, pathology, and surgical treatment used. While there have been several single predictors identified, no comprehensive method incorporates a patient's complex clinical presentation to predict the individual's postv operative outcome. In an era of value based surgery and increased scrutiny by Medicare/ Medicaid, predicting patient specific outcomes to identify optimal surgical candidates is imperative.

Methods: Using regression analyses, we developed nomograms based on the clinical data of 952 patients at the Cleveland Clinic that underwent anterior or posterior cervical decompression and/or fusion between 2007 and 2013. Modeled data included patient demographics, cov morbidities, presenting symptoms and duration of symptoms, indication for surgery, type and levels of surgery, as well as whether the patient had previous surgery. Outcomes included post-operative emergency department (ED) visit or readmission within 30 days, reoperation within 90 days, and changes in quality of life (QOL) outcomes, including the EuroQOL (EQv 5D), Patient Health Questionnairev 9 (PHQv 9), Pain/ Disability Questionnaire (PDQ), that exceeded the minimum clinically important difference (MCID). Bootstrap was used for internal validation of the nomograms. decompression and/or fusion between 2007 and 2013.

Results: Nomograms for clinical outcomes had higher concordance indices (Cv index) compared to those predicting QOL outcomes (Figures 1v 2). Cv index for ED visits, readmission, and reoperation were 0.639, 0.774, and 0.915, respectively; for EQv 5D: 0.619, for PHQ9: 0.584, and for PDQ: 0.655. Variables predicting the clinical outcomes varied, but included race and median income, BMI, cov morbidities, presenting symptoms, indication for surgery, surgery type and levels. For the QOL nomograms, the predictors included similar variables, but were significantly more affected by the preoperative QOL of the patient.

Discussion: Evidence suggests that statistical models provide superior prediction of outcomes as compared to both individual clinician predictions and averaged predictions of groups of clinicians. The nomograms presented herein enable both referring physicians and spine surgeons to determine postoperative clinical and QOL outcomes following cervical spine surgery. This allows patients and physicians to make more informed decisions about whether to pursue the elective procedures, as well as be better prepared for the outcomes. In contrast to studies identifying prognostic factors, this tool enables the clinician to combine the variables of an individual to provide a personalized assessment of what the patient can expect postoperatively. Future prospective studies can validate these nomograms in external cohorts and further refine the tools in larger patient databases. Using patient specific prediction tools, such as these nomograms, will lead to superior spine surgery outcomes and more cost effective care.

Figure 1.

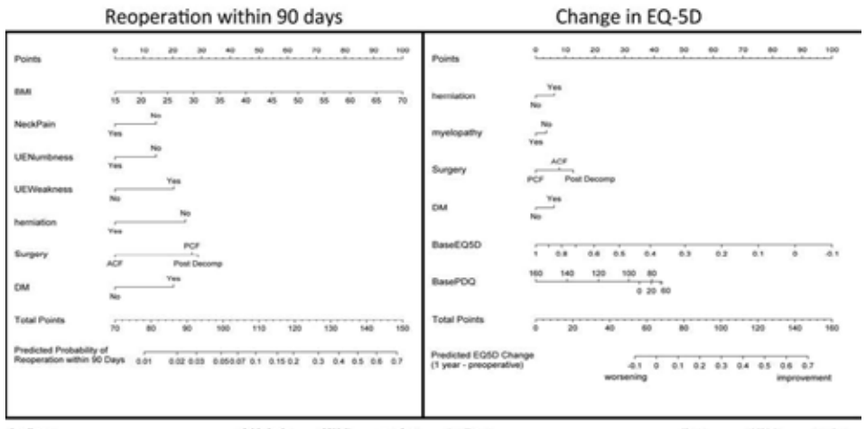


Predictor	Odds Ratio	95% CI	p-value
Race: Black vs. Non-Black	2.48	(0.79, 7.76)	0.12
BMI	1.05	(0.99, 1.11)	0.08
Median Income (per $1,000)	1.02	(0.99, 1.04)	0.10
Surgery			0.02
ACF vs. Posterior Decompression	1.11	(0.31, 3.95)	0.87
PCF vs. Posterior Decompression	4.24	(1.03, 17.46)	0.04
Spondylosis: Yes vs. No	0.53	(0.18, 1.60)	0.26
Levels	1.42	(0.94, 2.15)	0.09
Corrected Concordance Index	0.639		

Predictor	Odds Ratio	95% CI	p-value
Race: Black vs. Non-Black	3.84	(1.74, 8.44)	0.001
BMI	1.07	(1.02, 1.12)	0.002
Herniation: Yes vs. No	0.31	(0.13, 0.73)	0.008
Myelopathy: Yes vs. No	1.40	(0.68, 2.86)	0.36
Surgery Type			0.003
PCF vs. ACF	4.05	(1.72, 9.55)	0.001
Posterior Decompression vs. ACF	2.47	(1.10, 5.52)	0.03
Levels	1.33	(0.92, 1.92)	0.13
Terminal Level: Yes vs. No	0.67	(0.33, 1.35)	0.26
Cancer: Yes vs. No	1.52	(0.64, 3.62)	0.34
Corrected Concordance Index	0.774		

See Disclosure Index pages 40–88.

Figure 2.



Predictor	Odds Ratio	95% CI	p-value
BMI	1.18	(1.08, 1.29)	0.0003
Neck Pain: Yes vs. No	0.28	(0.08, 0.98)	0.04
UE Numbness: Yes vs. No	0.28	(0.07, 1.09)	0.06
UE Weakness: Yes vs. No	6.34	(1.71, 23.55)	0.006
Herniation: Yes vs. No	0.11	(0.01, 1.25)	0.07
Surgery Type			0.005
PCF vs. ACF	11.26	(1.89, 66.93)	0.008
Posterior Decompression vs. ACF	13.65	(2.72, 68.52)	0.001
Diabetes Mellitus: Yes vs. No	6.29	(1.50, 26.30)	0.01
Corrected Concordance Index	0.915		

Predictor	Slope	95% CI	p-value
Herniation	0.056	(0.003, 0.109)	0.04
Myelopathy	-0.032	(-0.091, 0.027)	0.29
Surgery			0.04
PCF	ref	---	
ACF	0.071	(-0.007, 0.149)	0.06
Posterior Decompression	0.113	(0.025, 0.208)	0.01
Diabetes Mellitus	0.055	(-0.016, 0.126)	0.13
Preoperative EQ5D*			< 0.0001
Preoperative PDQ*			0.0002
Adjusted Coefficient of Determination, R^2	0.441		
Concordance Correlation Coefficient, CCC	0.619		

- **Comparison of Long-Term (5-Year) Reoperation Rates and Outcomes of Long Fusions to the Cervico-Thoracic Junction: Multilevel ACDF with BMP-2 vs. Posterior Fusion**

Nicole Record, DO, *Paterson, NJ*
Michael Faloon, MD MS, Paterson, NJ
Ki Soo Hwang, MD, Paterson, NJ
Kumar G. Sinha, MD, Paterson, NJ
Kimona Issa, MD, Paterson, NJ
Conor Dunn, MS, Paterson, NJ
Arash Emami, MD, Paterson, NJ

** Bone Morphogenic Protein – 2 has a black box warning for use in the cervical spine.*

Introduction: Multilevel cervical decompression and fusion presents many issues for adequate surgical treatment and avoidance of complications to improve patient outcomes. Concerns ranging from restoration of lordosis to junctional degeneration and kyphosis to pseudoarthrosis afford the argument for the most appropriate treatment approach of anterior versus posterior as well as inclusion or not of C7-T1. This study aims to compare the long-term complication rates and outcomes of multilevel ACDF with ultra-low dose bone morphogenic protein-2 (BMP-2) to posterior fusions that either ended at or crossed the cervico-thoracic junction.

Materials/Methods: This is a retrospective review of 149 patients that underwent long fusions to the cervicothoracic junction between 2005 and 2010 and had greater than 5 years follow-up. Patients were divided into two Groups based on approach 1) 3-level ACDF and 2) Posterior Fusions. Group 2 was further subdivided based on most distal segment included 2A) C7 and 2B) T1. Patients with complete medical and radiographic records were included in the statistical analysis. Patients with less than 5-year follow-up were included in the analysis if complications were encountered. Complications were grouped according categories relating to 1) wound 2) neurologic 3) fusion status 4) implant and 5) global alignment and stratified by early, late, and long term, respectively < 2 years, < 5 years, and > 5 years. Final VAS and ONDI scores were compared.

Results: 92 patients were included in the final analysis. Group 1: 38, Group 2: 54 (A 29 B 25) 48 men and 44 women; respective mean age was 1) 52.9 years (29–73) and 2) 60.5 years (24–83); A) 61 years (30-83) & B) 60 years (24–77). Mean follow-up was respectively 1) 4.8 and 2) 5.8 years (4.80–8.5 years). Overall reoperation rates were 1) 15.7% to 2) 5.6% ($p = 0.06$). No statistical difference was seen between groups within any particular complication category. Radiographically, Group 1 had a significant difference in restoration of lordosis 45.6 deg – Group 2 0.62 deg ($p < 0.01$). PJK was not clinically relevant in either group. No differences were seen in radiographic adjacent segment degeneration though the only patient requiring revision was in Group 2A.

See Disclosure Index pages 40–88.

No difference was seen in revision for pseudoarthrosis though patients requiring revision were only seen in Group 1 and 2B.

Conclusion: Clinically relevant complications rates leading to reoperation for long cervical fusions were less than anticipated in all groups. Anterior procedures underwent a higher rate of revision procedures but had better restoration of lordosis and pain scores at 5 years. Stopping at or crossing the cervico-thoracic junction did not result in better overall clinical outcomes.

Risk Factors and Functional Outcomes of Re-Intubation after Anterior Cervical Spine Surgery: Results from AOSpine North America Multicenter Study on 8,887 Patients

***Narihito Nagoshi, MD**, Toronto, ON, Canada*
Michael G. Fehlings, MD, PhD, Toronto, ON, Canada
Hiroaki Nakashima, MD, Toronto, ON, Canada
Lindsay Tetreault, HBSc, Toronto, ON, Canada
K. Daniel Riew, MD, New York, NY
Zachary A. Smith, MD, Chicago, IL
Wellington K. Hsu, MD, Chicago, IL
Chadi Tannoury, MD, Boston, MA
Tony Y. Tannoury, MD, Boston, MA
Vincent C. Traynelis, MD, Chicago, IL
Paul M. Arnold, MD, Kansas City, KS
Thomas E. Mroz, MD, Cleveland, OH
Anthony De Giacomo, MD, Boston, MA
Bruce C. Jobse, MS, Boston, MA
Eric M. Massicotte, MD, Toronto, ON, Canada

Introduction: Anterior cervical spine surgery is one of the most common surgical procedures, and clinical recovery is generally satisfactory. However, the anterior approach does pose a risk for airway compromise requiring re-intubation due to postoperative soft-tissue edema or hematoma. Although this postoperative complication is suspected to be rare, it can result in poor and severe surgical outcomes when it does occur. To date, there are few large-scale studies that evaluate risk factors of and patient prognosis after re-intubation. The purpose of this study is 1) to determine the incidence of emergent re-intubation after anterior cervical surgery and risk factors associated with this complication, and 2) to ascertain its impact on functional and quality of life (QOL) outcomes.

Methods: A total of 8,887 patients who underwent anterior cervical spine surgery were retrospectively enrolled in the AOSpine North America Rare Complications of Cervical Spine Surgery study. Surgeries were performed between January 1, 2005 and December 31, 2011. Patients who had re-intubation within 30 days after surgery and required an anterior hematoma/edema evacuation were identified. Based on patient records, the following data were extracted: age, body mass index (BMI), smoking history, diagnosis, duration of operative time, blood loss, fusion levels, and duration of hospital stay. As a control group to analyze risk factors, we used data from 148 complication-free patients treated anteriorly who were registered in the AOSpine North America Cervical Spondylotic Myelopathy study. Patients' functional status was evaluated before surgery and at final follow-up using a variety of metrics, including the modified Japanese Orthopedic Assessment (mJOA) scale, the Nurick score, the Neck Disability Index (NDI), and the Short-Form 36 (SF-36) Health Survey. Means were compared using the appropriate t-test.

See Disclosure Index pages 40–88.

Results: Nine cases of a postoperative re-intubation were identified, representing an incidence of 0.10%. Patients' diagnoses were radiculopathy (n = 5), degenerative disc disease (n = 4), myelopathy (n = 4) and infection (n = 1). Two patients (22.2%) were smokers: one a current smoker and the other a previous smoker. With respect to risk factors, patients with re-intubation had a significantly higher BMI (p = 0.0002) and more blood loss (p = 0.0001) than patients without any complications (Table 1). The length of hospital stay in patients with re-intubation was significantly longer than in the control group (p = 0.0001) (Table 1). In terms of adverse events after re-intubation, one patient died, and the remaining eight patients recovered. At final-follow up, patients with re-intubation exhibited deterioration on the SF-36 Physical Component Score compared with their baseline scores (Table 2). Patients improved on other functional scales, but these gains were not significant (Table 2).

Conclusions: This large multicenter study demonstrated that re-intubation is an extremely rare complication, occurring in 10 out of 10,000 patients undergoing anterior cervical spine surgery. Relative to a control group, obesity and blood loss were major risk factors for this complication. Despite its rarity, the prognosis after re-intubation appears unfavorable. Our results showed that one patient died, and surviving patients did not achieve full functional recovery. Overall, re-intubation impairs functional recovery after surgery, and may even be a life threatening complication.

Table 1. Risk factors for re-intubation after anterior cervical spine surgery

	Re-intubation	Control	p-value
Age (years)	**48.89±11.76**	**57.07±12.18**	**0.0104**
Gender	55.56 M, 44.44 F	57.43 M, 42.57 F	0.6796
Body mass index	**32.15±8.65**	**29.79±6.69**	**0.0002**
Duration of operation (mins)	172.15±39.70	173.97±68.53	0.748
Blood loss (ml)	**231.43±344.11**	**151.91±198.21**	**0.0001**
Number of fusion level	3.22±0.97	3.11±0.87	0.118
Length of hospital stay	**5.57±6.19**	**3.70±5.53**	**0.0001**

Data were reported as the mean ± standard deviation (SD). $p < 0.05$ was considered statistically significant.

Table 2. Baseline and final follow-up scores in patients with re-intubation

	Baseline score	Final follow-up score	p-value
mJOA	17.00±1.67	17.40±1.34	0.208
Nurick	1.00±1.27	0.60±1.34	0.374
Neck Disability Index	26.40±10.33	26.00±19.32	0.942
SF-36 Physical Component Score	42.82±8.02	37.47±8.67	0.732
SF-36 Mental Component Score	42.26±11.14	47.30±16.20	0.816

mJOA: modified Japanese Orthopaedic Association scale, SF-36: Short- Form 36.

See Disclosure Index pages 40–88.

The Incidence of an Epidural Hematoma following Cervical Spine Surgery

***Greg D. Schroeder, MD**, Philadelphia, PA*
Alan S. Hilibrand, MD, Philadelphia, PA
Paul M. Arnold, MD, Kansas City, KS
David E. Fish, MD, MPH, Santa Monica, CA
Jeffrey C. Wang, MD, Los Angeles, CA
Zachary Z. Smith, MD, Chicago, IL
Wellington K. Hsu, MD, Chicago, IL
Ziya L. Gokaslan, MD, Baltimore, MD
Robert E. Isaacs, MD, Durham, NC
Adam Kanter, MD, Pittsburg, PA
Thomas E. Mroz, MD, Cleveland, OH
Ahmad Nassr, MD, Rochester, MN
Rick C. Sasso, MD, Carmel, IN
Michael G. Fehlings, MD, PhD, Toronto, ON, Canada
Zorica Buser, PhD, Los Angeles, CA
Mohamad Bydon, MD, Baltimore, MD
Elizabeth Lord, MD, Santa Monica, CA
Emily C. Nguyen, MD, Rochester, MN
K. Daniel Riew, MD, New York, NY

Introduction: One of the most devastating complications that can occur after a cervical spine surgery is an epidural hematoma, which can lead to irreversible neurological injury without prompt attention and treatment. However, if this complication is recognized quickly and the hematoma is evacuated, patients can make a full recovery. For surgeons to be able to accurately inform their patients on the risks and benefits of cervical spine surgery, it is important to establish the actual incidence of rare but potentially devastating complications such as a postoperative epidural hematoma. To date, the literature related to this complication is limited to small single-institution studies.

Methods: A multi-centered retrospective case series was performed at 23 institutions. Patients who underwent cervical spine surgery between January 1, 2005 and December 31, 2011 were reviewed, and all patients who developed an epidural hematoma were identified. IRBs were obtained from all institutions and the data was sent to a private research organization that collected and collated all of the data.

Results: 16,582 cervical spine surgeries were reviewed, and 15 cases of a postoperative epidural hematoma were identified, for an incidence of 0.090%. Demographic and operative details are available in Table 1. The complication resulted in an average length of stay of 9.36 +/- 9.35 days. All patients initially presented with a neurologic deficit, but nine patients had complete resolution of the neurologic deficit after hematoma evacuation. Importantly, among the patients who experienced a postoperative epidural hematoma, there was no significant improvement in health-related quality of life (HRQOL) metrics between the preoperative evaluation and the final follow up evaluation (Table 2).

Conclusion: The current study is the largest series to date to analyze the incidence of an epidural hematoma following cervical spine surgery. The results of this study suggest that an epidural hematoma is a very rare event, occurring in approximately 1 out of 1,000 cervical spine surgeries. This study is also the first study to report on the HRQOL outcomes after an epidural hematoma. Although these outcomes were not available for the entire cohort, it is likely that the patients in this study who developed an epidural hematoma had worse clinical outcomes than the other patients, as this study found no clinical improvement in HRQOL metrics versus preoperative baseline among the patients who experienced this complication.

See Disclosure Index pages 40–88.

Table 1. Demographic and operative details for patients with an epidural hematoma

Average Age	55.60 +/- 13.41
Number of Men	8 (53.3%)
Average Height (cm)	167.18 +/- 10.17
Average Weight (kg)	79.49 +/- 19.86
Diagnosis	
Myelopathy	10 (66.7%)
Radiculopathy	4 (26.7%)
Degenerative Disc Disease	2 (13.3%)
Instability	1 (6.7%)
Fracture	1 (6.7%)
Other	4 (26.7%)
Smoking Status	
Number of Current Smokers	6 (42.9%)
Number of Former Smokers	2 (14.9%)
Number of Non-Smokers	6 (42.9%)
Operative Details	
Number of Anterior Procedures	5 (33.3%)
Number of Posterior Procedure	10 (66.6%)
Operative Time (minutes)	211.60 +/- 108.95
Estimated Blood Loss (mL)	660.42 +/-1754.4
Level involved	
C2	2 (13.3%)
C3	11 (73.3%)
C4	12 (80.0%)
C5	13 (86.7%)
C6	13 (86.7%)
C7	10 (66.7%)
T1	2 (13.3%)
T2	2 (13.3%)

Table 2. The health related quality of life metrics for patients who developed a postoperative epidural hematoma.

	NDI	MJOA	NURICK	PHY-SF-36	MENT-sf-36
Baseline score (Not available for all patients)	42.67 +/- 17.74	13.00 +/- 3.56	1.64 +/- 1.52	24.67 +/- 3.44	40.91 +/- 13.95
Score at final follow up (Not available for all patients)	56.25 +/- 34.43	3.00 +/- 0.00	1.86 +/- 2.85	27.21 +/- 7.70	27.29 +/- 15.55
Number of patients with both pre-operative and follow-up outcomes reported	4	1	7	4	4
Average Difference	10.75 +/- 21.90	-5	0.43 +/- 1.90	2.25 +/- 4.16	-16.36 +/- 19.09
P-Value	0.4	NA	0.57	0.36	0.18

NDI = Neck Disability Index; MJOA = Modified Japanese Orthopedic Association; PHY-SF-36 = Physical Component of the Short Form (36) Health Survey; MENT-sf-36 = Mental Component of the Short Form (36) Health Survey

See Disclosure Index pages 40–88.

A Multicenter Study of the Presentation, Treatment, and Outcomes of Cervical Dural Tears

Kevin R. O'Neill, MD, Nashville, TN
Michael G. Fehlings, MD, PhD, Toronto, ON, Canada
Thomas E. Mroz, MD, Cleveland, OH
Zachary A. Smith, MD, Chicago, IL
Wellington K. Hsu, MD, Chicago, IL
Adam Kanter, MD, Pittsburg, PA
Michael P. Steinmetz; MD, Cleveland, OH
Paul M. Arnold, MD, Kansas City, KS
Praveen V. Mummaneni, MD, San Francisco, CA
Dean Chou, MD, San Francisco, CA
Ahmad Nassr, MD, Rochester, MN
Sheeraz A. Qureshi, MD, MBA, New York, NY
Samuel K. Cho, MD, New York, NY
Evan O. Baird, MD, New York, NY
Justin S. Smith, MD, PhD, Charlottesville, VA
Chadi Tannoury, MD, Boston, MA
Tony Y. Tannoury, MD, Boston, MA
Ziya L. Gokaslan, MD, Baltimore, MD
Robert A. Hart, MD, Portland, OR
Robert E. Isaacs, MD, Durham, NC
Rick C. Sasso, MD, Carmel, IN
David B. Bumpass, MD, St. Louis, MO
Mohamad Bydon, MD, Baltimore, MD
Mark Corriveau, MD, Cleveland, OH
Anthony De Giacomo, MD, Boston, MA
Adeeb Derakhshan, BS, Cleveland, OH
Bruce C. Jobse, MS, Boston, MA
Daniel Lubelski, MD, Cleveland, OH
Sungho Lee, MD, Cleveland, OH
Eric M. Massicotte, MD, Toronto, ON, Canada
Jonathan Pace, MD, Cleveland, OH
Gabriel Smith, MD, Cleveland, OH
Khoi Duc Than, MD, San Francisco, CA
***K. Daniel Riew, MD**, New York, NY*

Introduction: There have been 2 single-center studies that reported on the outcomes following the unintentional cervical dural tears, and have estimated the incidence of this complication to be 1%. Despite reviewing thousands of patients in these studies, the overall number of patients with a dural tear was low.

Because of the rarity of this complication, even experienced surgeons with large cervical spine practices may have limited experience with cervical dural tear management. In order to understand the presentation, treatment, and outcome of this complication, a multi-center study was performed to pool collective experiences with cervical dural tears.

Methods: Multiple surgeons from 23 medical institutions retrospectively identified and investigated 21 rare complications of cervical spine surgery that occurred in their practices between 2005-2011, including unintentional cervical dural tears. Patients were over 18 years old, and IRBs were obtained from all institutions. Patient demographic data and surgical history were obtained. Clinical outcomes following surgery were assessed, and any reoperations to control cerebrospinal fluid (CSF) draiange were recorded. Neck disability index (NDI), modified Japanese Orthopaedic Association (mJOA), Nurick classification (NuC), and Short-Form 36 physical (SF12-PCS) and mental component scores (SF36-MCS) were recorded at baseline and final follow up at certain centers. All data was collected and collated by a private research organization. Statistical analyses were performed by the same independent group, with paired t-tests used to determine significance ($p < 0.05$).

Results: There were 109 cases of cervical dural tears identified from 13,946 surgeries performed during the study period. There were 47 females (43%), the average age was 57 ± 14 years, and the average BMI was 24.6. The most common indications for surgery were myelopathy (64%) and radiculopathy (22%). An anterior approach was used in 61%, a posterior approach in 35%, and circumferential approach in 5% of cases. The most common levels involved were C5 (92%) and C6 (87%). Average operative time was 208 mins with an average blood loss of 585 ml. The average hospital stay was 6.5 ± 7.6 days. In 67% of cases no further postoperative treatments of the dural tear were require, while there were 10 patients (9%) that required a subsequent surgery for dural repair. In 101 cases (93%) there was no clinical sequelae following successful dural tear repair, while there were 8 cases (7%) with symptoms that possibly attributable to the dural tear. Surprisingly there was no significant change ($p>0.05$) from baseline in any of the outcome scores, although scores were only available in subsets of patients [NDI (n = 31), mJOA (n = 25), NuC (n = 51), SF36 (n = 27)].

Conclusions: In this multi-center study, we report our findings on the largest reported series (n=109) of cervical dural tears. In most cases no subsequent interventions to control CSF drainage were required, while 9% required revision operation. In a majority of cases (93%), there was no clinical sequelae directly attributable to the occurrence of a dural tear. Future studies will focus on what patient and surgical factors were associated with the need for reoperations to control CSF drainage and with diminished patient-reported outcomes.

See Disclosure Index pages 40–88.

Hospital-Acquired Pneumonia Occurs in 20.5% of Cervical Spinal Cord Injury Patients and is Associated with Poor Inpatient Outcomes: An Analysis of 5,198 Patients in the National Trauma Data Bank

***Andre M. Samuel, BBA**, New Haven, CT*
Pablo J. Diaz-Collado, MD, New Haven, CT
Michael C. Fu, MD, New Haven, CT
Adam M. Lukasiewicz, MSc, New Haven, CT
Matthew L. Webb, AB, New Haven, CT
Daniel D. Bohl, MPH, New Haven, CT
Bryce A. Basques, BS, New Haven, CT
Jonathan N. Grauer, MD, New Haven, CT

Introduction: Cervical spinal cord injury patient often face a complex inpatient course putting them at increased risk of hospital-acquired infections, including pneumonias. To date, risk factors and outcomes after hospital-acquired pneumonias (HAP) have not been studied in this patient population.

Material/Methods: The 2011 and 2012 National Trauma Data Bank (NTDB) was utilized to identify all patients with cervical spinal cord injuries. NTDB is the largest national database of trauma patients with over 900 centers contributing annually.

The incidence of hospital-acquired pneumonia was determined based on NTDB chart-abstracted adverse event data elements. Multivariate logistic regression was then used to identify independent associations of various risk factors with occurrence of hospital acquired pneumonias.

Finally, multivariate logistic regression was used to determine the independent association of hospital-acquired pneumonias with various inpatient outcomes measures (death, inpatient adverse events, discharge destination, and length of stay), after controlling for gender, Charlson Comorbidity Index, cervical spine injury level, spinal cord injury type, Injury Severity Score (ISS), length of stay, intensive care unit stay, ventilator use, and other inpatient adverse events.

Results: A total of 5,198 patients with cervical spinal cord injury were identified in the 2011–2012 NTDB. The overall incidence of HAP was 20.5% (1,065) patients. Complete spinal cord injuries (compared to central cord injuries), longer inpatient length of stay, longer intensive care unit (ICU) stay, and longer time on mechanical ventilation were independently associated with HAP (Table 1).

After controlling for all other risk factors, including patient comorbidities, ISS, and other inpatient complications, HAP was associated with increased odds of mortality, inpatient adverse events, discharge to an extended-care facility, and longer length of stay (Table 2).

Conclusion: The overall rate of HAP is high after cervical spinal cord injuries. As these patients often require extended inpatient hospitalizations with time in the intensive care unit and on mechanical ventilation, practitioners must be mindful of factors that increase risks of HAP. These nosocomial infections are associated with poor inpatient outcomes; therefore, optimization of protocols for aggressive prevention and management is necessary.

Table 1.

	Frequency	Percentage of total population	% with HAP **(Overall: 20.5%)**	Multivariate odds ratio for HAP (95% confidence interval)	P-value
Gender					
Female	1,174	23%	16%	-	-
Male	4,024	77%	22%	-	-
Charlson Comorbidity Index					
0	1,448	28%	26%	Reference	
1	839	16%	23%	1.12 (0.87 - 1.45)	0.374
2	966	19%	18%	0.95 (0.74 - 1.23)	0.718
3	769	15%	18%	1.01 (0.76 - 1.33)	0.971
4	677	13%	16%	0.97 (0.72 - 1.31)	0.846
5 +	499	10%	18%	1.19 (0.86 - 1.65)	0.291
Cervical spine injury level					
Upper (C1 - C4)	1,859	36%	18%	1.05 (0.77 - 1.43)	0.758
Mixed	575	11%	17%	Reference	
Lower (C5 - C7)	2,757	53%	23%	1.05 (0.78 - 1.42)	0.748
Spinal cord injury type					
Complete cord injury	**1,453**	**28%**	**40%**	**1.44 (1.10 - 1.90)**	**0.009**
Incomplete cord injury	1,859	36%	17%	1.15 (0.90 - 1.47)	0.264
Central cord injury	1,886	36%	9%	Reference	-
Injury Severity Score					
0 - 14	452	9%	6%	Reference	-
15 - 19	1,957	38%	9%	1.29 (0.78 - 2.13)	0.315
20 - 24	488	9%	13%	1.31 (0.75 - 2.29)	0.347
25 - 29	1,205	23%	31%	1.69 (1.02 - 2.80)	0.040
30 +	1,096	21%	39%	1.55 (0.94 - 2.57)	0.088
Length of stay					
0 - 6	1,060	20%	1%	Reference	-
7 - 13	**1,733**	**33%**	**6%**	**3.08 (1.60 - 5.94)**	**0.001**
14 - 20	**880**	**17%**	**24%**	**6.19 (3.18 - 12.03)**	**< 0.001**
21 - 27	**552**	**11%**	**42%**	**10.21 (5.20 - 20.03)**	**< 0.001**
28 - 34	**338**	**7%**	**45%**	**9.83 (4.92 - 19.65)**	**< 0.001**
35 +	**635**	**12%**	**57%**	**14.89 (7.55 - 29.36)**	**< 0.001**

See Disclosure Index pages 40–88.

ICU days					
0	810	16%	3%	Reference	-
1 - 2	571	11%	2%	0.98 (0.48 - 1.98)	0.952
3 - 5	1,080	21%	3%	1.01 (0.57 - 1.79)	0.981
6 - 8	655	13%	9%	1.36 (0.78 - 2.39)	0.283
9 - 11	**373**	**7%**	**23%**	**2.86 (1.64 - 4.98)**	**< 0.001**
12 - 14	**331**	**6%**	**35%**	**3.05 (1.74 - 5.36)**	**< 0.001**
15 +	**1,378**	**27%**	**53%**	**2.94 (1.72 - 5.03)**	**< 0.001**
Ventilator days					
0	2,748	53%	5%	Reference	-
1 - 2	454	9%	6%	0.93 (0.59 - 1.47)	0.753
3 - 6	**443**	**9%**	**19%**	**2.68 (1.91 - 3.75)**	**< 0.001**
7 - 13	**462**	**9%**	**41%**	**3.76 (2.76 - 5.13)**	**< 0.001**
14 - 20	**443**	**9%**	**52%**	**3.98 (2.85 - 5.54)**	**< 0.001**
21 +	**648**	**12%**	**62%**	**3.99 (2.87 - 5.53)**	**< 0.001**

Note: Gender was not included in the multivariate analysis due to colinearity with injury severity. Risk factors in **boldface** were found to be statistically significant in multivariate analysis after false discovery rate control (P < 0.01)
ICU = intensive care unit

Table 2.

Outcome	Incidence for patients WITHOUT HAP	Incidence for patients WITH HAP	Multivariate effect size* (95% confidence interval)	P-value
Death	5.0%	9.8%	OR = 1.60 (1.15 - 2.20)	0.005
Inpatient adverse events†	16.2%	48.4%	OR = 1.65 (1.38 - 1.96)	< 0.001
Not discharged to home‡	78.3%	96.2%	OR = 1.93 (1.31 - 2.83)	0.001
Additional length of stay§	14.51 days	33.96 days	10.93 days (9.68 - 12.18)	< 0.001

* Multivariate analyses control for gender, Charlson Comorbidity Index, cervical spine injury level, spinal cord injury type, Injury Severity Score, length of stay, intensive care unit use, ventilator use, and other inpatient adverse events.
† Inpatient adverse events include urinary tract infection, acute respiratory distress syndrome, thromboembolic events, acute kidney injury, stroke, and myocardial infarction.
‡ Includes patients discharged to rehabilitation, skilled nursing, and intermediate care facilities.
§ Length of stay analysis is reported in mean length of stay and multivariate linear regression coefficient, rather than incidence rate and multivariate odds ratio.
All multivariate associations were statistically significant after false discovery rate control.
OR = odds ratio, HAP = hospital-acquired pneumonia

Predictive Model for Cervical Alignment Outcomes following Surgical Correction of Adult Spinal Deformity

***Peter G. Passias, MD**, Westbury, NY*
Cheongeun Oh, PhD, New York, NY
Cyrus M. Jalai, BS, New York, NY
Nancy J. Worley, BS, New York, NY
Renaud Lafage, MS, New York, NY
Justin K. Scheer, BS, Chicago, IL
Eric O. Klineberg, MD, Sacramento, CA
Robert A. Hart, MD, Portland, OR
Han-Jo Kim, MD, New York, NY
Justin S. Smith, MD, PhD, Charlottesville, VA
Virginie C. Lafage, PhD, New York, NY
Christopher P. Ames, MD, San Francisco, CA
International Spine Study Group, Brighton, CO

Introduction: Cervical deformity (CD) following surgical correction of adult spinal deformity (ASD) has been defined by the following measurements: CL > 20°, C2-C7 SVA > 40mm, or C2-C7 kyphosis >10°. While several studies have analyzed predictors of developing CD, few have defined and identified predictors of optimal cervical alignment (CA) following thoracolumbar corrective surgery. This study uses advanced predictive modeling to identify predictors of developing sub-optimal cervical alignment for surgical ASD patients.

Materials/Methods: This study retrospectively reviewed a prospectively-collected multicenter database for surgical ASD patients with baseline and 2-year follow-up. Post-op CA at 2-years was defined according to the following radiographic criteria: 0° ≤ T1S-CL ≤ 40°, 0mm ≤ C2-C7 SVA ≤ 40mm, or C2-C7 lordosis > 0°. Three thresholds were determined according to these criteria: T1) only 1 criterion, T2) only 2 criteria, T3) all 3 criteria. Patients that did not meet all three were considered not cervically aligned. Data collected included basline demographic, radiographic, and surgical variables. Logistic regression was first conducted to assess each factor's ''predictability'' in each threshold. An odds ratio (OR) was estimated for each predictor, together with the 95% confidence interval (CI) and p-value. Multivariable logistic regression models using a backward stepwise predictor selection was performed to generate a data set–specific prediction model. To establish a final prediction model, a series of prediction models were built by sequentially adding predictors from the ranked list, and a final model was chosen based on the model with the lowest Akaike information criterion. Internal validation of the prediction model was performed by calculating area under the curve (AUC) of the corresponding final prediction model by drawing the receiver operating characteristic (ROC). AUC values are reported with the 95% confidence interval. Table 1 shows the final model with AUC under each definition of outcomes.

See Disclosure Index pages 40–88.

Results: 225 surgical ASD patients were included. 208 patients (92.4%) were grouped in T3, while 17 (7.6%) fell outside all three CA criteria ranges. Patients in both groups were similar regarding mean age (56.02 vs. 61.47 years, p = 0.150) and BMI (27.10 vs. 27.64 kg/m^2, p = 0.716), but patients that met all 3 CA criteria had an increased prevalence of females (88.9% vs. 66.7%, p = 0.017). The final predictive model had an AUC of 89.22% (DeLong) and included the following variables: C2 sacral slope, C2-T3 CL, T1S-CL, C2-C7 CL, Pelvic Tilt, C2-S1 SVA, PI-LL, and number of SPO's during index. In this model, the following variables were identified as predictors of poor CA: number of SPO's (OR: 1.336, p = 0.017), and C2-T3 CL (OR: 1.048, p = 0.005). Models for predictors of all thresholds are reported in Table 1.

Conclusions: This study created a statistical model that predicts good CA in patients who have undergone corrective ASD surgery. Using T3 (patients meeting all 3 CA criteria at 2-years post-op) was the most effective model for predicting poor cervical alignment, and included increased baseline C2-T3 angle and increased Smith-Peterson osteotomies during index. This study could be used to aid surgeons in patient counseling efforts and to direct future research.

Table 1. Baseline radiographic and surgical variables that were included in the final cervical alignment predictive model for each threshold (T1, T2, T3). Shaded variables represent those that were significant predictors in the final model and that yielded the highest predictability.

Variable	OR (95% CI)	AUC	Final Model AUC
T1 Threshold			
Baseline C2-SS	0.929 (0.959-0.900)	71.281	
Baseline T1S-CL	0.931 (0.961-0.901)	71.193	
Baseline C2-C7 SVA	0.959 (0.979-0.940)	70.634	
Baseline C2-S1	1.049 (1.073-1.026)	69.190	**75.83%** (82.94%-68.72%)
Baseline C2-T3 SVA	0.978 (0.992-0.964)	64.821	
Baseline C2-T3	1.029 (1.049-1.011)	62.517	
Baseline C2-C7 CL	1.026 (1.046-1.006)	58.719	
Rod Diameter	1.391 (1.906-1.015)	57.358	
T2 Threshold			
Baseline C2-SS	0.910 (0.941-0.880)	75.481	
Baseline T1S-CL	0.915 (0.946-0.886)	74.657	
Baseline C2-T3	1.045 (1.066-1.024)	69.131	
Baseline C2-C7 CL	1.048 (1.072-1.025)	66.976	
Baseline C2-C7 SVA	0.972 (0.989-0.955)	63.152	**67%** (74.79%-59.21%)
Baseline C2-T3 SVA	0.986 (0.998-0.975)	59.074	
Osteotomy Use	2.056 (4.304-1.173)	58.172	
Rod Diameter	1.396 (1.910-1.021)	56.566	
T3 Threshold			
Baseline C2-SS	0.915 (0.968-0.865)	75.047	
Baseline C2-T3	1.048 (1.083-1.014)	74.246	
Baseline TS-CL	0.924 (0.975-0.875)	73.091	
Nb SPO Osteotomies	1.336 (1.694-1.053)	70.895	**89.22%** (97.49%-80.96%)
Baseline C2-C7 CL	1.047 (1.088-1.008)	70.559	
Baseline PT	0.957 (1.002-0.914)	69.627	
Baseline C2-S1	1.034 (1.069-1.001)	65.605	
Baseline PI-LL	0.977 (1.001-0.955)	65.031	

See Disclosure Index pages 40–88.

Extent of Proximal Fusion correlates with Worse Clinical Outcomes in Cervical to Pelvis Fusions

***Han-Jo Kim, MD**, New York, NY*
Sravisht Iyer, MD, New York, NY
Alexander A. Theologis, MD, San Francisco, CA
Todd J. Albert, MD, New York, NY
Lawrence G. Lenke, MD, New York, NY
Vedat Deviren, MD, San Francisco, CA
Venu M. Nemani, MD, PhD, New York, NY
Oheneba Boachie-Adjei, MD, New York, NY
Shane Burch, MD, San Francisco, CA
Jun Mizutani, MD, Nagoya, Japan
Eric O. Klineberg, MD, Sacramento, CA
Themistocles S. Protopsaltis, MD, New York, NY
Justin S. Smith, MD, PhD, Charlottesville, VA
Justin K. Scheer, BS, Chicago, IL
Christopher P. Ames, MD, San Francisco, CA

Introduction: Correction of adult deformity may necessitate fusions crossing the cervicothoracic junction. In cases where this is necessary, there is little evidence in the literature that guides the choice of cervical Upper Instrumented Vertebrae (UIV). There is no information on how the choice of UIV might affect health related quality of life (HRQOL) outcomes. We hypothesized that patients with UIVs in the upper cervical spine (C1-2) would have a significantly lower HRQOL when compared to patients fused to the lower cervical (C6-7) spine.

Methods: We performed a multi-center, retrospective review of patients that had undergone correction of adult deformity between 2003 and 2014. Patients were included if they had a fusion to the sacrum/pelvis with a UIV C1-C7. Patient demographics, history, diagnosis, operative procedure and Scoliosis Research Society-22r (SRS-22r) scores were collected. An independent Student's t-test was used to compare means and a Kruskal Wallis test was performed to compare across all groups. Bivariate Pearson correlations were performed. Significance was set at $p < 0.05$. UIVs were divided in regions: Upper Cervical (C1-2), Mid Cervical (C3-5), Lower Cervical (C6-7).

Results: 49 patients met inclusion and 41 (83.6%) had sufficient data for analysis. The average age was 44 years with and average follow up time of 2.7 years. Distribution of UIV was as follows: 14 C1-C2, 34.1%; 8 C3-C5, 19.5%; 19 C6-C7, 46.3%. PJK was the most common indication for fusion to the cervical spine (34.1%), followed by kyphosis (22.4%) and kyphoscoliosis (12.2%). The majority of cases (72.2%) were revisions. A lower UIV was correlated to higher post-operative Activity ($r = 0.41$, $p = 0.014$), Pain ($r = 0.48$, $p = 0.002$) Self Image ($r = 0.42$, $p = 0.008$) and Total ($r = 0.43$, $p = 0.006$) scores. There was a difference in post-operative Activity ($p = 0.04$), Pain ($p < 0.01$), Self Image ($p = 0.03$), Satisfaction ($p < 0.01$) and Total ($p = 0.01$) scores with the UIV groups in the upper cervical spine having a lower score than the lower cervical spine (Table 1). However, there was no difference in the change in SRS scores. C1-2 fusions also had lower pre-operative Activity ($p = 0.03$) and Self Image ($p = 0.03$) scores.

Conclusion: A higher cervical UIV is correlated to worse HRQOLs in patients fused to the pelvis. Extending cervical fusions more proximally in this group of patients can compromise the SRS-22r Activity, Pain, Self Image and Total scores. When choosing the proximal extent of fusion constructs in this patient population, efforts should be taken to fuse as short as possible proximally.

See Disclosure Index pages 40–88.

|Table 1. SRS-22r scores in cervical to pelvis fusion based on choice of UIV.

	Activity		Pain		Self Image		Mental Health		Satisfaction		Total	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
	Pre-operative Scores											
Upper Cervical (C1-C2)	2.3	0.7	2.3	0.8	2.4	0.9	3.3	0.9	3.5	1.0	2.7	0.6
Mid Cervical (C3-C5)	2.6	1.2	2.6	1.0	2.8	0.9	3.1	0.7	3.7	0.8	2.9	0.9
Lower Cervical (C6-C7)	3.4	1.0	2.9	0.7	3.5	0.9	2.4	1.3	3.6	0.9	3.3	0.7
P-Value	*0.03*		*0.07*		*0.03*		*0.11*		*0.86*		*0.09*	
	Post-operative Scores											
Upper Cervical (C1-C2)	2.6	0.9	2.5	0.9	2.6	1.0	3.4	1.0	3.4	0.6	2.8	0.7
Mid Cervical (C3-C5)	3.4	1.4	3.5	0.7	3.5	0.9	3.9	1.1	4.7	0.3	3.7	0.6
Lower Cervical (C6-C7)	3.7	1.2	3.5	0.9	3.6	0.9	4.1	0.9	3.9	0.6	3.7	0.8
P-Value	*0.04*		*<0.01*		*0.03*		*0.16*		*<0.01*		*0.01*	
	Change in Scores											
Upper Cervical (C1-C2)	0.5	0.6	0.2	0.9	0.3	0.7	0.2	0.8	0.1	1.2	0.2	0.
Mid Cervical (C3-C5)	0.9	1.4	1.1	0.9	0.7	1.4	1.0	0.3	1.1	1.0	0.9	0.7
Lower Cervical (C6-C7)	0.1	0.6	0.7	0.8	0.1	0.9	1.4	1.8	0.2	1.0	0.3	0.6
P-Value	*0.49*		*0.29*		*0.78*		*0.11*		*0.12*		*0.14*	

A Novel Radiographic Indicator of Developmental Cervical Stenosis

***Phillip H. Horne, MD, PhD**, New York, NY*
Lukas P. Lampe, MD, New York, NY
Joseph T. Nguyen, MPH, New York, NY
Richard J. Herzog, MD, New York, NY
Todd J. Albert, MD, New York, NY

Introduction: Developmental cervical stenosis (DCS) predisposes patients to neurologic compression and loss of function through cervical cord neurapraxia and myelopathy. The historical plain film measurement to assess DCS, the Torg ratio, has been shown to provide high sensitivity, but low specificity for identifying DCS. Despite efforts to better approximate true sagittal canal diameter from plain film measurements, a more sensitive and specific radiographic index has not been reported. The goal of this study is to develop a novel index for DCS which utilizes a previously unreported spinal measurement, the distance between the spinolaminar line and the posterior border of the lateral mass (SL). The hypothesis of this study is that a ratio of SL distance to spinal canal diameter will be a sensitive and specific index for DCS and provide an objective screening tool to assess for DCS.

Methods: This radiographic study analyzed cervical spine lateral radiographs of adult patients (n = 150; average age 53.5 ± 11.4 years) who have not undergone previous cervical spine surgery. No clinical information was reviewed to associate symptomatology or underlying diagnosis. Cervical levels C3-C6 were measured on plain films for multiple dimensions: spinolaminar line-lateral mass (SL) distance, lateral mass-vertebral body (FB) distance, spinolaminar line-vertebral body (canal diameter, CD), and vertebral body (VB) diameter (Figure 1). Ratios of these measurements: (SL/CD, SL/FB, FB/CD, SL/VB, CD/VB, FB/VB) were calculated to eliminate effects of magnification from plain film measurements. The corresponding true spinal canal diameter was measured at levels C3-6 for each patient using CT mid-sagittal sections. Statistical analysis was performed by calculating correlation coefficients of the ratios to true canal diameter, with $p < .05$ as significant. Receiver operating characteristic (ROC) curve analysis was performed to identify a plain film measurement ratio with optimal sensitivity and specificity, using true canal diameter less than 12mm as defining DCS.

Results: Plain film measurements showed strong correlation of CD and SL dimensions to sagittal CT canal diameter at all levels (CD: r = 0.73–0.81; SL: r = 0.48–0.68). The ratios of CD/body (Torg ratio) and SL/body provided strong correlation to CT diameters at all levels (r = 0.53-0.65, $p < .01$). SL/CD and FB/CD ratios also showed significant correlation at all four levels, strongest at C5 and C6 (both r = 0.54 at C5, r = 0.45 at C6, all levels $p < .01$). ROC curve analysis showed the ratio FB/CD > 0.73 indicated a canal diameter less than 12mm (DCS) with sensitivity (83%) and false positive rate (1-specificity, 25%) at C5 (Figure 2).

See Disclosure Index pages 40–88.

Other levels demonstrated similar but less optimal statistical profiles for this ratio. Other ratios including the Torg ratio, or the hypothesized SL/CD ratio, did not provide a cut off value that predicted DCS with adequate sensitivity and specificity.

Conclusions: This analysis provides a novel index for DCS, the FB/CD ratio. This represents the best radiographic measurement available to indicate DCS in the adult spine patient. Ongoing studies of interobserver reliability are being performed, with the ultimate goal of providing an objective screening tool for physicians to detect developmental cervical stenosis and prompt surgical referral in appropriate patients.

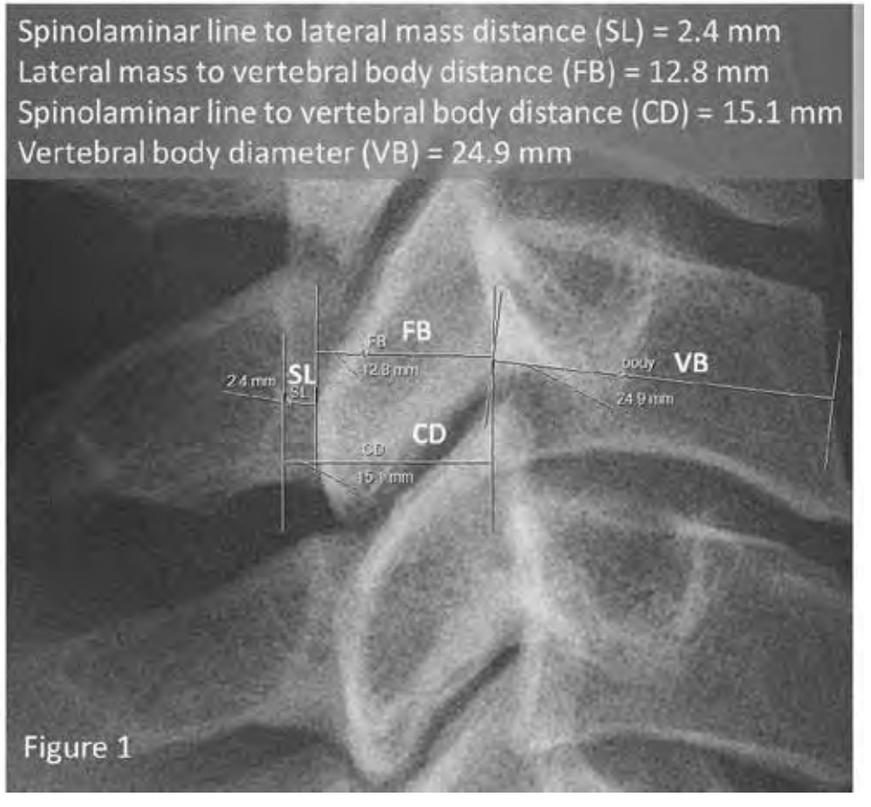
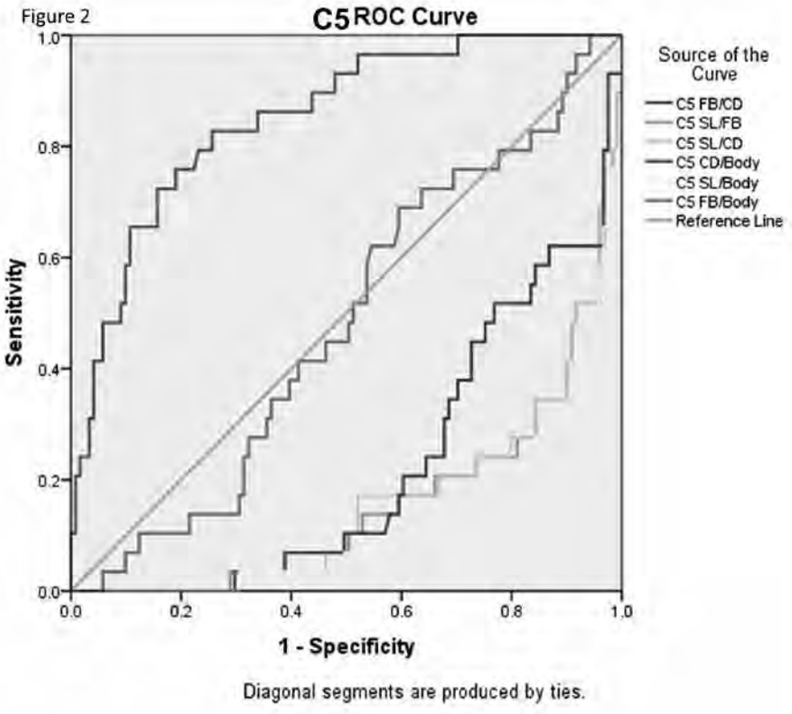


Figure 2



Diagonal segments are produced by ties.

See Disclosure Index pages 40–88.

A Novel Comprehensive MRI Classification System for Cervical Foraminal Stenosis

***Sang-Hun Lee, MD, PhD**, Seoul, Republic of Korea*
So-Young Park, MD, Seoul, Republic of Korea
Ki-Tack Kim, MD, Seoul, Republic of Korea
Sang-Phil Hwang, MD, Seoul, Republic of Korea
Soo-Jin Jang, MD, Seoul, Republic of Korea
Jeffrey C. Wang, MD, Los Angeles, CA

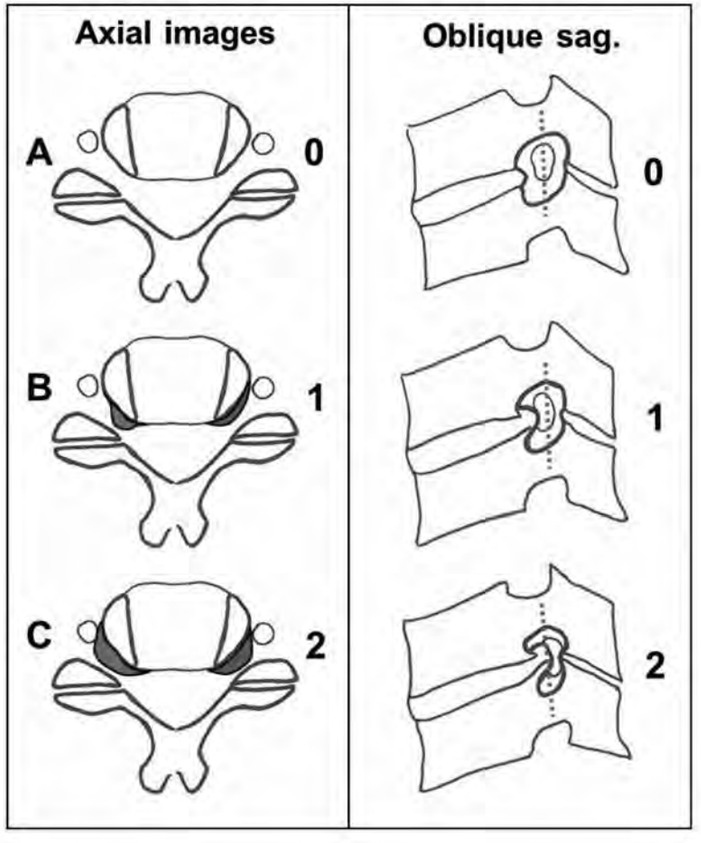
Introduction: Although cervical radiculopathy emanating from foraminal stenosis (FS) is very common clinical entity, there exists no clear guideline to describe the shape and degree of FS. MRI studies using oblique sagittal images (OSI) of the cervical spine can evaluate the cervical foramen. A comprehensive classification system considering both morphological features and the degree of the nerve root compression has not yet been described. The goal of this study is to propose a novel, reliable, and comprehensive MRI classification system for cervical FS.

Method: We retrospectively analyzed 50 consecutive patients (a total of 400 cervical foramina, from C3/4 to C6/7) with cervical radiculopathy with MRI studies demonstrating FS. Two independent reviewers (a spine surgeon and a musculoskeletal radiologist having more than ten years clinical experience) blindly classified the cervical FS by the authors' classification system (Figure 1). 1) Morphological characteristics on the T2 axial images (T2AI) were divided into A: no stenosis, B: focal type (compression area < 50% of foramen length), or C: diffuse type (> 50%). 2) Degree of nerve root compression was graded both on T2AI and T2OSI. On T2AI, the grade was 0 (no compression), 1 (maximal compression of the nerve root < 50% compared with the extra-foraminal root diameter), or 2 (> 50% compression). On T2OSI, the grade was 0, 1 (maximal compression of nerve root does not pass the midline of interpedicular space) or 2 (compression passes over the midline or severe nerve root deformation). The classification was performed by two settings on the same foramen; setting 1 - T2AI only (both morphology and degree of compression) and setting 2 - using both T2AI (morphology) and T2OSI (degree of compression) separately (Figure 2). Inter- and intra-observer reliability (Inter-OR and Intra-OR) of morphology (A, B, or C), degree of nerve root compression (0, 1, or 2) and classified types (A0~C2) were analyzed using kappa statistics.

Results: The morphological grade of the foramen on T2AI showed that the Intra-OR was outstanding (κ = 0.81–0.92) and the Inter-OR is good (κ = 0.67–0.88). The degree of the nerve root compression showed outstanding Intra-OR on the T2AI (κ = 0.79–0.91) and on T2OSI (κ = 0.89–0.94). The Inter-OR of the degree of nerve root compression was higher in T2OSI (κ = 0.69–86) than in T2AI (κ = 0.55- 0.80). Based on the authors' classification system, a total of five types of cervical FS were classified (A0, B1, B2, C1, C2). Intra-OR between the classification using setting 1 and 2 was almost perfect (κ = 0.92–0.94). But inter-OR was higher in the classification using setting 2 than setting 1 (κ = 0.83:0.63).

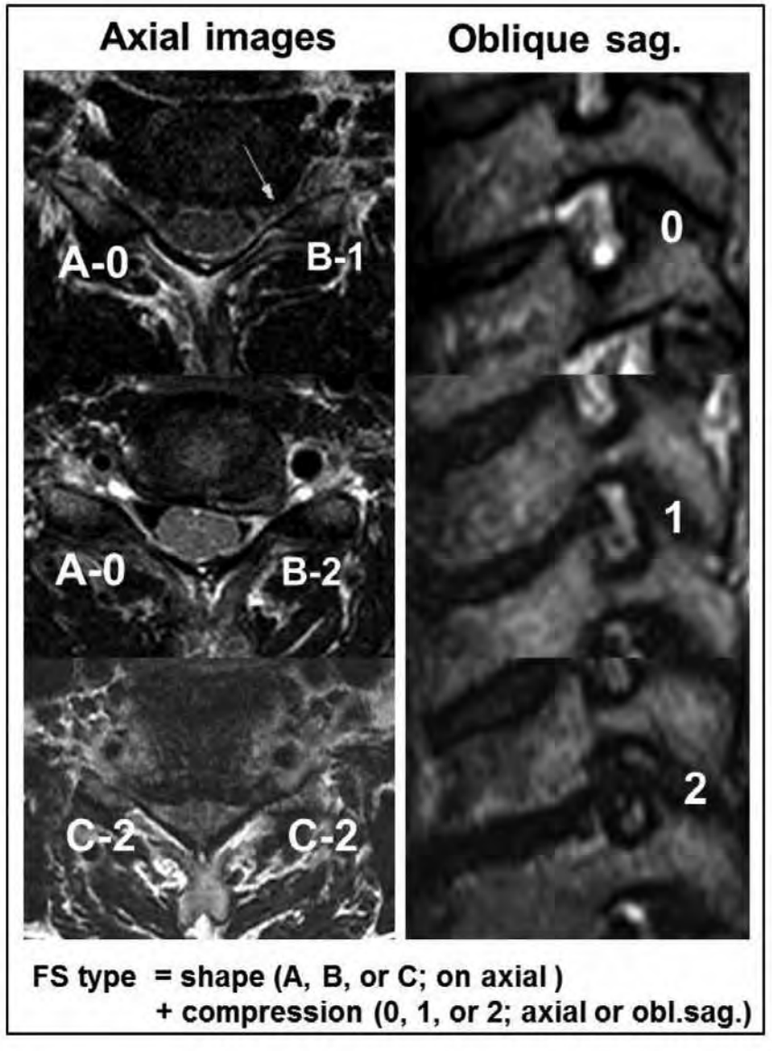
Conclusions: The authors' novel classification system could be a simple and reliable system to evaluate both the shape and degree of cervical FS using T2 axial images with/without OS images. The use of T2 OS images in combination with T2 axial images was better to grade the degree of nerve root compression than axial images only. The relevance of this system with clinical findings and treatment strategy should be further studied.

Figure 1.



See Disclosure Index pages 40–88.

Figure 2.



The Total Cost to the Healthcare System for the Treatment of Cervical Myelopathy

***Gregory D. Schroeder, MD**, Philadelphia, PA*
Mark F. Kurd, MD, Philadelphia, PA
Kristen E. Radcliff, MD, Philadelphia, PA
Jason W. Savage, MD, Chicago, IL
Jeffery A. Rihn, MD, Philadelphia, PA
D. Greg Anderson, MD, Philadelphia, PA
Alan S. Hilibrand, MD, Philadelphia, PA
Alexander R. Vaccaro, III, MD, PhD, Philadelphia, PA
Christopher K. Kepler, MD, MBA, Philadelphia, PA

Introduction: Cervical myelopathy is a common reasons patients over 65 years of age undergo cervical spine surgery, and in recent years there has been an increased awareness in the need to deliver not only high quality, but also cost effective treatment. Commonly this is reported as the cost per quality-adjusted life year gained, however, this method fails to account for the cost of complications associated with untreated cervical myelopathy. Cervical myelopathy is a progressive disease, and if left untreated, over time it may lead to an increase in overall healthcare expenditures. The purpose of this study is to compare the total health care costs for patients treated with and without surgery for cervical myelopathy.

Methods: The Center for Medicare and Medicaid Services Carrier File for the years 2005–2012 was reviewed using the PearlDiver Technologies database (Warsaw, IN). This file represents the 5% sampling of physician billings to Medicare across all service locations, and it was used to identify all patients with a new diagnosis of cervical myelopathy by ICD-9 code. All patients were required to have had 12 months without the diagnosis of cervical myelopathy prior to the index diagnosis, and after the initial diagnosis, the diagnosis must have been reported twice within the next 12 months. Patients were separated by operative and non-operative treatment, and the total healthcare expenditures per patient were collected and normalized to 2012 dollars. To ensure at least one year of follow-up, only patients with a new diagnosis prior to December 31, 2011 were included, and because of the drastic increase in healthcare expenditures at the end of life, only patients who were alive at the end of the study period were included in the cost analysis.

Results: A total of 3,191 patients met inclusion criteria, and 1,783 (55.87%) underwent surgical treatment. Compared to patients who underwent surgery, patients treated without surgery were more likely to be male (58.05% vs. 48.24%, p = 0.001), and have an age-adjusted Charleson comorbidity index of 12 or more (43.20% vs. 35.45%, p = 0.0001). A six-year cost analysis could be performed on the 307 patients diagnosed in 2006, and no significant difference between the total healthcare expenditures between patients treated with and without surgery ($166,992 vs. $153,556, p = 0.45) was identified. Similar results were identified for patients diagnosed with myelopathy in 2007 and 2008 (Table 1).

See Disclosure Index pages 40–88.

Surgical treatment resulted in an average increase in healthcare costs of $23,423.90 in the first year ($p < 0.001$); however, there was a non-significant decrease in total healthcare expenditures between the groups for all of the following years (Table 2).

Conclusion: In spite of the upfront cost of surgery, after three years, the total healthcare expenditures of patients treated with or without surgery for cervical myelopathy are similar. When evaluating the cost-effectiveness of surgery for myelopathy, it is critical to look beyond the cost of the surgery itself, and understand that there are substantial costs associated with failing to address this disease.

Table 1. Average total healthcare costs per patient from the time of diagnosis through 2012

	2006	**2007**	**2008**	**2009**	**2010**	**2011**
Non-operative	$153,556	$148,035	$119,884	$54,838	$39,288	$23,899
Operative	$166,192	$151,756	$116,512	$97,512	$65,313	$49,615
Net cost of surgery	$12,636	$3,721	-$3,372	$42,674	$26,025	$25,717
P Value	0.45	0.86	0.84	< 0.001	< 0.001	< 0.001

Table 2. Average total healthcare dollars spent per year per patient after the diagnosis of cervical myelopathy

	Non-operative treatment	Operative Treatment	Total increase in healthcare dollars spent with operative treatment	P Value
Less than one year	$17,387	$43,677	$26,290	< 0.001
One to two years	$18,309	$18,305	-$4	0.35
Two to three years	$20,130	$18,259	-$1,871	0.32
Three to four years	$21,645	$19,291	-$2,354	0.15
Four to five years	$15,634	$15,262	-$372	0.27
After five years	$10,704	$9,068	-$1,637	0.18

Sagittal Imbalance Might Be a Risk Factor of Increasing Post Laminoplasty Kyphosis

Yoshitaka Suzuki, MD, *Nagoya, Japan*
Tetsuya Ohara, MD, Nagoya, Japan
Taichi Tsuji, MD, Nagoya, Japan
Tosiki Saito, Nagoya, Japan
Ayato Nohara, MD, Nagoya, Japan
Ryoji Tauchi, MD, Nagoya, Japan
Noriaki Kawakami, MD, Nagoya, Japan

Introduction: The cervical sagittal changes that occur after laminoplasty have been documented in numerous studies. Many studies reported risk factors of kyphotic change after laminoplasty; one particular study utilized T1 slope as a reference for this. However, these are only regional measurements and don't include the overall spinal alignment. Furthermore, T1 slope is very difficult to identify on lateral x-ray. The aim of this study was to analyze the change of sagittal cervical alignment after laminoplasty and to determine the correlation of changes on C2-C7 sagittal alignment and whole spinal sagittal parameters preoperative and post-laminoplasty.

Materials/Methods: The subjects were 81 patients (M = 53, F = 28) with a mean age of 64.7 ± 11.1 years old. All underwent non-instrumented laminoplasty for a diagnosis of cervical spondylotic myelopathy. Preoperatively, sagittal curvature of the cervical spine was measured on lateral plain x-ray films using the Cobb method (C2-C7). In the stage one of the study, the patients were divided into three groups preoperatively: lordotic (< -5°; n = 51), neutral (-5° to 5°; n = 19), and kyphotic (> 5°; n = 11). The cervical sagittal alignment of each group was analyzed to determine if there was a change in each group. In the stage two of the study, we analyzed C2-7 changes sagittal alignment and categorized into three groups. We define lordotic change if increasing lordosis more than minus 10 degree, no change if within minus 10 to 10 degrees, and kyphotic change if increasing kyphosis more than plus 10 degrees. These changes were tabulated and compared to the following spinal parameters: C2 slope, C7 slope, center of the gravity (COG), thoracic kyphosis, lumbar lordosis, sacral slope (SS), sagittal vertical axis (SVA), and pelvic incidence (PI). Measurements were made preoperatively and two years postoperatively.

Results: A postoperative decrease in lordosis occurred in 67.7% of patients in the lordotic group and 63.1% in the neutral group, while 63.7% in the kyphotic group showed a decrease in kyphosis. Eighteen patients (22.2%) showed increasing kyphosis. The kyphotic changes in cervical sagittal alignment were correlated with large C7 slope, large cervical lordosis, less lumbar lordosis, large C2, C7, and COG SVA, lower SS and older patient, but not with thoracic kyphosis and PI.

See Disclosure Index pages 40–88.

Conclusion: This study demonstrated that cervical sagittal curvatures might be influenced by not only the laminoplasty itself, but also any causative factors that can contribute to preoperative abnormal cervical curvatures. Instead of focusing only on the postoperative malalignment of the cervical sagittal curvatures, surgeons should consider sagittal parameters of the entire spine when formulating their surgical strategy.

A 30-Meter Walking Test as a Measure of Cervical Spondylotic Myelopathy Severity: Test Characteristics and Results from Two Multicenter Cohort Studies

Parker E. Bohm, BA, BS, Kansas City, KS
Michael G. Fehlings, MD, PhD, Toronto, ON, Canada
Branko Kopjar, MD, PhD, Seattle, WA
***Paul M. Arnold, MD**, Kansas City, KS*

Introduction: Cervical Spondylotic Myelopathy (CSM) is a progressive, degenerative condition and the most common cause of spinal cord dysfunction worldwide. A timed 30-meter walking test (30MWT) has previously been recommended for testing disease severity in patients with CSM because of its objectivity, quantitative nature, and ease of administration. However, very little has been reported in the literature regarding its use.

Methods: We utilized data from two prospective CSM cohort studies to analyze properties of the 30MWT test for patients with CSM. All patients had symptomatic CSM and subsequently underwent surgical decompression. Each patient completed 3 trials of the 30MWT at baseline as well as 6, 12, and 24 months following surgery. Repeated measures analysis of variance (ANOVA) was used to examine test reproducibility, and Spearman's correlation coefficients were used to compare the results of the 30MWT to other validated scales used in the CSM population. Additionally, we used paired T-tests to assess the difference between baseline and 6-month post-operative 30MWT times. Standardized response mean was used to measure responsiveness. Patients who were physically unable to complete the 30MWT were assigned the highest baseline walking time for inclusion in the statistical analysis.

Results: Moderate correlation (-0.551) was seen between the 30MWT and the modified Japanese Orthopedic Association (mJOA) scale as well as the Nurick score (0.468) at baseline (Table 1). Low correlation was found between the 30MWT and the NDI (0.253) as well as the physical component of the Short-Form 36 Health Survey (-0.380). Walking time did not vary significantly between the three trials at baseline ($p = 0.66$). At 6 months post-op, patients completed the 30MWT 9.9 seconds faster compared to baseline ($p < 0.0001$). When the study population was restricted to the top 50% in terms of walking time, correlation with the mJOA and the Nurick scale increased to 0.601 and -0.557 at baseline, respectively.

Conclusions: The results from two prospective cohort studies demonstrate that the 30MWT is reproducible and moderately to highly correlated with other validated scales used with CSM patients. Because the 30MWT is simple, quick, affordable, and assess gait parameters not accurately assessed by other standard metrics, it should be used as an ancillary test for CSM patients.

See Disclosure Index pages 40–88.

Table 1. Correlations between 30MWT and other selected scales used in the CSM population

Comparator with 30MWT	Number of patients for comparison at Baseline	Walking Test Correlation at Baseline	Number of Patients for Comparison at 6 Months	Walking Test Correlation at 6 Months, N
Nurick	680	0.468	573	-0.369
mJOA	680	-0.551	573	-0.520
NDI	593	0.253	513	0.304
SF-36v2 PCS	663	-0.380	563	-0.351
SF-36v2 MCS	663	-0.274	563	-0.286
All correlations were statistically significant at $p < 0.0001$. Nurick indicates Nurick scale; mJOA, modified Japanese Orthopedic Association; NDI, Neck Disability Index; SF-36v2, Short-form 36; PCS, physical component score; MCS, mental component score				

Disability and Impairment of the Upper Limb and how they define the Patient with Degenerative Cervical Myelopathy (DCM)

Sukhvinder K. Kalsi-Ryan, BScPT, MSc, PhD*, Toronto, ON, Canada*
Jerri M. Clout, BS, Toronto, ON, Canada
Pouya Rostami, BS, Toronto, ON, Canada
Eric M. Massicotte, MD, Toronto, ON, Canada
Mohammed F. Shamji, MD, Toronto, ON, Canada
Michael G. Fehlings, MD, PhD, Toronto, ON, Canada

Introduction: Individuals with degenerative cervical myelopathy (DCM) can present with profound disability. One main consequence of DCM is loss or reduction of upper limb function. Identifying and validating methods for assessment of DCM is imperative for management of this disease. The World Health Organization's International Classification of Functioning defines impairment as loss of body structures and function, and disability as loss of ability. This study defines upper limb impairment as neurological deficit, characterized by sensory, motor and complex hand function tasks. Upper limb disability is defined as the inability to perform activities of daily living and characterized by the *Quick*DASH. The objectives of this study were to define relationships between impairment and disability of the upper limb; and between duration of symptoms and disability of the upper limb.

Methods: A prospective cross sectional study enrolling 140 patients at time of DCM diagnosis was conducted. Baseline assessments administered to quantify upper limb impairment and disability were: modified Japanese Orthopaedic Assessment (mJOA) to stratify sample according to severity of DCM; the Cervical Myelopathy Hand Measure (CMHM) to quantify impairment in sensation, strength and dexterity of the hand; and *Quick* Disability of the Arm Shoulder and Hand (*QuickDASH*) to quantify upper limb disability. Demographics and duration of symptoms were documented.

Results: N = 140; 58%-male, mean age-58 years. Pearson correlation coefficients between CMHM and *Quick*DASH (Table 1) revealed significant relationships between mild severity (mJOA score 15-17) subgroup for strength, sensation and dexterity, the moderate severity subgroup (mJOA score 12-14) with strength and dexterity, and the severe subgroup (mJOA score < 12) with strength. The covariate (mJOA UL) was significantly related to *QuickDASH* ($F(1, 58) = 6.939$, $p = 0.011$) indicating a duration of symptoms of greater than 12 months having an important effect on upper limb disability, ($F(27, 58) = 1.831$, $p = 0.027$) Figure 1.

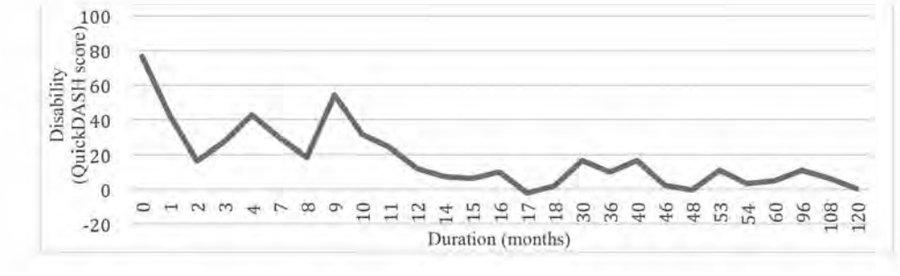
See Disclosure Index pages 40–88.

Conclusions: Strength, sensation and dexterity play a defining role in disability of the upper limb and are discriminant across all severity groups. Duration of symptoms has a significant impact on self-perceived disability where a longer duration results in diminished disability. Impairments in sensation, strength and dexterity are most significant in the early stages of DCM, and contribute to disability. Clinical Implications: 1) there is a greater understanding of presentation of upper limb disability when underlying impairment is also defined; 2) both *Quick*DASH and CMHM are valid, useful ancillary measures in defining DCM; and 3) duration of symptoms is a significant indicator that should be accurately defined and considered in clinical decision making. The QuickDASH, CMHM and the variable of duration of symptoms are useful to complement the findings of the mJOA specifically for mild DCM patients. The 12 month point is indicative that the process of physical and mental adaptation can take up to one year, making the first year an optimal time to initiate a treatment plan even in those patients that present with mild DCM.

Table 1. Relationship between QuickDASH and clinical measures of upper limb impairment after global stratification of the population using total mJOA scores

mJOA Total	**Mild (≥15) N=52**		**Moderate (12-14) N=57**		**Severe (≤11) N=31**	
	r	*p*	*r*	*p*	*r*	*p*
Quick DASH & Sensation	-0.347635	0.01	-0.10226997		-0.0586346	
Quick DASH & Strength	-0.574096	<0.001	-0.36119131	0.005	-0.4819897	0.006
Quick DASH & Prehension	0.2858157	0.038	0.043462503	0.029	0.07220395	

Figure 1. The relationship between self-reported disability and the duration of symptoms when controlling for mJOA by assigning it as the covariate
Note: the duration axis is not uniform



Noninvasive Evaluation by Magnetospinography of Electrophysiological Activity in the Cervical Spine after Peripheral Nerve Stimulation in Humans

***Satoshi Sumiya, MD**, Tokyo, Japan*
Shigenori Kawabata, PhD, Tokyo, Japan
Tsuyoshi Yamada, Tokyo, Japan
Toshitaka Yoshii, Tokyo, Japan
Tsuyoshi Kato, MD, PhD, Tokyo, Japan
Atsushi Okawa, Tokyo, Japan

Purpose: Conventional electrophysiological diagnostic techniques such as somatosensory evoked potentials, electromyography, and motor evoked potentials cannot be used to diagnose small lesions of the spinal cord or spinal nerves. Although nerve potential recordings using the inching technique can be used to reveal the position of lesions, electrodes must be placed close to the nerves to obviate distortion of currents by bone and other tissue. Thus, this invasive technique is typically used for only intraoperative measurements. In contrast, magnetic fields generated by neuronal currents are less affected by surrounding tissues and so may be used for high-resolution surface recordings of neural activity. We have developed a magnetospinography system with highly sensitive superconducting quantum interference device sensors for noninvasive electrophysiological analysis of spinal cord and spinal nerve function. In this study, we imaged neural activity in the cervical spine by surface magnetospinography following median nerve stimulation.

Methods: Ten healthy volunteers (mean age, 31.1 years; range 21–45 years) were placed relaxed in the supine position on a newly developed 120-channel magnetospinograph. Neuromagnetic fields were measured at the dorsal neck surface in response to surface stimulation of the median nerve at the elbow (3 Hz; monophasic square-wave pulses; 0.3 ms width; constant current of 3.6–11 mA, clearly above the motor threshold for each subject) and 2,000–4,000 responses were averaged. Current sources producing the magnetic fields were estimated using spatial filtering methods, and the estimated current field was superimposed on x-ray images of the cervical spine.

Results: Neuromagnetic fields were successfully recorded over the skin surface of all subjects. Estimated electric currents entered the lateral cervical spine from C4/5 to Th1/2. In the spinal canal, these signals changed direction and propagated caudal to cranial at 51.7 m/s to 96 m/s (mean, 74.9 m/s). The largest estimated currents were observed at the C6/7 and C7/Th1 intervertebral foramen.

Discussion: Our magnetospinography system could noninvasively image electric activity entering the C5-C8 and Th1 nerve roots and ascending the spinal cord. The originating nerve roots were consistent with the conduction pathway of the median nerve, and the conduction velocities in the spinal cord were equivalent to previous estimates. We propose that magnetospinography can contribute to the diagnosis and treatment of spinal cord and spinal nerve disorders.

See Disclosure Index pages 40–88.

Risk and Cost of Reoperation after Single Level Posterior Cervical Foraminotomy: A Large Database Study

Arash J. Sayari, BS, Los Angeles, CA
Alexander Tuchman, MD, Los Angeles, CA
Jeremiah R. Cohen, BS, Los Angeles, CA
John C. Liu, MD, Los Angeles, CA
Frank L. Acosta, MD, Los Angeles, CA
Mark J. Spoonamore, MD, Los Angeles, CA
Thomas C. Chen, MD, PhD, Los Angeles, CA
Patrick Hsieh, MD, Los Angeles, CA
Zorica Buser, PhD, Los Angeles, CA
***Jeffrey C. Wang, MD**, Los Angeles, CA*

Introduction: Cervical radiculopathy is a common symptom of degenerative cervical disease or lateral disc herniations, initially managed with physical therapy targeted injections. When conservative management fails, spine surgeons may select posterior cervical foraminotomy (PCF), an effective method of alleviating cervical radiculopathy symptoms, with distinct advantages over fusion procedures. However, there are concerns that PCF may be associated with high reoperation rates. Thus, we aimed to examine the risk of undergoing another cervical spine surgery following single level PCF, and to analyze the costs of such reoperations.

Methods: We searched orthopedic patient records from the standard analytical files of Medicare and United Healthcare (private insurance). Using inpatient and outpatient billing records, we created cohorts of patients who underwent single-level PCF, and also had various reoperations of interest, within 1, 2, and 4 years of follow-up. We also identified the per patient average charge (PPAC) for each reoperation cohort in the Medicare dataset.

Results: In the Medicare group, the incidence of any reoperation was 8.3%, 9.8%, and 10.5% within 1, 2, and 4 years of follow-up, respectively. Within 2 years of PCF, those < 65 years old were significantly more likely to undergo a second surgery, versus those ≥ 65 years old ($p < 0.001$). There was no statistically significant difference in the rate of reoperation in regards to sex, although the trend was toward a higher incidence in females. The PPAC was $8,520 for the initial PCF procedure. When a second cervical surgery was performed, the PPAC was $70,349 for anterior fusion, $15,760 for posterior decompression alone, and $77,976 for posterior decompression and fusion. In the private insurance group, the incidence of any reoperation was 13.6%, 16.7%, and 17.0% within 1, 2, and 4 years of follow-up, respectively. The overall risk of reoperation was significantly higher in the private insurance dataset than the Medicare dataset at 1, 2, and 4 year follow-up ($p <0.001$). There was also a significantly higher rate of posterior decompression and posterior decompression and fusion following PCF in the private insurance dataset compared to the Medicare dataset at 1, 2, and 4 year follow-up ($p < 0.001$).

Conclusion: The overall incidence of another cervical spine operation after single-level PCF was slightly higher in the Medicare population to that in previous literature, but much higher in the private insurance population, indicating that there are other factors that determine revision surgery after PCF. All previous literature regarding cervical spine reoperation rates after PCF reported rates much lower than the private insurance group in this study, and the most common reoperation after PCF varied between the Medicare and private insurance datasets. Costs varied widely based on the procedure performed. This study provides pertinent information that surgeons can use to discuss the risk of reoperation with their patients.

See Disclosure Index pages 40–88.

Over 10-Year Aggravation of Cervical Spine Instabilities in Rheumatoid Arthritis: A Prospective Cohort Study of Outpatients

***Hiroaki Hirata, MD, PhD**, Kobe, Japan*
Takashi Yurube, MD, PhD, Kobe, Japan
Masatoshi Sumi, MD, PhD, Kobe, Japan
Yoshiki Terashima, MD, Kobe, Japan

Introduction: It is essential to understand the natural history of cervical spine involvement in rheumatoid arthritis (RA). A prospective over 10-year cohort study was designed to clarify the aggravation of cervical spine instabilities which might introduce severe compression myelopathy in patients with RA.

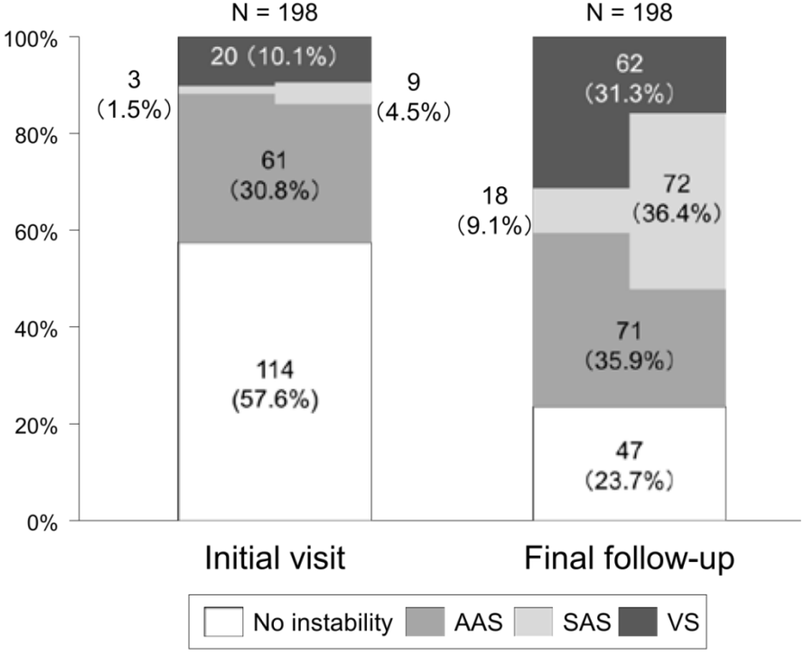
Methods: Radiographic cervical spine findings were classified into three instabilities: atlantoaxial subluxation (AAS: atlantodental interval [ADI] >3 mm), vertical subluxation (VS: Ranawat value < 13 mm), and subaxial subluxation (SAS: irreducible anteroposterior translation ≥2 mm). "Severe" extent of instabilities was defined as AAS with ADI ≥10 mm, VS with Ranawat value ≤ 10 mm, and SAS with translation ≥ 4 mm or at multiple levels. Cervical canal stenosis was further defined as the space available for the spinal cord (SAC) ≤ 13 mm due to "severe" AAS or "severe" VS or SAC ≤ 12 mm due to "severe" SAS. 634 outpatients diagnosed with "definite" or "classical" RA were assigned in this follow-up, and 503 of 634 patients were identified as those without "severe" cervical spine instabilities at baseline. 198 of 503 patients were prospectively followed for more than 10 years (follow-up rate, 39.4%; follow-up period, 11.2 ± 1.5 years). The incidence of the progression of prior instabilities and the development of additional instabilities including ''severe'' instabilities and cervical canal stenosis were investigated.

Results: The number of patients without any cervical spine instability decreased from 114 cases (57.6%) to 47 cases (23.7%) during over 10 years (P < 0.01). While the prevalence of AAS was not significantly changed, that of VS and SAS significantly increased from 10.1% to 31.3% and from 4.5% to 36.4%, respectively (P < 0.01) (Figure 1). Patients with AAS at baseline developed VS in 32.8% at the final follow-up, which was higher than those initially without instability in 19.3% (P = 0.046). 65.0% of patients with VS and 42.6% with AAS showed the development of SAS at the final follow-up more frequently than 26.3% without instability (P < 0.01 and P = 0.03, respectively). Further, 56 of 198 followed patients (28.3%) had "severe" instabilities with some combinations at the final follow-up. In patients initially with VS, the incidence of "severe" instability was 75.0%, which was significantly higher than in those without instability (14.0%) and with AAS (37.7%) (both P < 0.01). In addition, cervical canal stenosis was detected in 18.2% of 198 followed patients at the final follow-up. 40.0% of patients with baseline VS and 27.9% with baseline AAS resulted in the development of cervical canal stenosis, which was more frequent than 7.9% without instability (P < 0.01). 9 of 198 patients (4.5%) received cervical spine surgery for myelopathy during the follow-up period.

The incidence of surgery in patients with baseline VS (15.0%) and AAS (6.6%) was higher than in those without instability (1.8%) (P = 0.02 and P = 0.04, respectively) (Table 1).

Conclusion: This prospective follow-up study reveals significant increases in the incidence of VS and SAS during over 10 years. The incidence of severely aggravated instabilities, canal stenosis, and surgery in the cervical spine were consistently higher in patients with pre-existing instabilities, suggesting careful clinical follow-up of patients with cervical spine involvement in RA.

Figure 1. Changes in the incidences of cervical instabilities in 198 patients with RA during over 10 years.



See Disclosure Index pages 40–88.

Table 1. Prevalence of development of cervical spine involvement in 198 patients with RA.

		Cervical spine involvement at baseline				
	No instability (n=114)	**AAS** VS(-)SAS(±) (n=61)	**VS** AAS(±)SAS(±) (n=20)	**SAS** AAS(-)SAS(-) (n=3)	**Total** (n=198)	
Cervical involvement at final follow-up	**Instability**	**67 (58.8%)**	**61 (100.0%)**	**20 (100.0%)**	**3 (100.0%)**	**151 (76.3%)**
	AAS	44 (38.6%)	60 (98.4%)	15 (75.0%)	1 (33.3%)	120 (60.6%)
	VS	22 (19.3%)	20 (32.8%)	20 (100.0%)	0 (0.0%)	62 (31.3%)
	SAS	30 (26.3%)	26 (42.6%)	13 (65.0%)	3 (100.0%)	72 (36.4%)
	"Severe" instability	**16 (14.0%)**	**23 (37.7%)**	**15 (75.0%)**	**2 (66.7%)**	**56 (28.3%)**
	"Severe" AAS	6 (5.3%)	11 (18.0%)	2 (10.0%)	0 (0.0%)	19 (9.6%)
	"Severe" VS	9 (7.9%)	11 (18.0%)	14 (70.0%)	0 (0.0%)	34 (17.2%)
	"Severe" SAS	7 (6.1%)	6 (9.8%)	4 (20.0%)	2 (66.7%)	19 (9.6%)
	Cervical canal stenosis	**9 (7.9%)**	**17 (27.9%)**	**8 (40.0%)**	**2 (66.7%)**	**36 (18.2%)**
	Surgical intervention	**2 (1.8%)**	**4 (6.6%)**	**3 (15.0%)**	**0 (0.0%)**	**9 (4.5%)**

Operative Treatment in Patients with Suboccipital Spinal Metastasis: Is a Posterior Approach Alone Enough?

Panya Luksanapruksa, MD, *Bangkok, Thailand*
Jacob M. Buchowski, MD, MS, St. Louis, MO
David B. Bumpass, MD, St. Louis, MO
Neill M. Wright, MD, St. Louis, MO

Introduction: The incidence of suboccipital metastases is rare, but has increased due to longer life expectancy in patients with metastatic spine disease. Because of neighboring vital structures and anatomical complexity, operative treatment in this region remains a challenge. However, operative treatment can be successful in improving pain and/or neurological deficit. The purpose of this study was to examine clinical outcome and safety of operative treatment in suboccipital spinal metastasis.

Materials/Methods: Between 1999 and 2014, 17 patients with suboccipital metastases underwent posterior stabilization and fusion by using occipital plate combined with C2 pars/pedicular/laminar screws and cervical lateral mass screws. There were 5 women and 12 men with mean age of 64.8 years (48–80 years). Primary tumor pathology included lung (n = 5), breast (n = 4), urinary bladder (n = 2), multiple myeloma (n = 2), melanoma (n = 2), nasopharynx (n = 1) and renal cell (n = 1) cancers. The mean BMI was 26.6 (19-34.3). The mean Charlson comorbidity index was 9.9 (7–12). Most of lesions were found in C2 (n = 15), lateral mass of C1 (n =1) and occipital condyle/clivus (n=1). The mean preoperative Revised Tokuhashi score was 7.9 (5–13). Operative treatments were performed for surgically fit patients with a life expectancy of more than 3 months.

Results: All patients presented with severe neck pain without neurological deficit. No anterior surgery for tumour resection, debulking, and/or reconstruction was done. The median postoperative survival was 149 days. The mean operative blood loss was 247 ml (50–1100 ml) and mean operative time was 212 minutes (120–324 minutes). All patients reported marked improvement in neck pain and were able to resume daily activity living after surgery. There were three cases that had perioperative complications including urinary tract infection (n = 1), deep vein thrombosis (n = 1), cardiac arrthymia (n = 1). There was one perioperative mortality case due to myocardial infarction. No neurological complications were found. In the follow-up period, no postoperative complication occurred including implant loosening or surgical site infections. No patients required revision surgery for tumor progression, instability, or implant failure.

Conclusion: Our data indicate that posterior craniocervical fixation and fusion without anterior tumor resection, debulking, and/or reconstruction for treating suboccipital metastases cases is not only safe, but also results in good clinical outcomes especially with respect to reducing neck pain and improving quality of life in term.

See Disclosure Index pages 40–88.

The Effects of Anticoagulation or Antiplatelet Agents in Cervical Spine Surgery Patients

***Jong-Hyun Ko, MD**, Jeonju, Republic of Korea*
Ju-Rang Lee, MD, Jeonju, Republic of Korea
Kyung-Jin Song, MD, Jeonju, Republic of Korea

Introduction: It is well known that the use of anticoagulants or antiplatelet agents is associated with perioperative risk of blood loss in orthopedic surgery. However, the recommendation about discontinuation of such medications before cervical spine surgery and its specific effect on blood loss are still controversial.

Material and Methods: A retrospective study was conducted on 449 patients who underwent cervical spine surgery due to degenerative cervical spine disease from January 2009 to December 2014. The patients who took Warfarin were assigned to Group A (n = 8), clopidogrel as Group B (n = 22), aspirin as Group C (n = 71, C1 = 34; preoperative aspirin-discontinued, C2 = 37; continued group), and these combination as Group D (n = 20). We analyzed the sum of the infused solution and the transfused blood intraoperatively, and the amount of postoperative drained blood in each group. In addition, we evaluated the difference of the amount of the drained blood in the operation levels.

Results: Before the surgery, almost all patients who took Warfarin or clopidogrel had at least 7 days of discontinuation period, and 3 to 7 days conversion period to switch to LMWH injection. Aspirin-discontinued group had 5.7 days of discontinuation period averagely. Anticoagulants or antiplatelet agents were resumed on the day of removal of inserted drain (mean 3.6 days). Before removing drain, LMWH was administrated once or twice a day. In the aspirin-continued group (n = 37), the aspirin was restarted 1.2 days after surgery on average. The sum of the infused fluid solution and the transfused blood was largest in Group D, but it was not statistically significant (P = 0.099). The amount of postoperative drained blood was also greatest in Group D. All of the experimental group were statistically significant in the amount of postoperative drained blood (P value; A = 0.01, B < 0.01, C1 = 0.023, C2 < 0.01, D < 0.01). Furthermore, comparing pre-operative aspirin-discontinued group (C1) and continued-group (C2), the amount of postoperative drained blood showed statistically significant difference (P = 0.023). However, there was not any statistically significant difference in the amount of intraoperative and postoperative blood loss between aspirin-discontinued (C1) group and continued (C2) group after short level (one or two levels) ACDF.

Conclusions: It is critical for CV diseased patients to use anticoagulation or antiplatelet agent in order to prevent life-threatening complications. This result shows that discontinuation of antiplatelet agents or anticoagulants will be helpful to reduce the intraoperative blood loss even though there is an increase of postoperative drainage. Furthermore, if possible, it is necessary to discontinue the use of aspirin at least 5 days prior to the surgery since there is a significant postoperative blood loss in aspirin-continued group except for the short level (one or two levels) ACDF.

Morbidity and Mortality Associated with Transoral Approaches to the Cervical Spine

***Jeremy Steinberger, MD**, New York, NY*
Dante M. Leven, DO, PT, Brooklyn, NY
Branko Skovrlj, MD, New York, NY
Nathan J. Lee, BS, New York, NY
Parth Kothari, BS, New York, NY
Javier Z. Guzman Tejero, BS, MD, New York, NY
John I. Shin, MD, New York, NY
John M. Caridi, MD, New York, NY
Samuel K. Cho, MD, New York, NY

Introduction: Anterior approaches to the cervical spine can be an elegant and practical way to address anterior pathology. The transoral approach provides a direct access to C1, C2, and less commonly C3 without manipulation of critical structures, however, due to its rarity and unfamiliar anatomy, significant morbidity and mortality exist. The aim of this study was to analyze morbidity and mortality in patients undergoing transoral approaches to the cervical spine using a large national database.

Materials/Methods: American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database was queried for all patients ≥ 18 years old undergoing transoral approaches to the cervical spine registered in the database between 2008-2012. Patients were identified by the Current Procedural Terminology (CPT) codes in the ACS NSQIP database. Univariate and multivariate analyses were performed to assess morbidity and mortality associated with the procedure.

Results: 126 patients undergoing cervical spine surgery via transoral approach were identified, of which 27 patients (21.43%) had a postoperative complication, and three patients died (2.38%). Six (4.76%) had a pulmonary complication, two (1.59%) had a venous thromboembolism, two (1.59%) had a urinary tract infection, three (2.38%) had sepsis, and three (2.38%) had a wound complication. 20 patients required an intraoperative or postoperative blood transfusion (15.87%). Eight patients (6.35%) returned to the operating room (Table 1). Patients with operative time greater than four hours had a complication rate of 29.63%, compared to 7.07% in patients with operative time less than four hours (p = 0.001). Patients with length of stay greater than five days had a complication rate of 55.56%, compared to 16.16% in patients with length of stay less than five days (p < 0.0001) (Table 2). On multivariate analysis, there was an increased risk of complications with operative time greater than four hours (OR 7.794, 95% CI 1.835–33.1, p = 0.0054) and total length of stay greater than five days (OR 7.461, 95% CI 2.377–23.42, p = 0.0006).

See Disclosure Index pages 40–88.

Conclusions: Transoral approaches to the anterior cervical spine carry significant risks of morbidity and mortality. Maintaining operative time below four hours and length of stay less than five days may decrease morbidity and mortality.

Table 1. 30-Day Postoperative Outcomes for Transoral Surgery

Total N	**126**	
	N	**%**
Any Complicaton	27	21.43%
Death	3	2.38%
Pulmonary Complication	6	4.76%
Renal Complication	0	0.00%
CNS Complication	0	0.00%
Peripheral Nerve Injury	0	0.00%
Cardiac Complication	0	0.00%
VTE	2	1.59%
UTI	2	1.59%
Sepsis	3	2.38%
Wound Complication	3	2.38%
Graft Failure	1	0.79%
Intra/postoperative Blood Transfusion	20	15.87%
Other Outcomes		
Return to OR	8	6.35%
Unplanned Reoperation (2011-2012)	6	4.76%
Unplanned Readmission (2011-2012)	7	5.56%
LOS > 5 Days	31	24.60%

Table 2. Comorbidities and Operative Variables for those with and without Any Complication

	Total		**No Complication**		**Any Complication**		**P value**
Comorbidities	**N**	**%**	**N**	**%**	**N**	**%**	
Pulmonary Comorbidity	6	4.76%	3	3.03%	3	11.11%	0.081
Cardiac Comorbidity	70	55.56%	51	51.52%	19	70.37%	0.081
Peripheral Vascular Disease	3	2.38%	1	1.01%	2	7.41%	0.053
Renal Comorbidity	2	1.59%	2	2.02%	0	0.00%	0.457
Impaired Sensorium	0	0.00%	0	0.00%	0	0.00%	NA
Neuromuscular Injury	4	3.17%	2	2.02%	2	7.41%	0.157
Stroke	3	2.38%	2	2.02%	1	3.70%	0.611
Steroid Use	5	3.97%	4	4.04%	1	3.70%	0.937
Recent Weight Loss	1	0.79%	0	0.00%	1	3.70%	0.055
Bleeding Disorder	2	1.59%	2	2.02%	0	0.00%	0.457
Preoperative Blood Transfusion	2	1.59%	2	2.02%	0	0.00%	0.457
Operative Variables							
Total RVU, mean (SD)	51.93 (20.45)		51.19 (19.04)		54.64 (25.18)		0.440
Operative Time > 4 hours	15	11.90%	7	7.07%	8	29.63%	**0.001**
LOS > 5 Days	31	24.60%	16	16.16%	15	55.56%	**<0.0001**

Preoperative Functional Status as a Predictor of Morbidity and Mortality following Elective Cervical Spine Surgery

Shobhit V. Minhas, MD, New York, NY
Aditya S. Mazmudar, BA, Fairfax, VA
***Alpesh A. Patel, MD, FACS**, Chicago, IL*

Introduction: Cervical spine surgery has been demonstrated to be effective however a critical balance of risks and benefits remains at the heart of surgical decision-making. It is, therefore, imperative for surgeons to identify safe surgical candidates through risk stratification strategies. Preoperative functional status is an important factor, which may play a significant role in the perioperative course following these procedures. However, few studies have analyzed the role of this variable in a large patient population. In this study, our goals are to determine the rates of functionally dependent patients undergoing elective cervical spine procedures and to assess the effect of functional dependence on 30-day morbidity and mortality using a large, national cohort.

Methods: A retrospective analysis of the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) data files from 2006 to 2013 was conducted. Patients undergoing the anterior cervical fusions, posterior cervical fusions, cervical laminectomy, cervical laminotomy, cervical discectomy, or corpectomy were selected. Only patients undergoing elective procedures were analyzed. Patients were divided based on the following preoperative functional status parameters: 1) Independent (IG), comprising patients not requiring assistance or any equipment for activities of daily living (ADL), 2) Partially dependent (PDG), including those with equipment such as prosthetics, equipment, or devices and requires some assistance from another person for ADLs, and 3) Totally dependent (TDG), in which patients require total assistance for all ADLs. Patient demographics, comorbidities, and 30-day postoperative complications were compared among the three groups through Univariate analysis. Multivariate logistic regression models were then conducted to analyze the independent association of functional dependence on 30-day complications when controlling for procedure and comorbidity variances.

Results: A total of 24,357 patients were analyzed, including 23,620 (97.0%) IG, 664 (2.7%) PDG, and 73 (0.3%) TDG patients. Dependent patients were significantly older and had higher rates of all comorbidities ($p < 0.001$) other than obesity ($p = 0.214$). 30-day complication rates were higher for all complications ($p < 0.001$) other than neurological ($p = 0.060$) and surgical site complications ($p = 0.668$) (Figure 1). When controlling for type of procedure and for disparities in patient preoperative variables, multivariate analyses demonstrated that functional dependence was independently associated with sepsis [odds ratio (OR) 6.40, $p < 0.001$], pulmonary (OR 4.13, $p < 0.001$), venous thromboembolism (OR 4.27, $p < 0.001$), renal (OR 3.32, $p < 0.001$), and cardiac complications (OR 4.68, $p = 0.001$), along with mortality (OR 8.31, $p < 0.001$) (Table 1).

Conclusions: Functional dependence was associated with a significantly increased risk of almost all 30-day complications analyzed including mortality following elective cervical spine procedures. Spine surgeons should be aware of the inherent risks within this patient population and functional dependence may be considered to be a co-morbid confounding factor in outcomes analysis.

Figure 1. Rates of Post-Operative Complications based on Functional Status

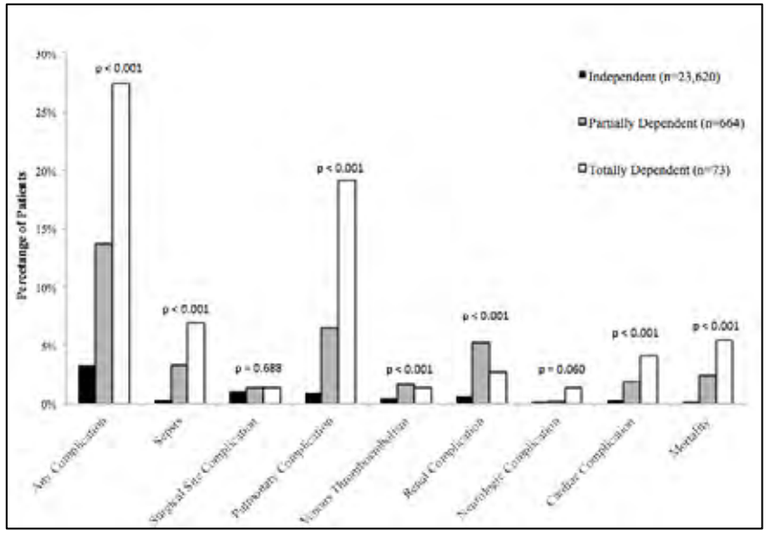


Table 1. Multivariate Analysis of the Effect of Functional Dependence on Postoperative Complications

Complication	*Odds Ratio*	*95% Confidence Interval*		*p*
		Lower	*Upper*	
Sepsis	6.40	3.21	12.75	< 0.001
Surgical Site Complication	0.62	0.22	1.71	0.351
Pulmonary Complication	4.13	2.59	6.58	< 0.001
VTE	4.27	2.10	8.69	< 0.001
Renal Complication	3.32	1.89	5.82	< 0.001
Neurological Complication	0.32	0.04	2.64	0.291
Cardiac Complication	4.68	1.95	11.22	0.001
Mortality	8.31	3.61	19.14	< 0.001

See Disclosure Index pages 40–88.

Stability of Clinical Outcome Measures following Anterior Cervical Spine Surgery

Donna D. Ohnmeiss, DrMed, Plano, TX
Richard D. Guyer, MD, Plano, TX
***Jack E. Zigler, MD**, Plano, TX*
Scott L. Blumenthal, MD, Plano, TX

Introduction: Two-year follow-up is often thought of as the minimum required term for evaluating clinical outcomes, although the rationale for such is not obvious. The purpose of this study was to investigate the stability of outcome measures over time following anterior cervical surgery, and secondly, to investigate the stability of individual patient scores over time.

Methods: A literature search was conducted to identify prospective studies involving anterior cervical spine surgery in at least 100 patients, collecting data at multiple pre-defined time points with minimum 24 month follow-up. Outcome measures were analyzed to determine if there were significant changes during follow-up. A separate study was performed on an internal dataset to determine stability of individual patient's scores over time (pre-op, 6 weeks, 3, 6, 12 and 24 months). Changes in individual scores were investigated by calculating the percentage of patients with at least a 15 point change in Neck Disability Index (NDI) scores (minimal clinically important difference value for the NDI).

Results: After deleting publications reporting on subsets of patients included in larger studies, 13 articles from 6 countries were reviewed. Most investigated total disc replacement and/or anterior cervical fusion. The most frequently used outcome measures were the Neck Disability Index (NDI) and visual analog scales (VAS) assessing pain with the SF-36 used in fewer studies. Rarely used were the EQ-5D and JOA. Regardless of assessment used, in no study was there a statistically significant change in mean scores after 3 month follow-up, nor was there a trend toward worsening scores after 3 months. This was also true of studies with follow-up extending beyond 2 years.

The second part of the study investigated individual patient scores. As in the publications, the mean NDI score improved significantly by 3 months (actually as early as 6 weeks) and remain improved throughout follow-up, with no significant changes. However, when analyzing each patient within the group, 63.9% had at least one minimum 15 point change in NDI scores between follow-up visits (value considered to be a clinically relevant change). Among 55 patients who completed all follow-up visits at 36, 48, and 60 months, 69.0% had at least one 15 point change in NDI score.

Discussion: In the published studies, mean outcome scores for groups of patients improved significantly by 6 weeks or 3 months after surgery and were stable during 2-year follow-up. This occurred regardless of the device, surgical technique, or outcome assessment. In a secondary study analyzing individual patient NDI scores, the majority of individual patients had at least one 15 point change during 24-month follow-up suggesting that stable mean scores are produced by compensatory improving and worsening among individual patients. These results suggest that while mean group scores are stable during follow-up, it should not be presumed that each patient's scores remain stable.

See Disclosure Index pages 40–88.

Does Patient Satisfaction Reflect Quantitative Pain and Function Measurements in Cervical Spine Surgery?

***Kristen E. Radcliff, MD**, Philadelphia, PA*
Domagoj Coric, MD, Charlotte, NC
Han-Jo Kim, MD, New York, NY
Elizabeth Roensch, BS, Austin, TX
Kyle Marshall, BS, Austin, TX
Todd J. Albert, MD, New York, NY

Background Context: Patient satisfaction with surgical treatment is a common qualitative metric used in FDA IDE clinical trials to assess treatment effectiveness. Often administered as a self-assessed questionnaire, a measurement of patient satisfaction gives an important evaluation of treatments success from a patient's perspective. The extent to which patient satisfaction reflects more quantitative clinical outcome measures of pain and function has not been well characterized.

Purpose: Here we examine data from an FDA IDE clinical trial of cervical total disc replacement (TDR) versus anterior cervical discectomy and fusion (ACDF) to determine whether patient satisfaction is related to subsequent surgeries, pain scores, function, and quality of life assessments at 5 years follow-up.

Study Design/Setting: An FDA IDE, randomized, prospective clinical trial was conducted across 24 sites in the U.S.

Patient Sample: A total of 186 ACDF and 389 TDR patients treated at one or two contiguous levels were pooled.

Outcome Measures: Patients were assessed for satisfaction, NDI, VAS neck pain, SF-12PCS/MCS scores, and subsequent surgery rate through 60 months.

Methods: A satisfaction questionnaire prompted patients to answer if they were "very satisfied," "somewhat satisfied," "somewhat dissatisfied," or "very dissatisfied" with their treatment. ANOVA with Tukey's test for multiple comparisons and Chi-square test were used to determine significant differences between clinical outcomes of patients in the four satisfaction categories.

Results: Data was available for 512 patients at 60 months with 437 patients as "very satisfied," 50 patients as "somewhat satisfied," 16 patients as "somewhat dissatisfied," and 9 patients as "very dissatisfied." Patient satisfaction was significantly associated with patient outcomes for NDI, VAS neck pain, and SF-12 MCS/PCS scores. Mean NDI was 15.12 ± 15.98 for the very satisfied, 36.62 ± 17.53 for somewhat satisfied, 38.25 ± 18.94 for somewhat dissatisfied, and 57.56 ± 21.42 for very dissatisfied patients. Mean VAS neck pain score was 15.19 ± 22.70 for very satisfied, 47.14 ± 29.64 for somewhat satisfied, 59.06 ± 30.45 for somewhat dissatisfied, and 64.67 ± 29.57 for very dissatisfied patients. The mean SF-12 MCS score was 52.17 ± 9.59, 45.74 ± 12.63, 46.62 ± 14.21 and 38.64 ± 12.12 for the very satisfied, somewhat satisfied, somewhat dissatisfied and very dissatisfied patients, respectively. Similarly, the mean SF-12 PCS score was 48.16 ± 10.59, 37.46 ± 9.19, 34.29 ± 5.45 and 29.72 ± 8.48 for the very satisfied, somewhat satisfied, somewhat dissatisfied and very dissatisfied patients, respectively. The secondary surgery rate was significantly different across groups with 5.03%, 6.00%, 31.25% and 22.22% of very satisfied, somewhat satisfied, somewhat dissatisfied and very dissatisfied patients requiring surgeries, respectively ($p < 0.0001$).

Patients that were very satisfied at 60 months demonstrated a significantly higher SF-12 MCS score at baseline than patients that were not classified as very satisfied (42.77 ± 11.77 vs. 39.74 ± 11.95, $p = 0.0424$). No significance was found in baseline NDI, VAS or SF-12 PCS scores between satisfaction groups.

Conclusion: The significance differences in NDI, VAS and SF-12 scores between satisfaction groups suggest that a qualitative measurement of patient satisfaction accurately reflects quantitative measurements of patient pain, function and quality of life. Additionally, results indicate that a significant relationship may exist between post-operative patient satisfaction and preoperative patient mental health.

See Disclosure Index pages 40–88.

Identifying Predictors of Upper Body Post-Operative Pain and Disability Improvement in Surgical Cervical Spine Radiculopathic Patients

***Peter G. Passias, MD**, New York, NY*
Kristen E. Radcliffe, MD, Philadelphia, PA
Robert E. Isaacs, MD, Durham, NC
Kristina Bianco, BA, New York, NY
Cyrus M. Jalai, BA, New York, NY
Nancy J. Worley, BA, New York, NY
Paul M. Arnold, MD, Kansas City, KS
Patrick C. Hsieh, MD, Los Angeles, CA
Alexander R. Vaccaro, III, MD, Philadelphia, PA
Michael C. Gerling, MD, New York, NY

Introduction: Effective and informed patient selection and counseling is key in improving surgical outcomes. Understanding the impact that certain patient baseline variables can have on post-operative outcomes is therefore essential in optimizing treatment for certain symptoms, such as radiculopathy from cervical spine pathologies. This study identifies baseline characteristics that were related to improved or worsened post-operative outcomes for patients undergoing surgical intervention for cervical spine radiculopathic pain.

Materials/Methods: This was a retrospective study which analyzed cervical spine patients with a diagnosis classification of 'degenerative' that were enrolled in a prospectively collected multicenter spine registry. Diagnoses included in the 'degenerative' category were those that caused radiculopathy: cervical disc herniation, cervical stenosis, cervical spondylosis without myelopathy. Baseline variables considered as predictors were: 1) age, 2) BMI, 3) gender, 4) history of cervical spine surgery, 5) baseline Neck Disability Index score, 6) baseline SF-36 Physical Component Summary (PCS) scores, 7) baseline SF-36 Mental Component Summary (MCS) scores, and 8) arm pain greater than neck pain. Univariate and multivariate analyses were run against 1-year post-operative NDI, VAS Neck, and VAS Arm pain scores, controlling for complications experienced and surgical technique.

Results: 643 patients were included in this study, with descriptive statistics reported in Table 1. Results from the multivariate analyses for outcome scores are reported in Table 2. From the multivariate analysis for neck disability, patients with a history of previous cervical spine surgery (0.428[0.845–0.216], p = 0.015) and higher NDI scores at baseline (0.954[0.980–0.929], p,=,0.001) were associated with reduced 50% improvements. For the analysis related to post-operative neck pain, higher SF-36 MCS scores at baseline were positively associated with improvement (1.023[1.037–1.008], p = 0.002).

Independent positive predictors for at least 50% improvement in arm pain at 1-year post-operative included presenting arm pain greater than back pain (1.539[2.265–1.045], p = 0.029), patients ages ≥ 52 (1.408[1.974–1.005], p = 0.047), and higher baseline SF-36 PCS (1.025[1.034–1.005], p = 0.025) and MCS (1.020[1.034–1.005], p= 0.007) scores.

Conclusion: This study identified specific patient characteristics, symptom location, and HRQOL scores which were associated with post-operative pain and disability improvement. In particular, baseline arm pain greater than neck pain and older age were determined to have the greatest impact on whether patients met at least 50% improvement in their upper body pain score. These findings are important for clinicians to optimize patient outcomes through effective pre-operative counseling.

Table 1. Descriptive analyses for radiculopathic cervical patients.

	NDI 50% Improvement from Baseline		VAS Neck 50% Improvement from Baseline		VAS Arm 50% Improvement from Baseline	
Variable	Met 50% Improvement (N=244)	Did Not Meet 50% Improvement (N=393)	Met 50% Improvement (N=280)	Did Not Meet 50% Improvement (N=350)	Met 50% Improvement (N=310)	Did Not Meet 50% Improvement (N=298)
Age	53.10 (11.32)	51.36 (9.90)	52.92 (10.94)	51.09 (9.83)	52.29 (10.51)	51.15 (10.10)
Age (#≥52 years)	125: ≤ 52 119: ≥ 52	224: ≤ 52 169: ≥ 52	144: ≤ 52 136: ≥ 52	205: ≤ 52 145: ≥ 52	162: ≤ 52 148: ≥ 52	179: ≤ 52 119: ≥ 52
BMI	28.39 (5.33)	28.84 (6.23)	28.69 (5.83)	28.75 (6.03)	28.94 (5.84)	28.55 (6.05)
Gender	89 = Male 155 = Female	135 = Male 258 = Female	96 = Male 184 = Female	127 = Male 223 = Female	108 = Male 202 = Female	101 = Male 197 = Female
Previous Cervical Surgical History	16 = Yes 134 = No	39 = Yes 152 = No	24 = Yes 151 = No	30 = Yes 135 = No	27 = Yes 150 = No	26 = Yes 121 = No
Baseline NDI	19.25 (11.37)	25.83 (9.75)	22.10 (10.19)	24.82 (10.99)	21.95 (10.24)	25.44 (10.87)
Baseline SF 36 PCS	36.62 (8.19)	33.79 (8.99)	35.81 (8.62)	33.77 (8.60)	35.88 (8.52)	33.24 (8.68)
Baseline SF 36 MCS	41.26 (12.77)	36.03 (13.18)	40.37 (12.90)	35.66 (12.96)	39.89 (13.10)	35.19 (12.68)
Arm Pain greater than Neck Pain?	73 = Yes 171 = No	85 = Yes 308 = No	70 = Yes 210 = No	87 = Yes 263 = No	99 = Yes 211 = No	63 = Yes 235 = No

See Disclosure Index pages 40–88.

Table 2. Multivariate analyses for 50% improvements at 1-year post-operative NDI, VAS Neck, and VAS Arm scores,

Multivariate Modeling for Patient-Reported Outcomes at 1-Year Post-Op		
Variable	Odds Ratio (95% CI)	P Value
50% NDI Improvement		
Previous cervical surgical history	0.428 (0.845-0.216)	**0.015**
Baseline NDI	0.954 (0.980-0.929)	**0.001**
50% VAS Neck Improvement		
Baseline SF 36 MCS	1.023 (1.037-1.008)	**0.002**
50% VAS Arm Improvement		
Age (≥52 years)	1.408 (1.974-1.005)	**0.047**
Baseline SF 36 PCS	1.025 (1.048-1.003)	**0.025**
Baseline SF 36 MCS	1.020 (1.034-1.005)	**0.007**
Arm Pain Greater than Back Pain	1.539 (2.265-1.045)	**0.029**

Validation of Patient-Reported Outcomes Measurement Information System (PROMIS) Computer Adaptive Tests (CATS) in Cervical Spine Surgery

***Alpesh A. Patel, MD, FACS**, Chicago, IL*
Surabhi Bhatt, BS, Chicago, IL
Wellington K. Hsu, MD, Chicago, IL
Jason W. Savage, MD, Chicago, IL

Introduction: PROMIS is a National Institutes of Health (NIH) funded adaptive, responsive assessment tool that measures patient-reported health status. Cervical spine disorders are common, often debilitating conditions that are treated surgically. The objective of this project is to validate the PROMIS pain behavior, pain interference, and physical function CATs in patients undergoing cervical spine surgery against historical outcomes that include the Neck Disability Index (NDI), and the Short-Form 12 (SF-12).

Materials/Methods: PROMIS (pain behavior, pain interference, and physical function), NDI, and SF-12 outcome measures were administered to 53 consecutive tertiary hospital patients treated surgically for degenerative cervical spine disorders. Assessments were administered at baseline (preoperatively) and postoperatively at 6 weeks and 3 months. We excluded patients presenting for revision surgery, tumor, infection, or trauma. Each patient prospectively completed the PROMIS CATs (physical function, pain interference, and pain behavior) and legacy measures (NDI, and SF-12) custom built into the Assessment Center website by using a secure login and password on a tablet.

Results: Of the 53 patients enrolled (mean age = 55.7, SD = 12.2), 90% completed all three assessments (pre-operative (T1), 6 weeks post-operative (T2), and 3 months post-operative (T3)). At T1, PROMIS and SF-12 scores were 8–10 points worse than the general population mean of 50. PROMIS scores were moderately to highly correlated with the NDI and SF-12 PCS (r = 0.44 to 0.61). Additionally, the general post-operative trajectory for all scores exhibited a dramatic improvement at 6 weeks with minimal additional improvement between 6 weeks and 3 months.

Conclusion: PROMIS is a valid and responsive tool to measure health outcomes in patients treated surgically for cervical spine disorders when compared to the NDI and SF-12. PROMIS may be preferable to the standard legacy instruments because of the efficacy in measuring treatment effect, ability to accurately evaluate multiple parameters, and avoidance of floor/ceiling effects.

See Disclosure Index pages 40–88.

Figure 1. Change in PROMIS mean scores

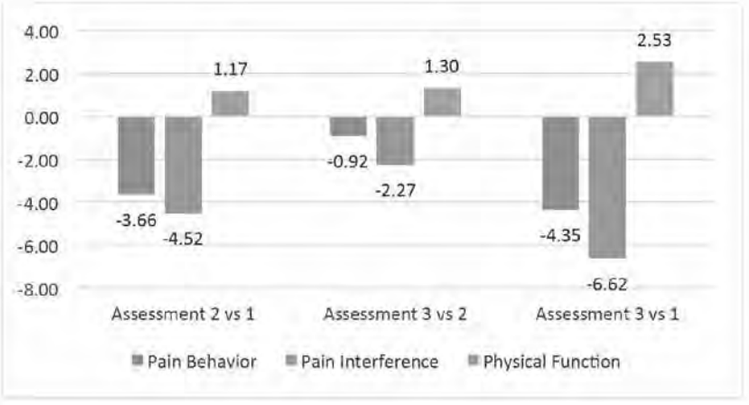
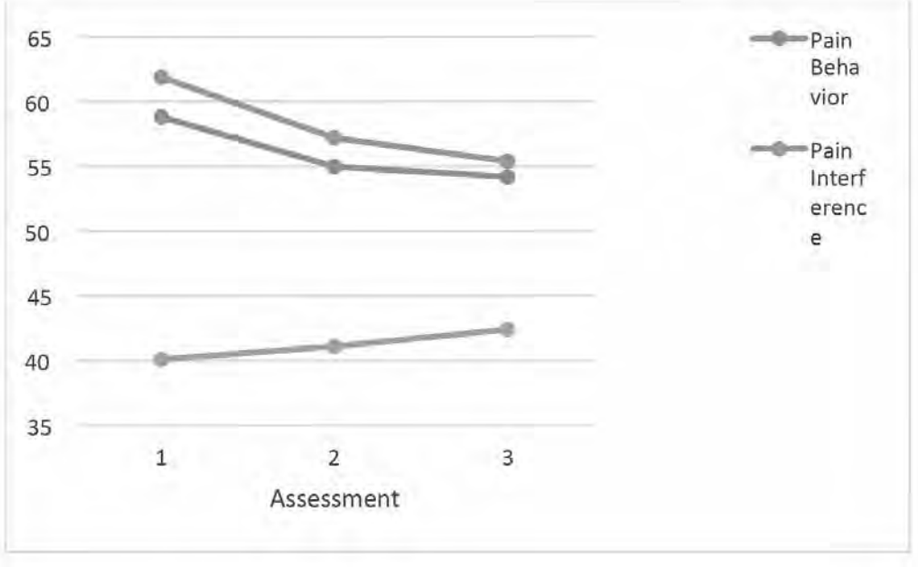


Figure 2. PROMIS T-scores over time (50 = general population mean)



MRI Prognostic Factors for Ambulatory Ability after Spinal Cord Injury without Bony Injury (SCIWOBI)

***Miki Komatsu, MD, PhD**, Bibai, Hokkaido, Japan*
Kota Suda, MD, Bibai, Hokkaido, Japan
Satoko Matsumoto, MD, Bibai, Hokkaido, Japan
Chikara Ushiku, MD, Bibai, Hokkaido, Japan
Katsuhisa Yamada, MD, Bibai, Hokkaido, Japan

Introduction: Damage of the spinal cord tends to be mild in SCIWOBI compared to severe fracture-dislocation. That is a reason that SCIWOBI have better ambulatory prognosis relative to those with bony injury. However, some patients are lead to a poor ambulatory prognosis. In spite of many reports analyzed ambulatory prognosis of SCIWOBI, the prognostic predictions are less well-established even now. While the spinal cord damage can be well delineated with MRI, their variations of neurological recovery make it difficult to estimate exact prognosis. The purpose of this study is to investigate prognostic factors of ambulatory ability after SCIWOBI using conventional MR imaging at admission.

Methods: From April 2008 to March 2011, 124 patients had a neural injury on MRI with normal radiographs and CT scan. These included OPLL and/or ASH patients in 61 (50.8%) cases. In this study, the clinical and MRI records of 63 SCIWOBI without OPLL or ASH cases were reviewed retrospectively. There were 51 males and 12 females, with an average age of 62.5 years. Twenty-nine cases without spinal canal stenosis were managed by conservatively and 34 cases were treated surgically (all double-door laminoplasty). Severities of paralysis at injury were Frankel A in 6 cases, B in 8, C in 30, and D in 19. Prognostic factors affecting ambulatory ability were analyzed using a logistic regression models and/or contingency table analysis.

Results: At final follow-up, 14 cases remained non-ambulatory and 49 cases recovered ambulation. All case showed no neurological deterioration in the Frankel grade. The craniocaudal length (CCL) of the high intensity area in T2 weighted MRI was significantly longer in non-ambulatory cases compared to the ambulatory cases ($p < 0.05$). The ROC curve analysis revealed that the expected cutoff point of CCL for abasia was fifteen mm, and all cases of CCL below 15mm recovered their ambulation. In 5 cases, we could identify bright high intensity spot in the middle of diffuse signal change area on sagittal T2 weighted MRI, and we named it ''Bright eye'' sign, and 4 out of these 5 cases remained non-ambulatory. In contrast, degree of spinal canal stenosis, such as the AP diameter of the spinal cord or stenosis ratio at the most stenotic level, showed no significant differences.

See Disclosure Index pages 40–88.

Conclusions: This study clarified prognostic prediction of ambulatory ability in case of SCIWOBI. The statistics revealed that CCL and “bright-eye” sign on MRI are risk factors for abasia. We previously reported that age and the stenosis ratio are the risk factors for abasia in cases of OPLL-SCIWOBI. However, this study failed to show the risk of stenosis. So, dynamic factor would be strongly related with neurological recovery in SCIWOBI. Since the static stenosis less effects on ambulatory recovery, qualitative evaluation of spinal cord with MRI is useful for prediction of ambulatory ability, and we would be able to predict the exact prognosis in near future.

Mechanism of Injury vs. AOSpine Classification: Is the Setting/Environment in which the Injury Occurs or the Morphology of the Spinal Column Injury the Better Predictor of Severity of Spinal Cord Injury?

Jin W. Tee, MD, *Vancouver, BC, Canada*
Marcel F. Dvorak, MD, Vancouver, BC, Canada
Nader Fallah, PhD, Vancouver, BC, Canada
Vanessa K. Noonan, Vancouver, BC, Canada
Charles G. Fisher, MD, MPH, Vancouver, BC, Canada
Brian K. Kwon, MD, PhD, Vancouver, BC, Canada
John Street, MD, PhD, Vancouver, BC, Canada
F. Cumhur Öner, Utrecht, Netherlands
Alexander R. Vaccaro, III, MD, PhD, Philadelphia, PA

Introduction: The mechanism of injury (MOI-assault, sport, fall, transport, other) is often provided as a descriptor of study participants in traumatic spinal cord injury (tSCI) research, however, the MOI is more related to the milieu or setting of the injury. The newly described AO Spine Injury Cervical and Thoracolumbar Classifications were developed to describe morphologic features of the spinal column injury and includes 3 broad categories: axial compression (A); distraction (B); and translation (C). We hypothesize that the AOSIC should have a higher correlation and predictive ability with respect to initial severity of neurological injury since it describes morphologic categories of increasing injury severity as opposed to the mechanism of injury, which simply describes the surroundings, or setting of the injury. Our aim was to determine if AOSIC improved prediction of severity of injury (ASIA Impairment Scale (AIS)) and total motor score at admission when compared with MOI and level of injury (cervical vs thoracic).

Methods: Patients who sustained an acute tSCI with neurological level between C1-L2 were identified from the Vancouver Rick Hansen Spinal Cord Injury Registry (RHSCIR) and comprised the analysis cohort. All patients were assessed with the International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) examination, providing baseline neurological severity (AIS A-D) and level of injury and total motor score (TMS). Mechanism of injury was dichotomized to transport/assault and sport/fall/other. Multinomial logistic regression and decision trees were used to determine the correlation of AOSIC to neurological injury at baseline as compared to MOI and level of injury (cervical C1-T1, thoracic T2-L2). Firstly we explored the performance of AOSIC compared to MOI in its ability to predict baseline neurological injury severity (AIS). Secondly we explored the performance of AOSIC compared to MOI in correlating with baseline total motor score (TMS).

Results: Details of the analysis cohort are in Table 1. The analysis cohort included 806 participants; 79.3% were male, mean age was 46.7 ± 19.9 years. The distribution of baseline neurological severity was 40.0% A, 11.3% B, 18.9% C, and 29.9% D; baseline level was 68.8% cervical and 31.2% thoracic.

See Disclosure Index pages 40–88.

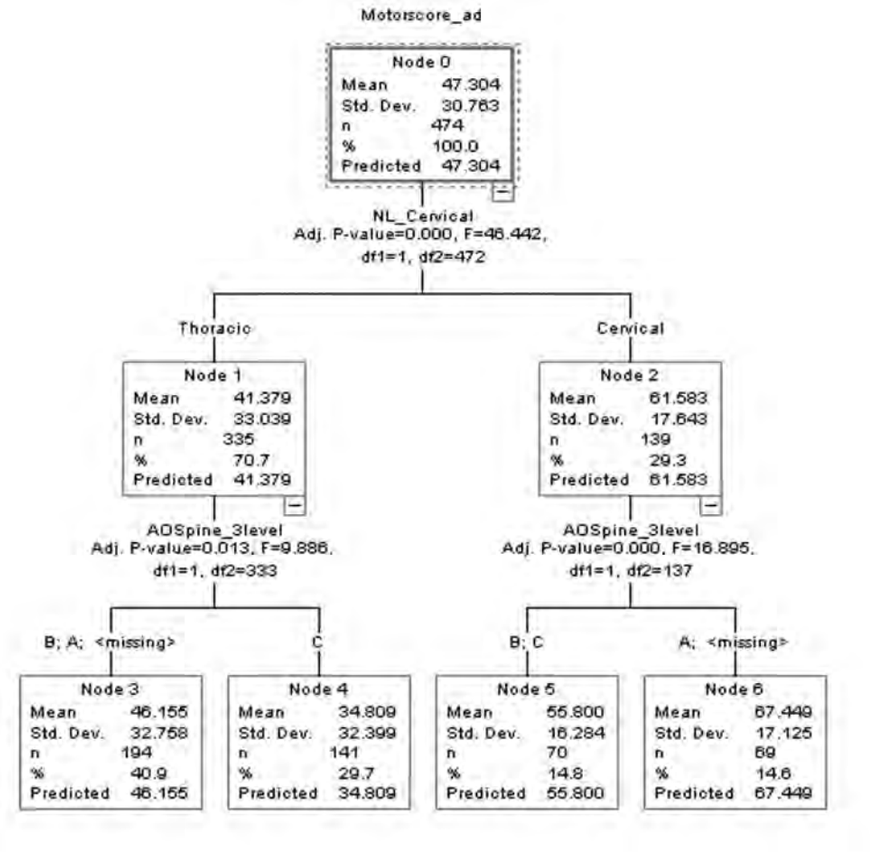
When comparing the association of AOSIC, MOI, and level to baseline AIS, AOSIC was a better discriminator than MOI and level (p = 0.000) When comparing the association of AOSIC, MOI, and level to baseline TMS, AOSIC was also a better discriminator than MOI and level (p = 0.01).

Conclusion: The more severe AOSIC injuries (C) correlate to more severe neurological injuries; AIS (A and B) while the MOI did not correlate to the severity of SCI. When describing the characteristics of study participants, it is more relevant to report on the AOSIC than the MOI since the AO Classification more closely correlates to the initial neurological severity of the injury than does the description of the setting in which the injury occurred – Mechanism of Injury. Reporting of MOI should be reserved for injury prevention studies, not spinal cord injury therapeutic trials.

Table 1. Demographics and injury characteristics of the analysis population (n = 806)

Variable	Value
Age at injury (years), mean (± SD)	46.7 ± 19.9
Male gender, % (n)	79.3 (639)
Level of injury, % (n)	
Cervical (C1-T1)	68.7 (554)
Thoracic (T2-L2)	31.2 (252)
Admission AIS, % (n)	
A	40.0 (322)
B	11.3 (91)
C	18.9 (152)
D	29.9 (241)
AO Spine Classification, % (n)	
A - axial compression	33.1 (267)
B - distraction	25.6 (206)
C - translation	37.8 (305)
Unreported	3.5 (28)
Mechanism of injury, % (n)	
Assault	5.5 (44)
Fall	42.4 (342)
Sport	20.1 (162)
Transport	28.3 (228)
Other	3.6 (29)
Unreported	0.1 (1)
Charlson Comorbidity Index, mean (± SD)	0.33 ± 0.89
Injury Severity Score at admission, mean (± SD)	27.5 ± 13.4
Total motor score (points), mean (± SD)	
Admission	46.7 ± 30.3
Discharge	58.9 ± 29.9

Figure 1. Association of motor score at admission as dependent variable with independent variables (Anatomical region, AOSpine, Mechanism of injury) using a decision tree model.



Support: Western Economic Diversification Fund and Rick Hansen Institute.

See Disclosure Index pages 40–88.

Incidence of and Risk Factors for Incorrect Level Needle Localization during Anterior Cervical Discectomy and Fusion Surgery (ACDF)

***Deepak Reddy, MD**, Louisville, KY*
David T. Endriga, MD, Louisville, KY
Eric M. Kiskaddon, MD, Louisville, KY
Steven D. Glassman, MD, Louisville, KY
Kelly R. Bratcher, RN, CCRP, Louisville, KY
Katlyn E. McGraw, BA, Louisville, KY
Leah Y. Carreon, MD, MSc, Louisville, KY

Introduction: Anterior cervical discectomy and fusion (ACDF) is a commonly performed procedure for patients with axial neck pain and upper extremity radiculopathy. During the surgery for ACDF, radiographic confirmation of the operative level before beginning the discectomy is often performed by placing a needle into the disc space. Studies have shown that a needle puncture could potentially lead to degenerative changes in an incorrectly marked disc level. However, the incidence and risk factors for an incorrect needle placement during an ACDF has not been reported. The purpose of this study is to report on the incidence of and risk factors for incorrect level needle localization during one- to two-level ACDF.

Methods: Patients older than 18 years old who underwent one- to two-level ACDF from 2008-2011 were identified. Standard demographic data was collected. Intraoperative radiographs were reviewed to determine fusion levels and placement of localizing needle prior to fusion. Incidence of and position of incorrect needle placement (proximal or distal to the fusion level) was collected.

Results: There were 828 cases included, 365 (44%) males and 463 (56%) females with a mean age of 49.8 years. There were 733 one-level and 95 two-level fusions. One hundred seventy-five (21%) of the localizing needles were placed proximal to the surgical level and 110 (13%) were placed distal to the surgical level. The proportion of incorrect needle placement was statistically significantly higher in one-level fusions (274/733, 37%) compared to two-level fusions (11/95, 12%, $p < 0.000$). Considering only one-level fusions, cases who had proximal needle placement had a statistically significantly higher BMI (34.4 kg/m^2) compared to those with distal (26.9 kg/m^2) or appropriate needle placement (29.9 kg/m^2, $p < 0.000$).

Conclusions: The incidence of incorrect needle placement during ACDF is 34%, with 21% placed proximal to the intended surgical level and 13% placed distal. The risk of incorrect needle placement is higher in one-level fusions and more distal fusion levels. In some cases, where patient anatomy makes adequate exposure challenging, needle placement into the proximal disc space may be intentional. Surgeons must be aware of the potential risk of inducing disc degeneration and consider other strategies, such as marking the vertebral body instead of the disc, to identify the appropriate surgical level.

ASIA Impairment Scale Predicts the Need for Tracheostomy after Cervical Spinal Cord Injury

Benjamin R. Childs, BS, Cleveland, OH
***Timothy A. Moore, MD**, Cleveland, OH*
John J. Como, MD, MPH, Cleveland, OH
Heather A. Vallier, MD, Cleveland, OH

Introduction: High neurologic level of injury, high Injury Severity Score (ISS), and low Glasgow Coma Scale (GCS) have been shown to predict tracheostomy in patients with cervical spinal cord injury. The objective of this study was to evaluate the ability of the American Spinal Injury Association (ASIA) impairment scale and neurological level of injury to predict the need for mechanical ventilation as well as tracheostomy**.**

Methods: Three hundred eighty-three patients with fractures, dislocations, or ligamentous injury of the cervical spine were included in this retrospective study. Charts were reviewed to determine demographics, ISS, GCS, presence and severity of chest injuries, length of hospital stay (LOS), ICU stay, mechanical ventilation time, and mortality.

Results: Fifty-nine patients (15.4%) underwent tracheostomy. An ASIA impairment scale of A had a specificity of 98.8% and sensitivity of 32.2% for predicting the need for tracheostomy. This yielded a 1.2% false positive rate. The ASIA impairment Scale remained the most significant predictor for tracheostomy after regression for ISS, GCS, and Chest Abbreviated Injury Scale. Neurological level of injury was not a significant predictor of tracheostomy.

Conclusions: An ASIA impairment scale of A at any level of injury is a specific predictor of the need for tracheostomy with a low false positive rate. Given the relatively low risk of early tracheostomy and the potential benefits, an ASIA impairment scale of A would be a sensible early criterion to determine the need for tracheostomy.

See Disclosure Index pages 40–88.

Clearing the C-Spine in Obtunded Trauma Patients Based on Admission CT: A Prospective Randomized Trial

***Christopher P. O'Boynick, MD**, Charlotte, NC*
Timothy M. Lonergan, MD, Memphis, TN
Howard M. Place, MD, St. Louis, MO

Introduction: The protocol surrounding cervical spine clearance in the obtunded blunt trauma patient with a normal cervical CT scan is highly debated and lacks standardization. This results in disjointed management of c-collar precautions and prolongs unnecessary immobilization in a potentially compromised patient. C-collars are associated with many complications including respiratory deterioration, skin breakdown, and venous thrombosis. The purpose of this study is to demonstrate that early clearance (48-72hrs) of the c-spine in obtunded trauma patients who have no identified injury based upon initial CT scan can be done safely and effectively. Additionally, we hope to demonstrate that our data agrees with literature indicating CT's adequacy as an imaging modality for c-spine clearance in the obtunded patient.

Methods: Ninety-six obtunded trauma patients were admitted to our facility with cervical CT scans negative for injury. Exclusions included c-spine fracture and abnormal spinal cord exam. One spine surgeon cleared the c-spine using cervical CT. Two spine surgeons awaited patient participation in a clinical exam prior to clearance. Randomization was based on the spine surgeon on call. The White & Panjabi stability scale and the cervical spine injury severity score determined radiographic stability. All patients cleared using CT alone underwent clinical exam once alert.

Results: Forty-one patients underwent c-spine clearance radiographically at a mean of 4 days (2-14d). Fifty-five patients remained immobilized until clinical exam was performed at an average of 15 days (2-44d). Radiographic clearance decreased immobilization by 11 days ($p < 0.001$). There was no difference in age ($p = 0.7$), admission GCS ($p = 0.9$), or hospital days ($p = 0.8$). Documented c-spine exam was available for all patients cleared radiographically when alert. Patient follow up was 100% and there were no missed injuries that resulted in instability in either group.

Conclusion: Removal of c-spine precautions based on a negative CT scan at admission is a viable option in trauma patients anticipated to remain obtunded for a significant amount of time. We were able to safely decrease the duration of unnecessary immobilization by 11 days. There were zero missed injuries that resulted in clinical instability.

42nd Annual Meeting – 2014
Hyatt Grand Cypress Hotel, Orlando, FL
Bruce V. Darden, II, MD, President
Wellington K. Hsu, MD, Program Co-Chair
Ronald A. Lehman, Jr., MD, Program Co-Chair

41st Annual Meeting – 2013
Hyatt Regency Century Plaza, Los Angeles, CA
K. Daniel Riew, MD, President
John M. Rhee, MD, Program Co-Chair
Justin S. Smith, MD, PhD, Program Co-Chair

40th Annual Meeting – 2012
Sheraton Chicago Hotel & Towers, Chicago, IL
Michael G. Fehlings, MD, PhD, President
James S. Harrop, MD, Program Co-Chair
Alexander R. Vaccaro, III, MD, PhD, Program Co-Chair

39th Annual Meeting – 2011
Phoenician Hotel, Scottsdale, AZ
Sanford E. Emery, MD, MBA, President
Jeffrey C. Wang, MD, Program Chair

38th Annual Meeting – 2010
Charlotte Westin Hotel, Charlotte, NC
John G. Heller, MD, President
Alexander Ghanayem, MD , Program Chair

37th Annual Meeting – 2009
The Grand America, Salt Lake City, UT
Todd J. Albert, MD, President
Frank M. Phillips, MD, Program Chair

36th Annual Meeting – 2008
Austin Renaissance Hotel, Austin, TX
Thomas A. Zdeblick, MD, President
Michael G. Fehlings, MD, PhD, Program Chair

35th Annual Meeting – 2007
The Palace Hotel, San Francisco, CA
Ronald I. Apfelbaum, MD, President
Todd J. Albert, MD, Program Chair

34th Annual Meeting – 2006
The Breakers, Palm Beach, FL
Vincent C. Traynelis, MD, President
Lee H. Riley, III, MD, Program Chair

33rd Annual Meeting – 2005
Manchester Grand Hyatt, San Diego, CA
Bradford L. Currier, MD, President
Robert F. Heary, MD, Program Chair

32nd Annual Meeting – 2004
Boston Marriott Copley Place, Boston, MA
Edward N. Hanley, Jr., MD, President
Sanford E. Emery, MD, Program Chair

31st Annual Meeting – 2003
Fairmont Scottsdale Princess, Scottsdale, AZ
Paul R. Cooper, MD, President
Jeffrey S. Fischgrund, MD, Program Chair

30th Annual Meeting – 2002
Fontainebleau Hotel, Miami Beach, FL
Paul A. Anderson, MD, President
Bruce V. Darden, II, MD, Program Chair

29th Annual Meeting – 2001
Double Tree Hotel, Monterey, CA
Nancy Epstein, MD, President
Vincent C. Traynelis, MD, Program Chair

28th Annual Meeting – 2000
Charleston Place, Charleston, SC
Christopher G. Ullrich, MD, President
John G. Heller, MD, Program Chair

27th Annual Meeting – 1999
Seattle Westin, Seattle, WA
Harry N. Herkowitz, MD, President
Ronald I. Apfelbaum, MD, Program Chair

26th Annual Meeting – 1998
Grand Hyatt at Buckhead, Atlanta, GA
John F. Raycroft, MD, President
Alexander R. Vaccaro, III, MD, PhD, Program Chair

25th Annual Meeting – 1997
Westin Mission Hills, Rancho Mirage, CA
Bruce E. Northrup, MD, President
Thomas A. Zdeblick, MD, Program Chair

24th Annual Meeting – 1996
The Breakers, Palm Beach, FL
Steven R. Garfin, MD, President
Jean-Jacques Abitbol, MD, Program Chair

23rd Annual Meeting – 1995
El Dorado Hotel, Santa Fe, NM
Frank J. Eismont, MD, President
Nancy Epstein, MD, Program Chair

22nd Annual Meeting – 1994
Stouffer Harborplace Hotel, Baltimore, MD
Thomas B. Ducker, MD, President
Edward C. Benzel, MD, Program Chair

21st Annual Meeting – 1993
Waldorf Astoria Hotel, New York, NY
Joseph S. Barr, Jr., MD, President
Paul A. Anderson, MD, Program Chair

CSRS Annual Meeting and Presidential History

20th Annual Meeting – 1992
Marriott's Desert Springs Resort,
Palm Desert, CA
Charles R. Clark, MD, President
Edward N. Hanley, Jr., MD, Program Chair

19th Annual Meeting – 1991
Four Seasons Hotel, Philadelphia, PA.
Henry LaRocca, MD, President
Harry N. Herkowitz, MD, Program Chair

18th Annual Meeting – 1990
Hilton Palacio del Rio, San Antonio, TX
Sanford J. Larson, MD, President
Steven R. Garfin, MD, Program Chair

17th Annual Meeting – 1989
Westin Canal Place Hotel, New Orleans, LA
Henry H. Bohlman, MD, President
Steven R. Garfin, MD, Program Chair

16th Annual Meeting – 1988
Sonesta Beach Hotel, Key Biscayne, FL
Augustus A. White, III, MD, President
Thomas B. Ducker, MD, Program Chair

15th Annual Meeting – 1987
The Westin, Washington, DC
Richard B. Raynor, MD, President
Charles R. Clark, MD, Program Chair

14th Annual Meeting – 1986
The Breakers, Palm Beach, FL
Thomas S. Whitecloud, III, MD, President
Manohar M. Panjabi, PhD, Program Chair

13th Annual Meeting – 1985
Cambridge Hyatt Regency, Cambridge, MA
E. Shannon Stauffer, MD, President
Joseph S. Barr, Jr., MD, Program Chair

12th Annual Meeting – 1984
New Orleans Hilton, New Orleans, LA
Donald S. Pierce, MD, President
Paul R. Cooper, MD, Program Chair

11th Annual Meeting – 1983
The Breakers, Palm Beach, FL
Henry H. Sherk, MD, President
Robert N. Hensinger, MD, Program Chair

10th Annual Meeting – 1982
Sheraton Centre Hotel, New York, NY
Joseph A. Epstein, MD, President
Rollin M. Johnson, MD, Program Chair

9th Annual Meeting – 1981
Hotel Del Coronado, Coronado, CA
David L. Filtzer, MD, President
Bruce E. Northrup, MD, Program Chair

8th Annual Meeting – 1980
The Breakers, Palm Beach, FL
Edward J. Dunn, MD, President
Henry H. Bohlman, MD, Program Chair

7th Annual Meeting – 1979
Hyatt Regency, Cambridge, MA
Robert W. Bailey, MD, President
Thomas S. Whitecloud, III, MD, Program Chair

6th Annual Meeting – 1978
Cross Keys Inn, Baltimore, MD
Alice L. Garrett, MD, President
Thomas E. Whitesides, Jr., MD , Program Chair

5th Annual Meeting – 1977
Forum XXX, Springfield, IL
Richard H. Rothman, MD, President
Richard B. Raynor, MD, Program Chair

4th Annual Meeting – 1976
Holiday Inn at Independence Hall –
Philadelphia, PA
Lee H. Riley, Jr., MD, President
Bruce E. Northrup, MD, Program Chair

3rd Annual Meeting – 1975
Hyatt Regency Hotel, Toronto, Ontario, Canada
Edward H. Simmons, MD, President
Lee H. Riley, Jr., MD, Program Chair

2nd Annual Meeting – 1974
Royal Orleans Hotel, New Orleans, LA
J. William Fielding, MD, President
Lee H. Riley, Jr., MD, Program Chair

1st Annual Meeting – 1973
Essex House, New York, NY
J. William Fielding, MD, President
Lee H. Riley, Jr., MD, Program Chair

In Memoriam

Deceased CSRS Members

Lewis D. Anderson, MD 1999
Claude Argenson, MD 2002
Robert W. Bailey, MD 1987
Elliott E. Blinderman, MD 2002
Henry H. Bohlman, MD 2010
Mario Boni, MD 1986
Francis R.S. Boumphrey, MD 2012
Craig D. Brigham, MD 2013
David W. Cahill, MD 2003
Ralph B. Cloward, MD 2001
Jerome M. Cotler, MD 2014
Li Yang Dai, MD 2012
Joseph A. Epstein, MD 2006
J. William Fielding, MD 1998
Prof Gianfranco Fineschi 2010
Jacob J. Graham, MD 2000
Henry H. Herkowitz, MD 2013
Prof Dr. Dietrich Hohmann 2012
Brian H. Huncke, MD 1995
Bernard Jacobs, MD 1992
Adolphe Jung, MD 1995
Steven E. Kopits, MD 2003
S. Henry LaRocca, MD ..... date unavailable
Sanford J. Larson, MD, PhD 2012
Leroy S. Lavine, MD 2005
Alan M. Levine, MD 2009
Patrizio Parisini, MD 2009
Wesley W. Parke, PhD 2005
Lourens Penning, MD 2010
Stephen A. Pye, Jr., MD 2005
Joseph Ransohoff, MD 2002
Lee H. Riley, Jr., MD 2001
Hubert L. Rosomoff, MD 2008
Raymond Roy-Camille, MD 1997
Anthony Sances, Jr., MD 2007
Henry H. Sherk, MD 2012
Edward H. Simmons, MD 2009
E. Shannon Stauffer, MD 2002
Henk Verbiest, MD 1997
Jose Maria Vieira, MD 2003
Thomas S. Whitecloud, III, MD 2003
Eric T. Yuhl, MD 2005

7TH Annual Meeting

April 21 – April 23, 2016
Coex, Seoul, Republic of Korea

Cervical Spine Research Society
Asia Pacific Section

President: Jin-Sup Yeom, MD, PhD

www.csrsap2016.org

32ND Annual Meeting

May 11 – May 13, 2016
Prague, Czech Republic

Cervical Spine Research Society
European Section Meeting

President: Bengt I. Lind, MD, PhD

www.csrsprague2016.org

CERVICAL SPINE RESEARCH SOCIETY

FOUNDED 1973

Membership Directory

a 1993 **Jean-Jacques Abitbol, MD**
California Spine Group
5395 Ruffin Rd Ste 201
San Diego CA 92123-1338
(858) 874-2306
Orthopaedics

c 1999 **Kuniyoshi Abumi, MD**
Sapporo Orthopaedic Hospital-Center For Spinal Disorders
13-56, Hassamu 13-4
Nishi-Ku
Sapporo 063-0833 Japan
81-116621118
Orthopaedics

e 2003 **Alun Ackery, Msc**
2212 Balaclava St
Vancouver BC M4L 3H1
Canada
(416) 603-5229
Neurosurgery

c 1988 **Max Aebi, MD, DHC, FRCSC**
Gerechtigkeitsgasse 48
Bern 3011 Switzerland
41-316315930
Orthopaedics

a 1994 **Dirk H Alander, MD**
Saint Louis University
School of Medicine
Dept Ortho Surg Desloge Towers 7th Fl
3635 Vista Ave at Grand Blvd
St Louis MO 63110-0250
(314) 577-8850
Orthopaedics

a 1995 **Todd J Albert, MD**
Hospital For Special Surgery
535 E 70th St Rm 836 W
New York NY 10272
(212) 606-1004
Orthopaedics

e 2000 **Yves Allieu, MD**
rue des Bouisses 1133
Montpellier 34070 France
33-467100936
Orthopaedics

a 2008 **Christopher P Ames, MD**
Univ of CA San Francisco
505 Parnassus Ave
Box 0112 Rm M779
San Francisco CA 94143
(415) 353-2348
Neurosurgery

a 1991 **Howard S An, MD**
Rush University Medical Center
1611 W Harrison St Ste 300
Chicago IL 60612
(312) 243-4244
Orthopaedics

a 2003 **D Greg Anderson, MD**
351 Tom Brown Rd
Moorestown NJ 08057-4001
(267) 339-3623
Orthopaedics

a 1989 **Paul A Anderson, MD**
University of Wisconsin
Dept of Orthopedics & Rehabilitation
1685 Highland Ave 6th Fl
Madison WI 53705-2281
(608) 263-5394
Orthopaedics

a 2003 **M Darryl Antonacci, MD**
Institute Spine and Scoliosis PA
3100 Princeton Pike Ste 1D
Lawrenceville NJ 08648-2300
(609) 912-1500
Orthopaedics

s 1993 **Ronald I Apfelbaum, MD**
1311 E Tomahawk Dr
Salt Lake City UT 84103
Neurosurgery

a 1988 **Mario J Arena, MD**
Jefferson University Hospitals
17 White Horse Pike Ste 3
Haddon Heights NJ 08035-1299
(856) 310-0002
Orthopaedics

a 2000 **Paul M Arnold, MD**
University of Kansas
Dept of Neurosurgery
3901 Rainbow Blvd
Kansas City KS 66160
(913) 588-7587
Neurosurgery

s 1975 **Neal I Aronson, MD**
Mid-Atlantic Neurosurg Assoc
2411 W Belvedere Ave Ste 402
Baltimore MD 21215-5231
(410) 601-8314
Neurosurgery

c 2005 **Takashi Asazuma, MD, PhD**
National Hospital Organization
Dept of Ortho Surgery
Murayama Medical Center
2-3-1 Gakuen,
Musashimurayama
Tokyo 208-0111 Japan
81-425611221
Orthopaedics

e 2006 **Roberto Assietti, MD**
Ospedale Fatebenefratelli
Corso Di Porta Huova 23
Milano 20123 Italy
39-0245486845
Neurosurgery

e 2005 **Stefano Astolfi, MD**
Rome, Italy
39-0630154353
Orthopaedics

e 2010 **Hiromi Ataka, MD**
Matsudo Orthopaedic Hospital
1-161 Asahi-cho
Matsudo 271-0043 Japan
81-473443171
Ortho Spine

a 2005 **Hyun W Bae, MD**
The Spine Institute
444 S San Vincente Blvd
Ste 901
Los Angeles CA 90048
(310) 828-7757
Orthopaedics

a 2000 **Jamie L Baisden, MD, FAANS**
Med College of Wisconsin
Dept of Neurosurgery
9200 W Wisconsin Ave
Milwaukee WI 53226
(414) 955-7188
Neurosurgery

c 2012 **Koang H Bak, MD, PHD**
Olympic Apt 317-902
Seoul 138-788
Republic of Korea
82-22908496
Neurosurgery

e 1999 **Philippe Bancel, MD**
Clinique Alleray-Labrouste
64 rue Labrouste
Paris 75015 France
33-144195043
Orthopaedics

s 1978 **Joseph S Barr, Jr, MD**
Massachusetts General Hospital
Zero Emerson Place Ste 120
Boston MA 02114-2241
(617) 726-3563
Orthopaedics

e 2004 **Ronald HMA Bartels, MD, PhD**
Radboud Univ
Nijmegen Med Ctr
Dept Neurosurgery
R Postlaan 5
Nijmegen 6500 HB Netherlands
31-243613477
Neurosurgery

e 2003 **Alexander Barysh, MD**
Sytenko Institute For
Spine and Joints Pathology
80 Pushkinskaya St
Kharkiv 61024 Ukraine
380-577041477
Orthopaedics

s 1983 **Ulrich Batzdorf, MD**
UCLA Medical Ctr
Div of Neurosurgery
Box 956901
Los Angeles CA 90095-6901
(310) 825-5079
Neurosurgery

s 1976 **Norman E Beisaw, MD**
119 Belmont St
Worcester MA 01605-2903
(508) 334-6375
Orthopaedics

a 2011 **Theodore A Belanger, MD**
7829 Woodcreek Way
Sachse TX 75048-2251
(972) 772-8767
Orthopaedics

a 2004 **Carlo Bellabarba, MD**
UWA Harborview Medical Ctr
Dept Orthopaedics
325 Ninth Ave MS 359798
Seattle WA 98199
(206) 744-3466
Orthopaedics

s 1988 **Edward C Benzel, MD, FAANS**
Cleveland Clinic Foundation
Dept Neurosurgery
9500 Euclid Ave Ste S40
Cleveland OH 44195
(216) 636-5860
Neurosurgery

e 2005 **Pierre Bernard, MD**
Centre Aquitain du Dos
2 rue Négrevergne
Merignac 33700 France
33-0557020000
Orthopaedics

a 1991 **Mark Bernhardt, MD**
Univ of Missouri-Kansas City
Truman Med Center
Depart of Ortho Surg
2301 Holmes St
Kansas City MO 64108
(816) 404-5404
Orthopaedics

a 2000 **Avi J Bernstein, MD**
The Spine Center
1875 Dempster Ste 425
Park Ridge IL 60068-1129
(847) 698-9330
Orthopaedics

a 2006 **Nitin N Bhatia, MD**
UC Irvine
Dept Orthopaedic Surgery
101 The City Dr Pavilion III
Orange CA 92868
(714) 456-1699
Orthopaedics

a 2014 **Maxwell Boakye, MD, FAANS**
308 Pepperbush Rd
Louisville KY 40207-5707
(650) 849-9599
Neurosurgery

s 1992 **Michael J Bolesta, MD**
14621 Vintage Lane
Addison TX 75001-3517
(214) 280-4394
Ortho Surgery

e 2005 **Ciaran Bolger, MD**
Beaumont Hospital
National Centre Neurosurgery
PO Box 1297 Beaumont Road
Dublin 9 Ireland
353-18368847
Neurosurgery

e 1994 **Jose Luis Bordas Sales, MD**
Rua Joao Pessoa, 111/708
Petropolis RJ Brazil
55 3434185022
Orthopaedics

a 2006 **Bikash Bose, MD**
Neurosurgery Consultants PA
Omega Professional Center
C 79 Omega Dr
Newark DE 19713
(302) 738-9145
Neurosurgery

a 1999 **Darrel S Brodke, MD**
Univ of Utah Ortho Center
590 Wakara Way
Salt Lake City UT 84108
(801) 587-5450
Orthopaedics

a 2004 **Dahari Brooks, MD**
Greensboro Orthopaedics
3200 Northline Ave Ste 160
Greensboro NC 27408-7613
(336) 545-5000
Orthopaedics

a 1996 **Richard S Brower, MD**
Crystal Clinic Orthopedic Cntr
20 Olive St Ste 200
Akron OH 44310
(330) 379-5569
Orthopaedics

s 1977 **Mark D Brown, MD, PhD**
University of Miami
Orthopaedics & Rehabilitation
PO Box 016960 R-2
Miami FL 33101-6960
(305) 243-6725
Orthopaedics

e 1995 **Eva Maria Buchholz, MD**
Marien-Krankenhaus
Bergisch Gladbach Clinic
Spine Center
Dr Robert Koch Str 18 Bergisch
Gladbach 51465 Germany
49-022029382600
Neurosurgery

a 2009 **Jacob M Buchowski, MD, MS**
Washington Univ In St Louis
Orthopaedic Surgery
660 S Euclid Ave,
Campus Box 8233
St Louis MO 63110
(314) 747-4950
Orthopaedics

a 1991 **Hans-Ulrich Bueff, MD**
5330 Moss Ln
Granite Bay CA 95746
(916) 784-5171
Orthopaedics

a 1994 **James C Butler, MD**
Elite Orthopaedic Specialists
1150 Robert Blvd Ste 240
Slidell LA 70458
(985) 646-3662
Orthopaedics

e 2003 **Thomas Cadoux-Hudson, MD**
Radcliffe Infirmary NHS Trust
Dept of Neurosurgery
Woodstock Road
Oxford OX2 6HE
United Kingdom
44-1865224945
Neurosurgery

s 1979 **Robert A Callahan, MD**
7616 S Fitzgerald St
Tampa FL 33616-2164
(863) 385-2222
Orthopaedics

a 1994 **Frank P Cammisa, Jr, MD**
Hospital For Special Surgery
523 E 72nd St 3rd Fl
East River Professional Bldg
New York NY 10021-4872
(212) 606-1946
Orthopaedics

a 2009 **Mitchell J Campbell, MD**
Norton Leatherman Spine Cntr
210 E Gray St Ste 900
Louisville KY 40202
(502) 584-7525
Orthopaedics

a 2008 **Andrew Cappuccino, MD**
Buffalo Spine Surgery
46 Davison Ct
Lockport NY 14094
(716) 438-2973
Orthopaedics

a 11999 **Gregory D Carlson, MD**
Orthopaedic Specialties Inst
280 S Main St Ste 200
Orange CA 92868
(714) 634-4567
Orthopaedics

s 1981 **Robert Carras, MD**
New York NY
(516) 354-3401
Neurosurgery

c 2001 **Jose M Casamitjana, MD**
Avda Diagonal, 491 6,1
Barcelona 08029 Spain
34-934106810
Orthopaedics

a 2009 **Ezequiel Cassinelli, MD**
5045 Carol Ln NW
Atlanta GA 30327-4614
(404) 425-1111
Orthopaedics

c 2011 **Bong-Soon Chang, MD**
Seoul National Univ Hospital
Orthopedic department
101 Daehangno, Jongno-gu
Seoul 110-744
Republic of Korea
82-220723864
Orthopaedics

c 1992 **Han Chang, MD, PhD**
Busan Korea Hospital
238, Suyeong-ro
Nam-gu Busan 612-862
Republic of Korea
82-10522828064
Orthopaedics

a 2002 **Jens R Chapman, MD**
Swedish Neurosciences Inst
1600 E Jefferson Ste 101
Seattle WA 98122
(206) 744-5707
Orthopaedics

a 2011 **Christopher D Chaput, MD**
8355 Poison Oak Rd Unit C
Temple TX 76502
(254) 724-4045
Orthopaedics

a 2011 **Ivan Cheng, MD**
175 Willowbrook Dr
Portola Vally CA 94028-7837
(650) 721-7616
Orthopaedics

a 2013 **Wayne K Cheng, MD**
Loma Linda University
Dept of Orthopaedic Surgery
11406 Loma Linda Dr Rm 213
Loma Linda CA 92354
(909) 558-6444
Orthopaedics

c 2001 **Kazuhiro Chiba, MD, PhD**
Depart of Orthopaedic Surgery
National Defense Med College
3-2 Namiki, Tokorozawa
Saitama 359-8513 Japan
81-429951663
Orthopaedics

c 2009 **Dong-Kyu Chin, MD**
Yongdong Severance Hosp
Dept Neurosurgery
Kangnam PO Box 1217
Seoul 135-720
Republic of Korea
82-220193390
Neurosurgery

a 2012 **Alexander C Ching, MD**
Oregon Spine Care
19255 SW 65th Ave Ste 200
Tualatin OR 97062
(503) 828-1150
Orthopaedics

c 2013 **Dae-Chul Cho, MD, PhD**
Kyungpook National Univ Hosp
Spinal Div Dept of Neurosurgery
130 Dongdukro Jung Ju
Daegu 700-721
Republic of Korea
82-534205649
Neurosurgery

c 2014 **Kyoung-Suok Cho, MD, PhD**
The Catholic University of
Korea College of Medicine
Dept of Neurosurgery
65-1 Kumoh-dong Uijongbu
Seoul 480-130
Republic of Korea
82-318203024
Neurosurgery

a 2014 **Samuel K Cho, MD**
Icahn School of Medicine
at Mount Sinai
5 East 98th St Box 1188
New York NY 10029
(212) 241-0276
Orthopaedics

c 2006 **Eun Seok Choi, MD, PhD**
Charm Joeun Hospital,
Spine Center
226-1 Songhyeon-Dong,
Dalseo-Gu Daegu 42818
Republic of Korea
82-1035404950
Neurosurgery

c 2014 **Tapanut Chuntarapas, MD**
422-3 Ratchavithee Road,
Ratchathevee
Bangkok 10400 Thailand
66-863743732
Neurosurgery

a 1980 **Charles R Clark, MD**
Univ of Iowa Hospitals
Dept Orthopaedics
200 Hawkins Dr MS 01012
Iowa City IA 52242-1009
(319) 356-2332
Orthopaedics

a 1993 **David H Clements, III, MD**
Cooper Bone & Joint Institute
3 Cooper Plaza Ste 408
Camden NJ 08103
(856) 968-7486
Orthopaedics

a 1989 **Jeffrey D Coe, MD**
Silicon Valley Spine Institute
221 E Hacienda Ave Ste A
Campbell CA 95008-6616
(408) 376-3300
Orthopaedics

a 1994 **Patrick J Connolly, MD**
UMass Memorial Medical Cntr
119 Belmont St
Spine Center South One
Worcester MA 01605
(508) 334-9762
Orthopaedics

s 1978 **Paul R Cooper, MD**
320 E 72nd St
New York NY 10021-4769
(212) 288-6778
Neurosurgery

e 2003 **Mauro Costaglioli, MD, PhD**
Loc Poggio dei Pini
Strada 11 No 14
Capoterra CA 09012 Italy
393389973045
Orthopaedics

e 1999 **H Alan Crockard, MD, FRCS**
49 Hillway Highgate
London N6 6AD
United Kingdom
44-2078298714
Neurosurgery

a 1992 **Bradford L Currier, MD**
Mayo Clinic
200 First St SW
Rochester MN 55905
(507) 284-8309
Orthopaedics

s 1983 **Joseph F Cusick, MD**
Medical College Of Wisconsin
Dept of Neurosurgery
9200 W Wisconsin Ave
Milwaukee WI 53226-3522
(414) 955-7188
Neurosurgery

a 2012 **Scott D Daffner, MD**
West Virginia University
Department of Orthopaedics
3400 Health Sciences Cntr 9196
Morgantown WV 26508-9196
(304) 293-2779
Orthopaedics

a 2009 **Andrew T Dailey, MD, FAANS**
Univ of Utah Sch of Med
Department of Neurosurgery
175 N Medical Dr East 5th Fl
Salt Lake City UT 84132
(801) 581-6908
Neurosurgery

a 1992 **Bruce V Darden, II, MD**
OrthoCarolina Spine Center
2001 Randolph Rd
Charlotte NC 28207-1215
(704) 323-3657
Orthopaedics

a 2009 **Michael D Daubs, MD**
Univ of Nevada School of Med
2040 W Charleston Blvd # 601
Las Vegas NV 89102
(702) 671-2394
Orthopaedics

a 1993 **Randy F Davis, MD**
Baltimore Washington Med Cntr
301 Hospital Dr Ste 802
Glen Burnie MD 21061
(443) 956-5087
Orthopaedics

a 1989 **Rick B Delamarter, MD**
Cedars Sinai Spine Center
444 S San Vicente Blvd Ste 900
Los Angeles CA 90048
(310) 828-7757
Orthopaedics

e 1995 **Prof Vicenzo Denaro**
Campus Bio-Medico University
Via Alvaro del Portillo 200
Rome 00128 Italy
39-06226511934
Ortho Spine Surgery

a 2009 **Gurvinder S Deol, MD**
Wake Orthopaedics LLC
3009 New Bern Ave
Raleigh NC 27610
(919) 232-5020
Orthopaedics

a 2012 **Clinton J Devin, MD**
Vanderbilt Orthopaedic Institute
MCE, South Tower Ste 4200
Nashville TN 37232-8774
(615) 500-4678
Orthopaedics

a 2000 **Denis J DiAngelo, PhD**
Univ TN Health Science Center
Biomedical Eng and Imaging
956 Court Ave Ste E226
Memphis TN 38163
(901) 448-7744
Research

e 1985 **Yves Dirheimer, MD**
27 rue Goethe
Strasbourg 67000 France
33-388353626
Rheumatology

a 1993 **William F Donaldson, III, MD**
Univ of Pittsburgh Medical Cntr
3471 Fifth Ave Ste 1010
Pittsburgh PA 15213
(412) 605-3218
Orthopaedics

e 1994 **John Dove, FRCS**
31 Quarry Ave Hartshill
Stoke-On-Trent ST4 7EW
United Kingdom
44-1782411517
Orthopaedics

a 1988 **Randall F Dryer, MD**
6818 Austin Cntr Blvd Apt 200
Austin TX 78731-3165
(512) 795-2225
Orthopaedics

s 1979 **Thomas Ducker, MD**
1010 Woodmont Ct
Greensboro GA 30642-4443
(706) 999-0048
Neurosurgery

e 2010 **John M Duff, MD**
Chemin de L'Azur 11
La Croix-sur-Lutry 1090
Switzerland
Neurosurgery

a 2006 **Neil Duggal, MD, MSc**
London Health Sciences Centre
339 Windermere Rd
London ON N6A 5A5 Canada
(519) 663-2926
Neurosurgery

s 1973 **Edward J Dunn, MD**
10 Uncle Freemans Rd
PO Box 87
West Dennis MA 02670-2307
(508) 394-6119
Orthopaedics

a 2002 **Marcel F Dvorak, MD**
University of British Columbia
Blusson Spinal Cord Centre
818 West 10th Ave Rm 6180
Vancouver BC V5Z 1M9
Canada
(604) 875-5859
Orthopaedics

s 1986 **Anthony P Dwyer, MD**
1011 South Valenta St # 141
Denver CO 80247-6817
(303) 399-8020 EXT 2344
Orthopaedics

a 2011 **Jason C Eck, DO, MS**
Center for Sports
Medicine and Orthopaedics
2415 McCallie Ave
Chattanooga TN 37404
(423) 624-2696
Orthopaedics

s 1982 **Walter C Edwards, MD**
2876 Wyngate NW
Atlanta GA 30305-2834
(404) 250-1180
Orthopaedics

e 2001 **Soren Peter Eiskjaer, MD**
Aalborg University Hospital
Postbox 365
Hobrovej 18-22
Aalborg 9100 Denmark
45-899322620
Orthopaedics

a 1981 **Frank J Eismont, MD**
Univ of Miami
PO Box 016960 D 27
Miami FL 33101-6960
(305) 585-7138
Orthopaedics

a 2009 **Hossein K Elgafy, MD, FRCSC**
University of Toledo Med Cntr
Dept Orthopaedic
3065 Arlington Ave
Toledo OH 43614
(419) 383-3515
Orthopaedics

e 1994 **Jean Pierre Elsig, MD**
Seestrasse 122
Kusnacht 8700 Switzerland
41-449142200
Orthopaedics

a 1991 **Sanford E Emery, MD, MBA**
West Virginia Univ HSC South
Dept of Orthopaedics
PO Box 9196-3400
Morgantown WV 26506-9196
(304) 293-1170
Orthopaedics

a 1982 **Nancy Epstein, MD**
Winthrop Neurosceince
200 Old Country Rd Ste 485
Mineola NY 11501
(516) 354-3401
Neurosurgery

c 1990 **Ian D Farey, MBBS, FRACS**
PO Box 2104 Boronia Park
Sydney NSW 2111 Australia
61-298172944
Orthopaedics

a 1998 **James C Farmer, MD**
Hospital For Special Surgery
535 East 70th St
New York NY 10021
(212) 606-1591
Orthopaedics

a 2009 **Amir H Fayyazi, MD, BS**
OAA Specialists
250 Cetronia Rd Ste 303
Allentown PA 18104-9168
(610) 973-6200
Orthopaedics

a 1993 **Michael G Fehlings MD, PhD**
Toronto Western Hospital
399 Bathurst St Ste 4W 449
Toronto ON M5T 2S8 Canada
(416) 603-5072
Research

e 2005 **Richard Ferch, MD**
PO Box 935
Hamilton NSW 2303 Australia
61-249621266
Neurosurgery

a 1991 **Jeffrey C Fernyhough, MD**
Florida Back Institute
1905 Clint Moore Rd Ste 309
Boca Raton FL 33496-2661
(561) 988-8988
Orthopaedics

a 1991 **Pierce J Ferriter, MD**
1421 Third Ave Fifth Fl
New York NY 10028
(212) 772-9711
Orthopaedics

a 2002 **Richard G Fessler, MD**
Rush University Medical Center
1725 W Harrison St Ste 855
Chicago IL 60612
(312) 942-6644
Neurosurgery

e 2009 **Vincent Fiere, MD**
Centre Orthopedique Santy
24, Avenue Paul Santy
Lyon 69008 France
33-437530048
Spine Surgery

a 1996 **Jeffrey S Fischgrund, MD**
Michigan Orthopaedic Institute
26025 Lahser Rd Fl 2
Southfield MI 48033-2606
(248) 663-1907
Orthopaedics

a 1999 **Kevin T Foley, MD, FAANS**
Semmes-Murphey Neurologic & Spine Institute
6325 Humphreys Blvd
Memphis TN 38120
(901) 751-6567
Neurosurgery

a 2005 **John C France, MD**
West Virginia University
Dept of Orthopaedic
PO Box 9196
Morgantown WV 26506
(304) 293-3900
Orthopaedics

a 2011 **Eric I Francke, MD**
1418 Oakridge View Dr
Mableton GA 30126
(770) 944-3033
Orthopaedics

a 2006 **Anthony Frempong-Boadu, MD**
NY Univ Med Center
Dept of Neurosurgery
550 First Ave
New York NY 10016
(212) 263-6514
Neurosurgery

e 1995 **Jean-Marc Fuentes, MD**
Clinique Rech
9 avenue Charles Flahault
Montpellier Cedex 5 34094
France
33-467545400
Neurosurgery

c 2001 **Yoshinori Fujimoto, MD, PhD**
Ushita-Higashi 3-16-13
Higashi-Ku
Hiroshima 732-0063 Japan
81-829363111
Orthopaedics

s 1988 **Francis W Gamache, Jr, MD**
1955 Beekman Ct
Yorktown Hts NY 10598-6258
(212) 988-5200
Neurosurgery

s 1983 **Steven R Garfin, MD**
UCSD Medical Center
200 W Arbor Dr Ste 8894
San Diego CA 92103-8894
(858) 488-9661
Orthopaedics

e 2001 **Giosue Gargiulo, MD**
ASO S Giovanni
Battista Molinette
Division Orthopedics
Corso Bramante 88/90
Torino 10126 Italy
39-0116335275
Orthopaedics

a 2013 **Ben J Garrido, MD**
Lake Norman Ortho Spine Cntr
170 Medical Park Rd Ste 102
Mooresville NC 28117
(704) 660-4750
Orthopaedics

a 1996 **Timothy A Garvey, MD**
Twin Cities Spine Ctr
Piper Building
913 E 26th St Ste 600
Minneapolis MN 55404-4515
(612) 775-6200
Orthopaedics

a 2011 **Matthew J Geck, MD**
Seton Spine and Scoliosis Cntr
1600 W 38th St Ste #200
Austin TX 78731
(512) 324-3580
Ortho Spine Surgery

a 2009 **Michael C Gerling, MD**
110 Duane St
New York NY 10007
(718) 915-2151
Orthopaedics

a 2005 **Peter C Gerszten, MD**
Univ of Pittsburgh Med Ctr
200 Lothrop Str Ste B 400 PUH
Pittsburgh PA 15213
(412) 647-0958
Neurosurgery

a 1999 **Alexander J Ghanayem, MD**
Loyola University Medical Cntr
Depart of Orthopaedic Surgery
2160 South 1st Ave
Maywood IL 60153
(708) 216-3475
Orthopaedics

a 2009 **Gary Ghiselli, MD**
Denverspine
7800 E Orchard Rd Ste 100
Greenwood Village CO 80111
(303) 697-7463
Orthopaedics

a 2008 **Zoher Ghogawala, MD, FACS**
Lahey Hospital & Medical Cntr
41 Mall Rd
Dept of Neurosurgery
Burlington MA 01805
(781) 744-3448
Neurosurgery

a 1988 **Kevin Gill, MD**
UT Southwestern Medical Cntr
1801 Inwood Rd
Dallas TX 75390-8883
(214) 645-2104
Orthopaedics

s 1983 **Franz E Glasauer, MD**
Buffalo NY
(716) 898-3809
Neurosurgery

a 1999 **John A Glaser, MD**
Medical Univ of South Carolina
Dept Orthopaedic Surgery
96 Jonathan Lucas Ste 708
Charleston SC 29425
(843) 792-0601
Orthopaedics

a 1989 **Cary D Glastein, MD**
Shore Orthopaedics
35 Gilbert St South
Tinton Falls NJ 07701
(732) 530-1515
Orthopaedics

c 2008 **Atul Goel, MD, PhD**
KEM Hospital &
Seth GS Med College
Prof and Head Dept
Neurosurgery
Parel Mumbai 400 012 India
91-224129884
Neurosurgery

s 1985 **Vijay K Goel, PhD**
U of Toledo Bioengineering
5046 Nitschke Hall MS 303
2801 W Bancroft St
Toledo OH 43606-3390
(419) 530-8035
Bioengineering

e 1995 **Jan Goffin, MD, PhD**
UZ Gasthuisberg
Department of Neurosurgery
Herestraat 49
Leuven 3000 Belgium
32-16344290
Neurosurgery

a 2002 **Ziya L Gokaslan, MD**
Johns Hopkins University
600 N Wolfe St
Meyer Bldg Rm 7 109
Baltimore MD 21287
(443) 287-4934
Neuro Spine

a 1999 **Jeffrey A Goldstein, MD**
NYU Hospital for Joint Disease
16 Manursing Way
Rye NY 10580
(212) 513-7711
Orthopaedics

s 1986 **Donald R Gore, MD**
Sheboygan Orthopedic Assoc
2920 Superior Ave Fl 1
Sheboygan WI 53081-1944
(920) 458-3791
Orthopaedics

c 1995 **Sumio Goto, MD**
1201-20 Miyako, Chuo
Chiba 260-0001 Japan
81-432330832
Orthopaedics

s 1973 **S Ashby Grantham, MD**
Englewood NJ
(201) 871-0130
Orthopaedics

a 2011 **Jonathan N Grauer, MD**
Yale Univ School of Medicine
Dept of Ortho
PO Box 208071
New Haven CT 06520-8071
(203) 737-7463
Orthopaedics

a 1993 **Gregory P Graziano, MD**
Henry Ford Hospital
2799 West Grand Blvd
Detroit MI 48202
(800) 436-7936
Orthopaedics

se 1987 **Dieter Grob, MD**
Schultess Klinik Spine Center
Lengghalde 2
Zurich 8008 Switzerland
41-13857436
Orthopaedics

a 2009 **Richard D Guyer, MD**
Texas Back Institute
6020 W Parker Rd Ste 200
Plano TX 75093-7916
(972) 608-5088
Orthopaedics

a 2001 **Regis W Haid, Jr, MD, FAANS**
Atlanta Brain and Spine Care
2001 Peachtree Rd NE Ste 575
Atlanta GA 30309-1476
(678) 904-7158
Neurosurgery

e 2004 **Iizuka Haku, MD**
Gunma Univ Grad Sch of Med
Dept of Orthopaedic Surgery
Gunma 3-39-22 Showa
Maebashi Gunma 371-8511
Japan
81-272208269
Orthopaedics

s 1986 **Edward N Hanley, Jr, MD**
Carolinas Medical Center
1025 Morehead Medical Dr
Ste 300
Charlotte NC 28204
(704) 355-5026
Orthopaedics

e 1989 **Juergen Harms, MD**
SRH Klinikum
Karlsbad-Langensteinbach
Guttmannstr 1
Karlsbad D-76307 Germany
49-07202616166
Spine Surgery

a 2001 **Mitchel B Harris, MD**
Brigham and Womens Hospital
75 Francis St
Department of Ortho Surg
Boston MA 02115
(617) 732-5385
Orthopaedics

a 2008 **James S Harrop, MD, FAANS**
Thomas Jefferson University
909 Walnut St
Philadelphia PA 19107
(215) 955-7000
Neurosurgery

a 2001 **Robert A Hart, MD**
OHSU
Mail Code OP31
3181 SW Sam Jackson Park Rd
Portland OR 97239
(503) 494-6406
Orthopaedics

a 2000 **Mark B Hartman, MD**
20141 Riverchase Dr
Cornelius NC 28031
(704) 892-7952
Orthopaedics

a 2001 **Robert F Heary, MD, FAANS**
Rutgers-New Jersey Med Sch
90 Bergen St Ste 8100
Newark NJ 07103
(973) 972-2334
Neurosurgery

a 2011 **Andrew C Hecht, MD**
Mount Sinai Medical Center
5 East 98th St
Spine Center, 4th floor,
Box 1188
New York NY 10029
(917) 463-8180
Orthopaedics

e 2000 **Rune L Hedlund, MD**
Sahlgrenska University Hospital
Gothenburg
Ortho Clinic
Gothenburg 41345 Sweden
46-858580000
Orthopaedics

c 2002 **Hwan Tak Hee, MD**
Pinnacle Spine & Scoliosis Cntr
3 Mount Elizabeth #04-07
Mount Elizabeth Medical Centre
Singapore 228510 Singapore
65-67370680
Orthopaedics

s 1984 **Alan E Heilman, MD**
Texas Orthopedic Hospital
7401 S Main St
Houston TX 77030
(713) 828-1307
Orthopaedics

a 1991 **John G Heller, MD**
Emory Spine Center
59 Executive Park South
Atlanta GA 30329
(404) 778-7112
Orthopaedics

s 1973 **Robert N Hensinger, MD**
Univ of Michigan Med Ctr
1500 E Medical Center Dr
Spc 5201
Ann Arbor MI 48109-5201
(734) 936-5715
Orthopaedics

s 1994 **Thomas R Highland, MD**
Columbia Ortho Group
1 S Keene St
Columbia MO 65201-7199
(573) 876-8634
Orthopaedics

a 1999 **Alan S Hilibrand, MD**
Rothman Institute at Jefferson
925 Chestnut St 5th Fl
Philadelphia PA 19107-4216
(267) 339-3620
Orthopaedics

c 1980 **Kiyoshi Hirabayashi, MD**
1-14-4 Jingumae, Shibuya
Tokyo 150-0001 Japan
81-334043996
Orthopaedics

c 2013 **Takashi Hirai, MD, PhD**
2-35-8 Kichijoji-Honcho
Musashino
Tokyo 1800004 Japan
81-358035279
Orthopaedics

a 1999 **Scott D Hodges, DO**
Center For Sports Med & Ortho
2415 McCallie Ave
Chattanooga TN 37404
(423) 624-2696
Orthopaedics

s 1973 **Mason Hohl, MD**
234 Marguerita Ave
Santa Monica CA 90402-1622
(310) 394-3938
Orthopaedics

a 2004 **Langston T Holly, MD, FAANS**
UCLA Medical Center
300 Stein Plaza Ste 562
Los Angeles CA 90095
(310) 267-5580
Neurosurgery

c 2011 **Jae Taek Hong, MD, PHD**
93-6 Chi-dong Paldal-gu
Suwon 442-723
Republic of Korea
Neurosurgery

c 2014 **Jae-Young Hong, MD**
Korea University Ansan
Hospitalgojan Dong
Gojan Dong DanwonGu
Ansan 425-707
Republic of Korea
82-314124944
Orthopaedics

a 2014 **MaryBeth Horodyski, EdD**
UF Orthopaedics & Sports Med
PO Box 112727
3450 Hull Rd
Gainesville FL 32610
(352) 335-1270
Research

a 2005 **John K Houten, MD, FAANS**
Marcus Neuroscience Institute
800 Meadows Rd
Boca Raton FL 33486
(516) 955-4600
Neurosurgery

a 2011 **Wellington K Hsu, MD**
NWU Feinberg School of Med
Dept Orthopaedic Surg 13th Fl
676 N Saint Clair Ste 1350
Chicago IL 60611
(312) 926-4471
Orthopaedics

a 2011 **Serena S Hu, MD**
Stanford Univesity Sch of Med
450 Broadway St MC: 6342
Redwood City CA 94063
(650) 721-7616
Orthopaedics

c 2013 **Yong Hu, MD**
Dept of Spinal Surgery,
Ningbo No 6 Hospital
NO 1059 Zhong Shan East Rd
Zhejiang Province
Ningbo City 315040 China
86-57487996113
Orthopaedics

e 2001 **Peter C G Hubach, MD**
Alkmaar Netherlands
31-725484444
Orthopaedics

a 1999 **Cameron B Huckell, MD**
Pinnacle Ortho & Spine Spec
700 Michigan Ave Ste 100
Buffalo NY 14203-1537
(716) 854-5700
Orthopaedics

a 2014 **Alexander P Hughes, MD**
Hospital For Special Surgery
523 E 72nd St, 3rd Fl
New York NY 10021
(212) 774-2992
Orthopaedics

a **Steven S Hughes, MD**
1996 Commonwealth Orthopedics
8320 Old Courthouse Rd # 100
Vienna VA 22182-3811
(703) 810-5212
Orthopaedics

e **Lalso Husag, MD**
1987 Haesiweg 27
Erlinsbach 5018 Switzerland
41-648386693
Neurosurgery

e **Masatake Ino, MD**
2012 Gunma Spine Center
Dept of Ortho Surg
828-1 Kamitoyooka
Takasaki, Gunma 3700871
Japan
81-81273438000
Orthopaedics

c **Ken Ishii, MD, PhD**
2009 Keio University School of Med
Department of Ortho Surg
35 Shinanomachi Shinjuku
Tokyo 160-8582 Japan
81-353633812
Orthopaedics

c **Manabu Ito, MD, PhD**
2011 National Hospital Organization
Hokkaido Medical Center
1-1 5Jo 7Chome Yamanote,
Nishi-ku, Dept of Spine and
Spinal Cord Disorders
Sapporo 063-0005 Japan
81-0116115820
Orthopaedics

c **Tatsuo Itoh, MD**
1981 Tokyo Womens Medical Univ
Yachiyo Medical Center
477-96 Owada-Shinden
Yachiyo-shi
Chiba 276-8524 Japan
81-474506000
Orthopaedics

e **Andre Jackowski, MD**
2000 Royal Orthopaedic Hospital
Northfield Woodlands
Birmingham B31 2AP
United Kingdom
44-1216854260
Neurosurgery

s **George B Jacobs, MD**
1995 5506 Harbour Preserve Cir
Cape Coral FL 33914
(239) 314-8355
Neurosurgery

e **Bernard Jeanneret, MD**
1989 Universitatsspital
Behandlungszentrum
Bewegungsapparat
Basel 4031 Switzerland
41-612657810
Orthopaedics

a **Louis G Jenis, MD**
1999 Massachusetts General Hospital
55 Fruit St Ste 3800
Boston MA 02114
(617) 724-8636
Orthopaedics

a **A Alexander M Jones, MD**
1993 27 Sassafras Trl
Savannah GA 31404
(303) 861-2266
Orthopaedics

e **Halldor Jonsson, Jr, MD**
1995 Institute for Surgical Sciences
Head Dept Orthopaedic Surgery
Landspitali Univ Hospital
Reykjavik IS-108 Iceland
354-1601000
Orthopaedics

c **Dr Takashi Kaito**
2011 Osaka Univ Grad Sch of Med
2-2 Yamadaoka
Dept of Orthopaedic Surgery
Suita 565-0871 Japan
81-668793552
Orthopaedics

c **Shuichi Kaneyama, MD, PhD**
2012 Kobe Rosai Hospital
4-1-23 Kagoike-dori Chuo-ku
Kobe Hyogo 651-0053 Japan
81-1782315901
Orthopaedics

a **James D Kang, MD**
1995 Brigham and Women's Hospital/
Harvard Medical School
75 Francis St
Boston MA 02115
(617) 732-5362
Orthopaedics

c **Eldin E Karaikovic, MD, PhD**
1998 Northshore Ortho Spine Center
Dept of Orthopaedics
1000 Central St Ste 880
Evanston IL 60201
(847) 570-2825
Orthopaedics

c **Mamoru Kawakami, MD, PhD**
2000 Wakayama Med
Univ Kihoku Hosp
Spine Care Ctr Dept Ortho Surg
219 Myoji Katsurago
Cho Ito Gun
Wakayama 649-7113 Japan
81-736228209
Orthopaedics

e **Pierre Kehr, MD**
1983 25 rue Schweighaeuser
Strasbourg 67000 France
33-388605037
Orthopaedics

a **Michael P Kelly, MD**
2014 Washington University
Dept of Ortho Surg
Campus Box 8233
660 South Euclid Ave
St Louis MO 63110
(314) 747-2511
Orthopaedics

a **David Hanwuk Kim, MD**
2008 New England Baptist Hospital
125 Parker Hill Ave
Boston MA 02120
(617) 754-5595
Orthopaedics

c **Jin-Hwan Kim, MD, PhD**
2011 Inje University Ilsan Paik Hosp
2240 Daehwa Dong Ilsanseo
Gu Goyang Si
Gyeonggido 411-406
Republic of Korea
82-319107828
Orthopaedics

c **Seok-Woo Kim, MD, PhD**
2013 Hallym Univ Sacred Heart Hosp
Dept Orthopaedic Surgery
896 Pyeongchon-dong
Anyang-Si Gyeonggi-Do
431-070 Republic of Korea
82-313806000
Orthopaedics

a **John S Kirkpatrick, MD**
2002 1416 Craftsman W Ave
Celebration FL 34747
(205) 533-0237
Orthopaedics

c **Hideki Kitagawa, MD**
1995 19-8 Omachi
Toyama City 939-8073 Japan
81-0764203833
Orthopaedics

c 2014 **Kazuya Kitamura, MD, PhD**
Hiratsuka City Hospital
1-19-1 Minamihara Hiratsuka
Kanagawa 254-0065 Japan
81-0463320015
Orthopaedics

e 2003 **Kenichi Kitaoka, MD**
Kochi Japan
81-888802386
Orthopaedics

s 1991 **Scott H Kitchel, MD**
Neurospine Institute LLC
74-B Centennial Loop Ste 300
Eugene OR 97401
(541) 393-0100
Orthopaedics

a 1999 **Jeffrey D Klein, MD**
NYU Hospital for Joint Diseases
380 Second Ave Ste 1001
New York NY 10010
(212) 460-0174
Orthopaedics

e 1995 **Patrick Kluger, MD**
Heinrich-Hammer-Strasse 12
Erbach D-89155 Germany
49-7305919235
Orthopaedics

c 2014 **Masao Koda, MD, PhD**
Chiba Unive Grad Sch of Med
1-8-1 Inohana Chuo-Ku
Chiba 2608670 Japan
81-495541531
Orthopaedics

e 2010 **Heiko Koller, PhD, MD**
Am Rathaus 9
Waldeck 34513 Germany
Ortho Spine

e 2004 **Zahariou Konstantinos, MD**
Carayannis Bros SA
Nina Yannouli
115 Vas Sofias Avenue
Athens 115 21 Greece
30-2106280000

a 2011 **Branko Kopjar, MD, PhD, MS**
University of Washington
4333 Brooklyn Ave NE
Health Sciences
T-14 #316 Box 359455
Seattle WA 98195-7660
(206) 607-6861
Neurosurgery

e 1986 **Demetre S Korres, MD**
10 Heyden St
Athens 104 34 Greece
30-2108830586
Orthopaedics

s 2002 **John P Kostuik, MD**
5921 N Echo Canyon Ln
Phoenix AZ 85018-1249
(571) 594-7419
Orthopaedics

e 2005 **Ralph Kothe, MD**
Klinikum Dortmund
Interdisziplinares
Wirbelsaulenzentrum
Beurhausstr 40
Dortmund 44137 Germany
49-23195321890
Orthopaedics

a 1981 **Martin H Krag, MD**
Univ of Vermont Med School
Dept of Ortho Rehab
Stafford Hall 430A
Burlington VT 05405-0084
(802) 656-4472
Orthopaedics

a 1999 **David L Kramer, MD**
20 Germantown Rd
Danbury CT 06810
(203) 744-9700
Orthopaedics

s 1991 **David R Kraus, MD**
Three Rivers Ortho Assoc
200 Delafield Rd Ste 1040
Pittsburgh PA 15215-3205
(412) 782-3990
Orthopaedics

c 2006 **Sung Uk Kuh, MD, PhD**
Yongdong Severance
Spine Hosp
146-92 Dogok-dong
Kangnam-gu
Seoul 135-720
Republic of Korea
82-220193404
Neurosurgery

a 2009 **Brian Kwon, MD**
New England Baptist Hospital
125 Parker Hill Ave
Boston MA 02120
(617) 754-6586
Orthopaedics

a 2014 **Brian K Kwon, MD, PhD**
Blusson Spinal Cord Center
818 West 10th Ave Rm 6196
Vancouver BC V5Z 1M9
Canada
(604) 875-5857
Orthopaedics

e 2004 **Jesus Lafuente Baraza, MD**
National Hospital
London United Kingdom
44-2078373611
Neurosurgery

e 2000 **Massimo Laus, MD**
S Orsola - M Malpighi Hospital
Via Albertoni 15
Bologna 40138 Italy
39-0516362670
Orthopaedics

a 2013 **Brandon D Lawrence, MD**
Univ of Utah Ortho Center
590 Wakara Way
Salt Lake City UT 84108
(801) 587-5450
Orthopaedics

a 2013 **Eric B Laxer, MD**
Orthocarolina Spine Center
2001 Randolph Rd
Charlotte NC 28207
(704) 323-3657
Orthopaedics

a 2013 **Darren R Lebl, MD**
Hospital For Special Surgery
523 E 72nd St Rm 101
New York NY 10021-4099
(212) 606-1052
Ortho Spine Surgery

c 2009 **Dong-Ho Lee, MD, PhD**
388-1 Pungnap 2-dong
Songpa-gu Seoul 138-736
Republic of Korea
82-230103898
Orthopaedics

c 2014 **Jae-Chul Lee, MD, PhD**
Soonchunhyang University
Seoul Hospital
Department of Orthopedics
657 Hannam-dong, Yongsan-gu
Seoul 140-763
Republic of Korea
82-27099250
Orthopaedics

a 2009 **Joon Yung Lee, MD**
Univ Health Center of Pittsburgh
3471 5th Ave Ste 1002
Pittsburgh PA 15213-3221
(412) 605-3298
Orthopaedics

c 2011
Jung Sub Lee, MD, PhD
Pusan National University Hosp
Department of Ortho Surg
1-10 Ami-Dong Seo-Gu
Busan 602-815
Republic of Korea
82-512407248
Orthopaedics

c 2009
Kwang-Bok Lee, MD, PhD
Chonbuk National Univ Hosp
634-18 Keuam-dong
Jeonju 560-761
Republic of Korea
82-632502586
Orthopaedics

a 2012
Michael Jihoon Lee, MD
University of Chicago Med Cntr
5841 S Maryland Ave
Ste MC6051
Chicago IL 60637-1654
(773) 834-3531
Orthopaedics

c 2006
Sang-Hun Lee, MD, PhD
Kyung Hee University Hospital
at Gangdong
#892 Dongnam-ro
Gangdong-gu Seoul 134727
Republic of Korea
82-24406152
Orthopaedics

a 2009
Ronald A Lehman, Jr, MD
Columbia University Med Ctr
Dept of Orthopaedic Surg PH 11
622 West 168th St
New York NY 10032
(212) 305-5974
Orthopaedics

e 1995
Klaus Liebig, MD
Erlenfeld 22A
Erlangen 91056 Germany
49-091378523667
Orthopaedics

e 2000
Bengt I Lind, MD, PhD
GHP Spine Center Göteborg AB
Gruvgatan 8
Vastra Frolunda 421 30 Sweden
46-31891263
Ortho Spine

a 1988
Ronald W Lindsey, MD
The University of Texas
Medical Branch Orthopaedics
301 University Blvd RSH 2.316
Galveston TX 77555-0165
(713) 953-8638
Orthopaedics

s 1983
Stephen J Lipson, MD
10 Nolte Cir
Weston MA 02493-1242
(781) 891-9884
Orthopaedics

c 2008
Gabriel K P Liu, MSc, FRCS
03-06 The Bayron
49 Saint Thomas Walk
Singapore S238140 Singapore
65-92338520
Orthopaedics

e 1982
Carlo Logroscino, MD
Abt Wirbelsaule & Ruckenmark
Policlinico Gemelli
Largo Gemelli 1
Roma 00168 Italy
39-063543174
Orthopaedics

s 1973
Donlin M Long, MD, PhD
Johns Hopkins Hospital
Dept of Neurosurgery
600 N Wolfe St Carnegie 466
Baltimore MD 21287-7709
(410) 614-3536
Neurosurgery

e 1983
Prof Rene Louis
4 bis Impasse Roc Fleuri
Marseille 13008 France
33-91913391
Orthopaedics

a 2002
Steven C Ludwig, MD
Univ of Maryland Med
Sys-Depart of Ortho
110 S Paca St Fl 6, Ste 300
Baltimore MD 21201
(410) 328-3330
Orthopaedics

e 2000
Willem F Luitjes, MD
Slotervaart Hospital
Louwesweg 6
Amsterdam 1066 EC
Netherlands
31-205124418
Neurosurgery

c 2014
Masaaki Machino, MD
Nagoya Univ Grad Sch of Med
65 Tsurumai Shouwa-ku
Nagoya 466-8560 Japan
81-527412111
Orthopaedics

e 1984
Professor Friederich Magerl
Roetelistrasse 2
St Gallen 9000 Switzerland
41-712234152
Orthopaedics

a 2011
Rex A W Marco, MD
Houston Methodist Orthopedics
& Sports Medicine
6550 Fannin St
Smith Tower Ste 2600
Houston TX 77030
(713) 363-7510
Spine

a 2001
Steven M Mardjetko, MD
Illinois Bone and Joint Institute
9000 Waukegan Rd Ste 200
Morton Grove IL 60053-2116
(847) 234-3886
Spine Deformity

e 2003
Antonio Martin-Benlloch, MD
Hospital Dr Peset
Av Gaspar Aguilar, 90
Valencia 46017 Spain
34-96386
Orthopaedics

c 2009
Morio Matsumoto, MD, PhD
Keio University Hospital
35 Shinanomachi
Shinjuku-ku
Tokyo 160 Japan
Orthopaedics

c 1999
Shunji Matsunaga, MD
Imakiire General Hospital
4-16 Shimotatsuo chou
Kagoshima 892-8502 Japan
81-992262211
Orthopaedics

c 2011
Yukihiro Matsuyama, MD, PhD
Hamamatsu Univ Sch of Med
1-20-1 Handayama Higashi-Ku
Hamamatsu 431-3192 Japan
Orthopaedics

s 1979
Philip J Mayer, MD, PC
311 E Main Ste A
Northville MI 48167
(248) 305-3336
Orthopaedics

e 1990
Christian Mazel, MD
Institut Mutualiste Montsouris
42 Boulevard Jourdan
Paris 75014 France
33-156616400
Orthopaedics

a 1986
Paul C McAfee, MD, MBA
521 Belfast Rd
Sparks MD 21152
(410) 337-8888
Orthopaedics

a 2013 **Scott C McGovern, MD**
Peninsula Orthopaedic Assoc
1675 Woodbrooke Dr
Salisbury MD 21804
(410) 749-4154
Orthopaedics

a 1990 **Robert A McGuire, Jr, MD**
2500 N State St
Jackson MS 39216
(601) 984-5142
Orthopaedics

e 1992 **Hossein Mehdian, MD**
University Hospital Queens Medical Ctr
Ctr for Spinal Studies & Surgery
Derby Road 101
Nottingham NG7 2UH
United Kingdom
44-1159709013
Orthopaedics

e 2005 **Robert P Melcher, MD**
Klinikum - Karlsbad Langensteinbach
Karlsbad-Langensteinbach
Germany
49-7202610
Orthopaedics

s 1980 **Robert A Mendelsohn, MD**
5630 Wisconsin Ave Apt 302
Chevy Chase MD 20815-4452
(301) 770-3134
Neurosurgery

a 2009 **Sergio A Mendoza-Lattes, MD**
Duke Orthopaedics
40 Duke Medicine Circle
5th Fl orange zone
DUMC Box 3077
Durham NC 27710
(919) 684-2023
Orthopaedics

a 2014 **Addisu Mesfin, MD**
University of Rochester
601 Elmwood Ave Box 665
Rochester NY 14642
(585) 275-5196
Orthopaedics

s 1985 **Paul R Meyer, Jr, MD**
2862 Arran Quay Ter
Valparaiso IN 46385-8078
(219) 886-4432
Orthopaedics

c 2004 **Hisanori Mihara, MD**
Yokohama Minami Kyosai Hosp
24-9 Moegino Aoba
Yokohama 227-0044 Japan
81-457822101
Orthopaedics

a 2011 **R Alden Milam, IV, MD**
OrthoCarolina Spine Center
2001 Randolph Rd
Charlotte NC 28207
(704) 323-3225
Orthopaedics

c 2011 **Akihito Minamide, MD, PhD**
Wakayama Medical University
Dept of Orthopaedic Surgery
811-1 Kimiidera
Wakayama 641-8510 Japan
81-734410645
Orthopaedics

a 1998 **Srdjan Mirkovic, MD**
575 Oak Tree Ln
Northfield IL 60093
(312) 664-6848
Orthopaedics

a 2000 **Sohail K Mirza, MD, MPH**
Dartmouth Hitchcock Med Ctr
One Medical Center Dr
Lebanon NH 03756
(603) 727-6647
Orthopaedics

c 2009 **Jun Mizutani, MD, PhD**
Nagoya City Univ Med School
Dept of Ortho Surgery
1 Kawasumi, Mizuho-cho
Mizuho-ku
Nagoya 467-8601 Japan
81-528538236
Orthopaedics

e 2006 **Hans Moller, MD**
Huddinge University Hospital
Karolinska Institutet
Dept of Orthopaedic Surgery
Stockholm SE-141 86 Sweden
46-5734413781
Orthopaedics

a 1990 **Pasquale X Montesano, MD**
Montesano Spine & Sport
11000 Prosperity Farms Rd
Ste 102
Palm Beach Gardens FL 34990
(561) 833-4869
Spine

c 2011 **Eun-Su Moon, MD**
Chonnam University Hospital
Kwangju City
Republic of Korea
82-229043662
Orthopaedics

a 2011 **Timothy A Moore, MD**
Metrohealth Medical Center
2500 MetroHealth Drive
Cleveland OH 44109
(216) 778-5373
Orthopaedics

s 1997 **Howard Moses, MD**
1560 Blue Mount Rd
Monkton MD 21111
(410) 329-6237
Neurosurgery

a 1993 **Ronald Moskovich, MD**
NYU Hospital for Joint Diseases
303 2nd Ave Ste 19
New York NY 10003-2747
(646) 453-7123
Orthopaedics

a 2009 **Thomas E Mroz, MD**
Cleveland Clinic
9500 Euclid Ave S-40
Cleveland OH 44195
(216) 445-9232
Orthopaedics

a 2013 **Praveen V Mummaneni, MD**
UCSF
Dept Neurosurgery
505 Parnassus Ave M-779
Box 0112
San Francisco CA 94143
(415) 353-3998
Neurosurgery

s 1980 **Michael J Murphy, MD**
47 Clapboard Hill Rd Ste 4
Guilford CT 06437-2282
(203) 453-2780
Orthopaedics

a 2003 **Daniel B Murrey, MD**
OrthoCarolina Spine Center
2001 Randolph Rd
Charlotte NC 28207-1215
(704) 323-2010
Orthopaedics

e 2000 **Sait Naderi, MD**
Dokuz Eylul University Hospital
Neurosurgery
Izmir 35340 Turkey
90-23225959593305
Neurosurgery

c 2014
Narihito Nagoshi, MD, PhD
Dept of Ortho Surg Keio Univ School of Med
35 Shinanomachi
Shinjuku-ku
Tokyo 160-8582 Japan
81-333531211
Orthopaedics

c 2009
Masaya Nakamura, MD, PhD
Keio University
Dept of Ortho Surg
35 Shinanomachi, Shinjuku-ku
Tokyo 160-8582 Japan
81-353633812
Orthopaedics

c 2008
Kazuyoshi Nakanishi, MD
Hiroshima Univ
School Biomed Sci
Dept Ortho Surgery
Kasumi 1-2-3
Minami-ku 734-8551 Japan
81-822400275
Orthopaedics

c 2012
Hiroaki Nakashima, MD
Nagoya University Graduate School of Medicine
Department of Ortho Surgery
Tsurumaicho 65
Nagoya Aichi 466-8550 Japan
81-527412111
Orthopaedics

a 2009
Ahmad Nassr, MD
Mayo Clinic
200 1st St SW
Rochester MN 55905
(507) 538-0514
Orthopaedics

s 1981
John C Nordt, III, MD
4720 S Le Jeune Rd
Coral Gables FL 33146-1817
(305) 662-2851
Ortho Spine

s 1975
Bruce E Northrup, MD
3500 West Chester Pike #118
Newtown Sq PA 19073-4101
(610) 642-3900
Neurosurgery

a 2011
Eric W Nottmeier, MD
1875 Beach Ave
Atlantic Beach FL 32233
(904) 953-2252
Neurosurgery

a 2011
Pierce D Nunley, MD
Spine Institute of Louisiana
1500 Line Ave Ste 200
Shreveport LA 71101-4643
(318) 629-5555
Orthopaedics

a 2009
Joseph R O'Brien, MD, MPH
George Washington University
2150 Pennsylvania Ave NW
Dept of Orthopaedic Surgery
Washington DC 20037
(202) 741-3300
Orthopaedics

s 1979
Patrick F O'Leary, MD, FACS
1015 Madison Ave 4th Fl
New York NY 10075
(212) 249-8100
Orthopaedics

e 1997
Claes Olerud, MD, PhD
Uppsala University Hospital
Department of Orthopedics
Uppsala SE-751 85 Sweden
46-1866117224
Orthopaedics

a 2014
Douglas G Orndorff, MD
Spine Colorado
One Mercado St Ste 200
Durango CO 81301
(970) 903-7520
Orthopaedics

c 2011
Yasushi Oshima, MD, PhD
The Univ of Tokyo Hospital
Dept of Ortho Surgury
7-3-1 Hongo Bunkyo-ku
Tokyo 113-8655 Japan
81-358008656
Orthopaedics

e 2012
Ali Fahir Ozer, MD
Saklibahce Konaklari
Kiskli Cd B8
Istanbul 3467 Turkey
90-2123381154
Neurosurgery

s 1979
Manohar Panjabi, PhD
Yale Univ School of Med
Dept of Ortho and Rehab
PO Box 208071
New Haven CT 06520-8071
(203) 785-2812
Biomechanics

e 2005
Panayiotis Papagelopoulos, MD
Athens University Medical School
A' Orthopaedic Dept
17 Mavrommateon St
Athens 104 34 Greece
30-2106721355
Orthopaedics

c 2001
Jong-Beom Park, MD, PhD
Dept Ortho Surgery,
Uijeongbu St Mary's Hospital
Catholic Univ of Korea
School of Med
271, Cheon Bo-Ro
(65-1 Kumho-Dong)
Uijongbu-si Kyunggi-Do
480-717 Republic of Korea
82-29332852
Orthopaedics

c 2009
Moon-Soo Park, MD, PHD
Hallym Univ Medical Center
896 Pyungchon-dong
Donagan-gu
Anyang Gyunggi 431-070
Republic of Korea
82-313806000
Orthopaedics

c 2009
Yung Park, MD
National Health Insurance Med Cntr College of Med
Yonsei Univ Dept Ortho Surgery
Goyang Gyunggi-do 410-719
Republic of Korea
82-319000270
Orthopaedics

a 2014
Peter G Passias, MD
360 Furman St Apt 1102
Brooklyn NY 11201-4575
(516) 357-8777
Orthopaedics

a 2009
Alpesh A Patel, MD, FACS
Northwestern University
676 N Saint Clair St Ste 1350
Chicago IL 60611-2958
(312) 695-6800
Orthopaedics

a 2011
Ashvin I Patel, MD
6050 Cattleridge Blvd
Sarasota FL 34232
(941) 371-7723
Orthopaedics

a 2003
Tushar C Patel, MD
1441 Mayhurst Blvd Ste 400
Mclean VA 22102
(703) 810-5223 EXT 1815
Orthopaedics

e 2006
Paul W Pavlov, MD, PhD
ISSSAR
Louiseweg 5
Nijmegen 6523 NA Netherlands
31-653218651
Spine Surgery

e 2003
Wilco Peul, MD, PhD
Leids Universitair
Medisch Centrum
Neurosurgery Dept
Albinusdreef 2, Postbus 9600
Leiden 2300 RC Netherlands
31-715263457
Neurosurgery

a 2002
Frank M Phillips, MD
Midwest Orthopaedics at Rush
1611 W Harrison St Ste 300
Chicago IL 60612
(312) 432-2333
Orthopaedics

s 1975
Donald S Pierce, MD
22 Lathrop Rd
Wellesley MA 02482-7012
(781) 235-0070
Orthopaedics

c 2013
Chaiwat Piyaskulkaew, MD
Lerdsin Hospital
190 Institute of Orthopaedics,
Silom Rd
Bangkok 10500 Thailand
66-23539844
Orthopaedics

e 2010
Spiros G Pneumaticos, MD
Lefkosias 47
Politia Athens 14562 Greece
Orthopaedics

e 2000
Bart Poffyn, MD
Gent University Hospital
185 De Pintelaan
Gent 9000 Belgium
32-92402233
Orthopaedics

e 2002
Vincent Pointillart, MD, PhD
Hopital Tripode,
Service Prof Vital
Place Amelie Raba Leon
Bordeax Cedex 33076 France
33-556798718
Orthopaedics

a 2011
Ravi K Ponnappan, MD
Jersey Spine Associates
750 Route 73 S Ste 301
Marlton NJ 08053-4191
(609) 601-4920
Ortho Spine

a 2014
Mark L Prasarn, MD
University of Texas
Department of Orthopaedics
6400 Fannin Ste 1700
Houston TX 77030
(713) 486-1849
Orthopaedics

e 2001
Bambang Prijambodo, MD
Airlangga Univ Med School
Dr Soetomo Teaching Hospital
J1, Mayjond Prof Dr Moestopo
No 6-8 Surabaya 60286
Indonesia
62-315501481
Orthopaedics

a 2014
Themistocles Protopsaltis MD
NYU Hospital For Joint
Diseases
301 E 17th St, Ste 413
New York City NY 10003
(212) 598-2708
Orthopaedics

a 2000
Christian M Puttlitz, PhD
Colorado State University
A101 Engineering
1374 Campus Delivery
Fort Collins CO 80523
(970) 491-0956
Biomechanics

a 2011
Sheeraz A Qureshi, MD, MBA
250 Mercer St Apt B1606
New York NY 10012
(212) 241-3909
Orthopaedics

a 2013
Kristen E Radcliff, MD
Rothman Institute
Thomas Jefferson University
925 Chestnut 5th Fl
Philadelphia PA 19107
(609) 573-3301
Orthopaedics

a 2009
Ashraf A Ragab, MD
Comprehensive Spine Institute
1988 Gulf to Bay Blvd Ste 1
Clearwater FL 33765-3550
(727) 953-8090
Orthopaedics

s 1987
Nasim A Rana, MD
Northwestern University
675 N St Clair Ste 17-100
Chicago IL 60611-2878
(312) 695-6800
Orthopaedics

c 2003
Nahshon Rand, MD
Israel Spine Center
Assuta Hospital
20 Habarzel St
Tel-Aviv 69710 Israel
97-237645400
Orthopaedics

se 1988
Wolfgang Rauschning, MD
Academic University Hospital
Dept of Orthopaedic Surgery
Uppsala 751 85 Sweden
46-18663000
Orthopaedics

a 2003
Bernard A Rawlins, MD
Hospital For Special Surgery
535 E 70th St
New York NY 10021
(212) 606-1632
Orthopaedics

s 1980
John F Raycroft, Jr, MD
Box 269
South Glastonbury CT
06073-0269
(860) 549-3210
Orthopaedics

s 1975
Richard Raynor, MD
870 United Nations Plz Apt 11F
New York NY 10017-1818
(917) 301-0214
Neurosurgery

a 1987
Glenn R Rechtine, II, MD
7004 Verde Vista Circle
Asheville NC 28805
(828) 424-7801
Orthopaedics

a 2003
Thomas M Reilly, MD
Indiana Spine Group
13225 N Meridian St
Carmel IN 46032
(765) 236-8700
Orthopaedics

a 2004
Charles A Reitman, MD
108 Smith St Apt J
Charleston SC 29403
(843) 792-8959
Orthopaedics

a 2005
John M Rhee, MD
Emory Spine Center
59 Executive Park South
Ste 3000
Atlanta GA 30329
(404) 778-7021
Orthopaedics

a 2006
Alfred L Rhyne, MD
OrthoCarolina
2001 Randolph Rd
Charlotte NC 28207-1215
(704) 323-3658
Orthopaedics

s 1998
James E Ricciardi, MD
1507 Harmony St
New Orleans LA 70115
(504) 568-4680
Orthopaedics

e 2003
Marcus Richter, MD
St Josefs-Hospital
Wiesbaden GmbH
Germany
49-6111773701
Orthopaedics

a 1999
K Daniel Riew, MD
Columbia University
622 West 168th St, PH-11
Dept of Orthopaedic Surgery
New York NY 10032
(212) 305-5974
Orthopaedics

a 2011
Jeffrey A Rihn, MD
Rothman Institute
925 Chestnut St Fl 5
Philadelphia PA 19107-4290
(267) 339-3623
Orthopaedics

a 1999
Lee H Riley, III, MD
211 Woodlawn Rd
Baltimore MD 21210
(410) 955-6930
Orthopaedics

a 2009
Rolando F Roberto, MD
University of California Davis
4860 Y St Ste 3800
Sacramento CA 95817
(916) 734-6233
Orthopaedics

e 2012
Yohan Robinson, MD
Akademiska Sjukhuset
Ing 61, 6 tr
Uppsala 75185 Sweden
46-186119031
Orthopaedics

e 1982
Prof Udo Rodegerdts
Beim Andreasbrunnen 3
Hamburg 20249 Germany
49-4045039387
Orthopaedics

s 1978
David A Roth, MD
131 Black Bear Dr Unit 1911
Waltham MA 02451-0228
(781) 891-4041
Neurosurgery

h 1973
Richard H Rothman, MD
Rothman Institute
925 Chestnut St 5th Fl
Philadelphia PA 19197
(215) 955-3458
Orthopaedics

a 1990
Barton L Sachs, MD, MBA
Medical University of
South Carolina
169 Ashley Ave Ste 260
PO Box 322
Charleston SC 29425
(843) 792-1168
Orthopaedics

e 1999
George Sapkas, MD
Metropolitan Hospital
Ethn Makariou 9 & El
Venizelou 1
N Faliro TK 185 47 Greece
30-32107213885
Orthopaedics

a 1999
Rick C Sasso, MD
Indiana Spine Group
13225 N Meridian St
Carmel IN 46032-5480
(317) 228-7000
Orthopaedics

c 1995
Kazuhiko Satomi, MD
Kyorin University
Dept of Ortho
6-20-2 ShinKawa, Mitaka-shi
Tokyo 181-8611 Japan
81-422475511
Orthopaedics

s 1992
Richard Saunders, MD
Lebanon CT
(603) 448-4455
Neurosurgery

a 2014
Jason W Savage, MD
7282 Forestwood Dr
Independence OH 44131
(312) 926-4444
Orthopaedics

e 2001
Constantin Schizas, MD
Hopital Orthopedique de la
Suisse Romand
Av Pierre Decker 4
Lauusanne 1005 Switzerland
Orthopaedics

s 1982
Lutz H Schlicke, MD
582 Riviera Dr
Tampa FL 33606-3808
(813) 714-6069
Orthopaedics

e 2014
Johannes Schroeder, MD
ZW-O Spine Cntr Osnabrueck
Am Finkenhuegel 3
Osnabrueck 49076 Germany
49-541945460
Neurosurgery

a 2014
P. Bradley Segebarth, MD
OrthoCarolina
2001 Randolph Rd
Charlotte NC 28207
(704) 323-2101
Orthopaedics

a 2011
Lali Sekhon, MD, PhD
Nevada Neurosurgery
75 Pringle Way Ste 1007
Reno NV 89502-1475
(775) 657-8844
Neurosurgery

a 2009
Christopher I Shaffrey, MD
University of Virginia
Dept Neurological Surgery
PO Box 800212
Charlottesville VA 22908
(434) 243-9714
Neurosurgery

a 2005
Francis H Shen, MD
PO Box 800159
Charlottesville VA 22908
(434) 243-0291
Orthopaedics

c 2009
Hongxing Shen, MD
Changhai Hospital
No 168 Changhai Rd
11F Bldg 6
Dept of Orthopaedics
Yanpu Shanghai 200433 China
86-0886218
Orthopaedics

c 1994
Takachika Shimizu, MD
Gunma Spine Center
828-1 Kamitoyooka
Takasaki Gunma 370-0871
Japan
81-273438000
Orthopaedics

c 2009
Hyun-Chul Shin, MD, PhD
Kangbook Samsung Medical Ctr
108, Pyung-Dong, Jongno-ku
Seoul 110-746
Republic of Korea
82-220012160
Neurosurgery

c 1999
Won-Han Shin, MD
1174 Jung-Dong
Wonmi-Gu
Bucheon Gyeongg 420-767
Republic of Korea
82-326215104
Neurosurgery

c 1992
Kenichi Shinomiya, MD, PhD
Yokohama City
Red Cross Hospital
Orthopedics
3-12-1 Shinyamasita, Nakaku
Yokohama 231-8682 Japan
81-358035271
Orthopaedics

c 2004 **Tateru Shiraishi, MD, PhD**
Ichikawa General Hospital
Dept Orthopaedics
5-11-13, Sugano, Ichikawa
Chiba 272-8513 Japan
81-473220151
Orthopaedics

e 2003 **Yuri A Shulev, MD**
City Hospital 2
Neurosurgery Dept
Uchebny per 5
Saint Petersburg 194354
Russian Federation
7-8125107849
Neurosurgery

a 1999 **Vincent J Silvaggio, MD**
Three Rivers Ortho Assoc
200 Delafield Rd Ste 1040
Pittsburgh PA 15215-3205
(412) 782-3990
Orthopaedics

e 1995 **Ernst Sim, MD**
Vienna Austria
43-160150
Ortho Trauma

a 1993 **Edward D Simmons, MD**
Simmons Ortho & Spine Assoc
235 North St Ste 2
Buffalo NY 14201-1435
(716) 882-0035
Orthopaedics

a 2001 **John M Simpson, MD**
Tuckahoe Orthopaedics
1501 Maple Ave Ste 200
Richmond VA 23226
(804) 285-2300
Ortho Spine Surgery

a 2012 **Kern Singh, MD**
Rush University Medical Center
1611 W Harrison St #400
Chicago IL 60612
(312) 432-2373
Orthopaedics

c 2013 **Martin Skeppholm, MD, PhD**
Stockholm Spine Center
Upplands Vasby
Lowenstromska Sjukuset
19489 Sweden
46-850902700
Ortho Spine Surgery

a 2005 **Richard L Skolasky, Jr, ScD**
Johns Hopkins University
601 N Caroline St JHOC 5244
Baltimore MD 21287
(410) 502-7975
Research

a 1999 **Andrew V Slucky, MD**
PO Box 373
Tiburon CA 94920
(510) 752-1529
Orthopaedics

a 2011 **Justin S Smith, MD, PhD**
Univ of Virginia Health System
Department of Neurosurgery
P O Box 800212
Charlottesville VA 22908
(434) 243-9331
Neurosurgery

a 1992 **Michael D Smith, MD**
140 Wildhurst Rd
Tonka Bay MN 55331
(952) 925-2425
Orthopaedics

e 1987 **Antonio Solini, MD**
Azienda Sanitaria Ospedaliera
S G Battista di Torino
Corso Bramante 88
Torino 10126 Italy
39-116335918
Orthopaedics

c 2013 **Kwang-Sup Song, MD**
Dongjak-gu Heukseok-ro 102
Seoul 156-755
Republic of Korea
82-262991589
Orthopaedics

c 2009 **Kyung-Jin Song, MD, PhD**
Chonbuk University Hospital
Dept of Orthopaedic Surgery
634-18 Keum-am
Dong Duk-jin Gu
Jeonju Jeonbuk 561-712
Republic of Korea
82-6322501770
Orthopaedics

s 1973 **Wayne O Southwick, MD**
Yale Univ School of Med
PO Box 208071
New Haven CT 06520-8071
(203) 785-2579
Orthopaedics

a 2009 **Leo R Spector, MD**
Orthocarolina Spine Center
2001 Randolph Rd
Charlotte NC 28207
(704) 323-2225
Orthopaedics

a 1990 **Jeffery L Stambough, MD**
Tristate Ortho Treatment Cntr
4600 Smith Rd Ste B
Cincinnati OH 45212-2784
(513) 221-4848
Orthopaedics

a 2014 **Michael P Steinmetz, MD**
Cleveland Clinic
9500 Euclid Ave
Center for Spine Health S-40
Cleveland OH 44195
(216) 445-6797
Neurosurgery

a 2004 **Brian D Stemper, PhD**
Med Coll of WI VA Medical Cntr
Dept Neurosurgery Research
5000 W National Ave Ste 151
Milwaukee WI 53295
(414) 384-2000
Research

c 2011 **Kota Suda, MD**
Spinal Cord Injury Center,
Hokkaido Chuo Rosai Hosp
Higashi - 4, Minami - 1, 3-1
Bibai 072-0015 Japan
81-126632151
Orthopaedics

c 2009 **Kyung-Soo Suk, MD, PhD**
Yonsei Univ College of Med
Kangnam Severance Hospital
Dept of Ortho Surgery, Yonsei
University College of Medicine
146-92 Dokokdong Kangnamku
Seoul 135-720
Republic of Korea
82-29588345
Orthopaedics

c 2009 **Masatoshi Sumi, MD, PhD**
Kobe Rosai Hospital
4-1-23 Kagoike-dori Chuo-ku
Kobe Hyogo 651-0053 Japan
81-782315901
Orthopaedics

c 2011 **Yu Sun, MD, PhD**
Puth Orthopaedics
49 North Garden Rd
Haidian District
Beijing 100171 China
86-1082267380
Orthopaedics

c 2009 **Toshihiko Taguchi, MD, PhD**
Ymaguchi Univeristy
School of Medicine
Dept of Ortho
1-1-1 Minami-Kogushi
Ube Yamaguchi 755-8505
Japan
81-836222265
Orthopaedics

c 2013 **Masahiko Takahata, MD, PhD**
Kyorin Univ School of Med
6-20-2 Shinkawa Mitaka-City
Tokyo 181-8611 Japan
81-475511
Ortho Surgery

c 2011 **Katsushi Takeshita, MD, PhD**
Jichi Medical University
Department of Orthopedic Surg
3311-1 Yakushiji, Shimotsuke
Tochigi 329-0498 Japan
81-338155411
Orthopaedics

c 2008 **Nobuhiro Tanaka, MD**
Hiroshima Sch of Med
Dept of Ortho Surg
Kasumi 1-2-3 Minami-ku
Hiroshima 734-8551 Japan
81-822575233
Orthopaedics

e 2012 **Tetsu Tanouchi, MD**
Gunma Spine Center
828-1 Kamitoyooka
Takasaki Gunma 370-0871
Japan
81-273438000
Spine

c 2013 **Ryoji Tauchi, MD**
Meijo Hospital
1-3-1 Sannomaru
Naka-ku
Nagoya 460-0001 Japan
81-527412111
Orthopaedics

a 2014 **Bobby K Tay, MD**
60 Mooring Rd
San Rafael CA 94901
(415) 476-1167
Orthopaedics

sc 1982 **Kazuo Terayama, MD**
Metoba 2-4-29
Matsumoto 390-0806 Japan
81-263339493
Orthopaedics

c 2009 **Vo Van Thanh, MD**
Hospital for Trauma-Ortho
22/3, Nguyen Hien Street
11 AF Cu Xa Do Thanh,
Ward 4
Hochiminh Distric 3 70000
Viet Nam
84-838322330
Orthopaedics

s 1987 **Frederick W Tiley, MD**
Willamette Spine Center
2480 Liberty St Ste 160
PO Box 2749
Salem OR 97301-8388
(503) 581-5476
Orthopaedics

a 2000 **Nathaniel L Tindel, MD**
NY Cntr For Spinal Disorders
425 East 79th St Ste 1H
New York NY 10075
(212) 249-3840
Orthopaedics

s 1980 **Joseph S Torg, MD**
401 Conestoga Rd
Saint Davids PA 19087-4811
(215) 707-1321
Orthopaedics

a 2009 **P Justin Tortolani, MD**
Union Memorial Hospital
3333 N Calvert St Ste 400
Baltimore MD 21218
(410) 554-2175
Orthopaedics

c 1992 **Yoshiaki Toyama, MD**
Keio Univ School of Med
Dept of Ortho Surgery
35 Shinanomachi Shinjuku-ku
Tokyo 160-8582 Japan
81-353633811
Orthopaedics

a 1996 **Vincent C Traynelis, MD**
Rush University Medical Center
Department of Neurosurgery
1725 W Harrison St Ste 855
Chicago IL 60612
(312) 942-1854
Neurosurgery

a 1996 **Clifford B Tribus, MD**
Univ of WI Hospitals and Clinics
1685 Highland Ave 6th Fl
Madison WI 53705-2281
(608) 263-9456
Orthopaedics

s 1976 **George Truchly, MD**
1795 Noel Pl Unit 106
Melbourne FL 32935-1702
(914) 528-0692
Orthopaedics

a 2003 **Eeric Truumees, MD**
Seton Spine and Scoliosis Cntr
1600 West 38th St Ste 200
Austin TX 78731
(512) 324-3580
Orthopaedics

a 2000 **Paul J Tsahakis, MD**
5019 Old Course Dr
Charlotte NC 28277
(704) 367-4800
Orthopaedics

a 1982 **Christopher G Ullrich, MD**
2623 Lemon Tree Ln
Charlotte NC 28211-3643
(704) 365-4714
Neuroradiology

e 1995 **Christoph Ulrich, MD**
Steingaustr 42
Owen 73277 Germany
49-7161642222
Ortho Trauma

s 1987 **Friedrich Unterharnscheidt MD**
3520 Greentree Rd
Lexington KY 40517-3115
(859) 269-2494
Neuropathology

a 1996 **Alexander R Vaccaro, III, MD**
Rothman Institute
925 Chestnut St 5th Fl
Philadelphia PA 19107-4216
(267) 339-3623
Orthopaedics

c 2014 **Thanut Valleenukul, MD**
Bumrungrad International Hosp
33 Sol Nana Nua
Bangkok 10110 Thailand
66-26672885
Orthopaedics

e 1994 **Prof Carlos Villas Tome**
Clinica Universitaria
Dept Cirugia Ortop y Trauma
Universidad de Navarra
Pamplona 31008 Spain
34-482554004551
Orthopaedics

s 1982 **S Murthy Vishnubhakat, MD**
North Shore Univ Hospital
300 Community Dr
Manhasset NY 11030
(516) 562-4300
Neurology

e 2003 **Jean-Marc Vital, MD**
CHR Hospital Pellegrin
Place Amelie Raba Leon
Bordeaux 33076 France
33-556795528
Orthopaedics

c 2005 **Eiji Wada, MD**
Ehime Prefectural Central Hosp
Dept of Ortho Surgery
83 Banchi Kasuga-Machi
Matsuyama Ehime 790-0024
Japan
81-899434136
Orthopaedics

s 1982 **Franklin C Wagner, Jr, MD**
Spine and Neurosurgery Assoc
1301 Secret Ravine Pkwy
Ste 200
Roseville CA 95661-3102
(916) 771-3300
Neurosurgery

a 2001 **Jeffrey C Wang, MD**
USC Spine Center
1520 San Pablo St Ste 2000
Los Angeles CA 90033
(323) 319-3334
Orthopaedics

c 2012 **Shenglin Wang, MD**
Peking University
Third Hospital
No 49 North Huayuan Rd
Beijing 10091 China
86-1082267382
Orthopaedics

s 1987 **William C Watters, III, MD**
Bone & Joint Clinic of Houston
6624 Fannin Ste 2600
Houston TX 77030-2338
(713) 790-1818
Orthopaedics

e 1982 **Andreas Weidner, MD, PhD**
Spineconsult GmbH
Wilhelmstr 137
Osnabruck 49078 Germany
49-54194096400
Neurosurgery

h 2006 **James N Weinstein, DO, MS**
Dartmouth-Hitchcock Med Ctr
Dept of Orthopaedics
One Medical Center Dr
Lebanon NH 03756
(603) 653-3580
Orthopaedics

a 2003 **William C Welch, MD**
235 S Eighth St
Philadelphia PA 19106
(215) 829-6700
Neurosurgery

a 1991 **F Todd Wetzel, MD**
Temple Univ School of Medicine
Dept of Orthopaedic Surgery
3401 N Broad St 5th Fl OPB
Philadelphia PA 19140
(215) 707-4064
Orthopaedics

a 2012 **Peter G Whang, MD, FACS**
PO Box 208071
New Haven CT 06520-8071
(203) 785-2584
Ortho Spine

s 1973 **Augustus A White, III, MD**
Harvard Medical School
401 Park Dr Ste 201
Boston MA 02215-3351
(617) 998-8802
Orthopaedics

s 1973 **Thomas E Whitesides, Jr, MD**
Emory University
958 Calvert Ln NE
Atlanta GA 30319-1202
(404) 731-8395
Orthopaedics

s 2009 **Charles H Wingo, MD**
The Spine Institute on the
Emerald Coast
PO Box 613216
Watersound FL 32461
(850) 460-2350
Orthopaedics

a 2009 **Beth A Winkelstein, PhD**
Univ of Pennsylvania
Depart of Bioengineering
210 S 33rd St
240 Skirkanich Hall
Philadelphia PA 19104-6321
(215) 573-4589
Biomechanics

e 2012 **Jasper F C Wolfs, PhD**
Medical Center Haaglanden
Dept of Neurosurgery
Lijnbaan 32
The Hague 2512VA
Netherlands
31-703302000
Neurosurgery

a 2009 **Jean-Paul Wolinsky, MD**
The Johns Hopkins Hospital
Dept of Neurosurgery
600 N Wolfe St Meyer Bldg
Rm 5-109
Baltimore MD 21287
(410) 955-4424
Neurosurgery

c 2014 **Eugene Wong, MD**
109 Road 17/16 Petaling Jaya
Selangor 46400 Malaysia
Orthopaedics

a 2004 **Neill M Wright, MD**
Washington Univ Neurosurgery
Campus Box 8057
660 S Euclid Ave
St Louis MO 63110
(314) 362-3630
Neurosurgery

s 1978 **Isadore G Yablon, MD**
924 Hire Cir
Ocoee FL 34761-3165
(407) 909-0055
Orthopaedics

e 2012 **Akiyoshi Yamazaki, MD, PhD**
Niigata Central Hosp
Dept of Ortho
Shinko-cho 1-18 Chou-ku
Niigata 950-8556 Japan
81-252857003
Orthopaedics

c 2009 **Masashi Yamazaki, MD, PhD**
Faculty of Medicine,
University of Tsukuba
Dept of Orthopaedic Surgery
1-1-1 Tennodai Tsukuba-City
Ibaraki 305-8575 Japan
81-432262117
Orthopaedics

c 2009 **Jin Sup Yeom, MD, PhD**
Dept of Ortho
Seoul Natl Unv Bundang Hosp
300 Goomi-Dong, Bundang-Ku
Sungnam City Gyungki-do
463-707 Republic of Korea
Orthopaedics

a 1988 **Narayan Yoganandan, PhD**
Med College of Wisconsin
Dept Neurosurgery
9200 W Wisconsin Ave
Milwaukee WI 53226-3522
(414) 384-3453
Bioengineering

e 2012 **Toru Yokoyama, MD**
Hirosaki University
School of Medicine
Dept of Ortho Surgery
5-Zaifucho
Hirosaki 036-8250 Japan
81-172395083
Orthopaedics

c 1996 **Kazunori Yone, MD**
Kagoshima Univ
Dept of Phys Therapy
8-35-1 Sakuragaoka
Kagoshima 890-8544 Japan
81-992756771
Orthopaedics

c 1988 **Kazuo Yonenobu, MD, DMSC**
Graduate School of Health
Care Sciences, Jikei Institute
1-2-8 Miyahara Yodogawa-ku
Osaka Osaka 532-0003 Japan
81-797206550
Orthopaedics

e 2012 **Ikuho Yonezawa, MD, PhD**
Juntendo U School of Med
2-1-1 Hongo Bunkyouku
Tokyo 13-8421 Japan

a 2000 **Jung U Yoo, MD**
OHSU
Dept of Ortho and Rehab
3181 SW Sam Jackson Park Rd, OP31
Portland OR 97239
(503) 494-6406
Orthopaedics

c 2009 **Do-Heum Yoon, MD**
250 Seongsanno
Seodaemun-gu
Seoul 120-752
Republic of Korea
82-222282157
Neurosurgery

a 2014 **S Tim Yoon, MD**
The Emory Spine Center
59 Executive Park South, Ste 3000
Atlanta GA 30329
(404) 778-7155
Orthopaedics

c 2001 **Munehito Yoshida, MD, PhD**
Wakayama Medical University
811-1 Kimiidera
Depart of Ortho Surgery
Wakayama 640-8510 Japan
81-734410645
Orthopaedics

c 2013 **Toshitaka Yoshii, MD, PhD**
Tokyo Medical & Dental Univ
Yushima 1-5-45 Bunkyo-ku
Tokyo 113-8519 Japan
(615) 936-0363
Research

a 1999 **William F Young, MD**
2136 Sycamore Hills Dr
Fort Wayne IN 46814
(260) 460-3100
Neurosurgery

a 2009 **Jim A Youssef, MD**
Durango Orthopaedic Assocs
1 Mercado St #200
Durango CO 81301-7300
(970) 247-5362
Orthopaedics

c 2011 **Wen Yuan, MD**
Changzheng Hosp of 2nd Military Med Univ
No 415 Fengyang Road
Shanghai 200003 China
86-2181885621
Orthopaedics

c 2008 **Wai Mun Yue, MD**
No 1E Shelford Road #05-37
Singapore 286890 Singapore
65-63214603
Ortho Surgery

c 2009 **Yasutsugu Yukawa, MD, PhD**
Chubu Rosai Hospital
Dept Orthopaedic Surgery
1-10-6 Komei, Minato-ku
Nagoya 455-8530 Japan
81-526525511
Orthopaedics

c 2014 **Takashi Yurube, MD, PhD**
Kobe University
Graduate Sch of Med
Dept of Ortho
7-5-1 Kusunoki-cho Chuo-ku
Kobe 650-0017 Japan
81-783825985
Orthopaedics

a 1991 **Thomas A Zdeblick, MD**
University of Wisconsin
1685 Highland Ave
Madison WI 53705-2281
(608) 263-3178
Orthopaedics

a 2000 **Seth Zeidman, MD**
Rochester Brain & Spine
Neurosurgery & Pain Mgmt
400 Red Creek Dr Ste 120
Rochester NY 14623
(585) 334-5560
Neurosurgery

c 2014 **Feifei Zhou, MD**
Peking University Third Hospital
49 North Garden Rd
Beijing 100191 China
86-13581787350
Orthopaedics

a 1994 **Jack E Zigler, MD**
5612 Stone Cliff Ct
Dallas TX 75287
(972) 608-5037
Orthopaedics

c 1999 **Mehmet Zileli, MD**
1416 Sok 7 Kahramanlar
Izmir 35230 Turkey
90-5323422599
Neurosurgery

e 2005 **Bjorn Zoega, MD, PhD**
Landspitali University Hospital
Dept of Orthopaedics
Eiriksgata 5, 3B
Reykjavik 101 Iceland
354-18245560
Orthopaedics

Arizonia
John P Kostuik, MD, Phoenix – *s*

California
Jean-Jacques Abitbol, MD, San Diego – *a*
Christopher P Ames, MD, San Francisco – *a*
Hyun W Bae, MD, Los Angeles – *a*
Ulrich Batzdorf, MD, Los Angeles – *s*
Nitin N Bhatia, MD, Orange – *a*
Hans-Ulrich Bueff, MD, Granite Bay – *a*
Gregory D Carlson, MD, Orange – *a*
Ivan Cheng, MD, Portola Vally – *a*
Wayne K Cheng, MD, Loma Linda – *a*
Jeffrey D Coe, MD, Campbell – *a*
Rick B Delamarter, MD, Los Angeles – *a*
Steven R Garfin, MD, San Diego – *s*
Mason Hohl, MD, Santa Monica – *s*
Langston T Holly, MD, Los Angeles – *a*
Serena S Hu, MD, Redwood City – *a*
Praveen Mummaneni, MD, San Francisco – *a*
Rolando F Roberto, MD, Sacramento – *a*
Andrew V Slucky, MD, Tiburon – *a*
Bobby K Tay, MD, San Rafael – *a*
Franklin C Wagner, Jr, MD, Roseville – *s*
Jeffrey C Wang, MD, Los Angeles – *a*

Colorado
Anthony P Dwyer, MD, Denver – *s*
Gary Ghiselli, MD, Greenwood Village – *a*
Douglas G Orndorff, MD, Durango – *a*
Christian M Puttlitz, PhD, Fort Collins – *a*
Jim A Youssef, MD, Durango – *a*

Connecticut
Jonathan N Grauer, MD, New Haven – *a*
David L Kramer, MD, Danbury – *a*
Michael J Murphy, MD, Guilford – *s*
Manohar Panjabi, PhD, New Haven – *s*
John F Raycroft, Jr, MD,
South Glastonbury – *s*
Richard Saunders, MD, Lebanon – *s*
Wayne O Southwick, MD, New Haven – *s*
Peter G Whang, MD, FACS, New Haven – *a*

Delaware
Bikash Bose, MD, FAANS, FACS, Newark - *a*

District of Columbia
Joseph R O'Brien, MD, MPH, Washington – *a*

Florida
Mark D Brown, MD, PhD, Miami – *s*
Robert A Callahan, MD, Tampa – *s*
Frank J Eismont, MD, Miami – *a*
Jeffrey C Fernyhough, MD, Boca Raton – *a*
MaryBeth Horodyski, EdD, LAT, ATC, FNATA,
Gainesville – *a*
John K Houten, MD, FAANS, Boca Raton – *a*
George B Jacobs, MD, Cape Coral – *s*
John S Kirkpatrick, MD, Celebration – *a*
Pasquale X Montesano, MD,
Palm Beach Gardens – *a*
John C Nordt, III, MD, Coral Gables – *s*
Eric W Nottmeier, MD, Atlantic Beach – *a*
Ashvin I Patel, MD, Sarasota – *a*
Ashraf A Ragab, MD, Clearwater – *a*
Lutz H Schlicke, MD, Tampa – *s*
George Truchly, MD, Melbourne – *s*
Charles H Wingo, MD, Watersound – *s*
Isadore G Yablon, MD, Ocoee – *s*

Georgia
Ezequiel Cassinelli, MD, Atlanta – *a*
Thomas Ducker, MD, Greensboro – *s*
Walter C Edwards, MD, Atlanta – *s*
Eric I Francke, MD, Mableton – *a*
Regis W Haid, Jr, MD, FAANS, Atlanta – *a*
John G Heller, MD, Atlanta – *a*
A Alexander M Jones, MD, Savannah – *a*
John M Rhee, MD, Atlanta – *a*
Thomas E Whitesides, Jr, MD, Atlanta – *s*
S Tim Yoon, MD, PhD, Atlanta – *a*

Illinois
Howard S An, MD, Chicago – *a*
Avi J Bernstein, MD, Park Ridge – *a*
Richard G Fessler, MD, Chicago – *a*
Alexander J Ghanayem, MD, Maywood – *a*
Wellington K Hsu, MD, Chicago – *a*
Eldin E Karaikovic, MD, PhD, Evanston – *c*
Michael Jihoon Lee, MD, Chicago – *a*
Steven M Mardjetko, MD, Morton Grove – *a*
Srdjan Mirkovic, MD, Northfield – *a*
Alpesh A Patel, MD, FACS, Chicago – *a*
Frank M Phillips, MD, Chicago – *a*
Nasim A Rana, MD, Chicago – *s*
Kern Singh, MD, Chicago – *a*
Vincent C Traynelis, MD, Chicago – *a*

Indiana
Paul R Meyer, Jr, MD, Valparaiso – *s*
Thomas M Reilly, MD, Carmel – *a*
Rick C Sasso, MD, Carmel – *a*
William F Young, MD, Fort Wayne – *a*

Iowa
Charles R Clark, MD, Iowa City – *a*

Kansas
Paul M Arnold, MD, Kansas City – *a*

Kentucky
Maxwell Boakye, MD, FAANS, Louisville – *a*
Mitchell J Campbell, MD, Louisville – *a*
Friedrich Unterharnscheidt, MD, Lexington – *s*

Louisiana
James C Butler, MD, Slidell – *a*
Pierce D Nunley, MD, Shreveport – *a*
James E Ricciardi, MD, New Orleans – *s*

Maryland
Neal I Aronson, MD, Baltimore – *s*
Randy F Davis, MD, Glen Burnie – *a*
Ziya L Gokaslan, MD, Baltimore – *a*
Donlin M Long, MD, PhD, Baltimore – *s*
Steven C Ludwig, MD, Baltimore – *a*
Paul C McAfee, MD, MBA, Sparks – *a*
Scott C McGovern, MD, Salisbury – *a*
Robert A Mendelsohn, MD, Chevy Chase – *s*
Howard Moses, MD, Monkton – *s*
Lee H Riley, III, MD, Baltimore – *a*
Richard L Skolasky, Jr, ScD, Baltimore – *a*
P Justin Tortolani, MD, Baltimore – *a*
Jean-Paul Wolinsky, MD, Baltimore – *a*

Massachusetts
Joseph S Barr, Jr, MD, Boston – *s*
Norman E Beisaw, MD, Worcester – *s*
Patrick J Connolly, MD, Worcester – *a*
Edward J Dunn, MD, West Dennis – *s*
Zoher Ghogawala, MD, FACS, Burlington – *a*
Mitchel B Harris, MD, Boston – *a*
Louis G Jenis, MD, Boston – *a*
James D Kang, MD, Boston – *a*
David Hanwuk Kim, MD, Boston – *a*
Brian Kwon, MD, Boston – *a*
Stephen J Lipson, MD, Weston – *s*
Donald S Pierce, MD, Wellesley – *s*
David A Roth, MD, Waltham – *s*
Augustus A White, III, MD, PhD, Boston – *s*

Michigan
Jeffrey S Fischgrund, MD, Southfield – *a*
Gregory P Graziano, MD, Detroit – *a*
Robert N Hensinger, MD, Ann Arbor – *s*
Philip J Mayer, MD, PC, Northville – *s*

Minnesota
Bradford L Currier, MD, Rochester – *a*
Timothy A Garvey, MD, Minneapolis – *a*
Ahmad Nassr, MD, Rochester – *a*
Michael D Smith, MD, Tonka Bay – *a*

Mississippi
Robert A McGuire, Jr, MD, Jackson - *a*

Missouri
Dirk H Alander, MD, St Louis – *a*
Mark Bernhardt, MD, Kansas City – *a*
Jacob M Buchowski, MD, MS, St Louis – *a*
Thomas R Highland, MD, Columbia – *s*
Michael P Kelly, MD, St Louis – *a*
Neill M Wright, MD, St Louis – *a*

Nevada
Michael D Daubs, MD, Las Vegas – *a*
Lali Sekhon, MD, PhD, Reno – *a*

New Hampshire
Sohail K Mirza, MD, MPH, Lebanon – *a*
James N Weinstein, DO, MS, Lebanon – *h*

New Jersey
D Greg Anderson, MD, Moorestown – *a*
M Darryl Antonacci, MD, Lawrenceville – *a*
Mario J Arena, MD, Haddon Heights – *a*
David H Clements, III, MD, Camden – *a*
Cary D Glastein, MD, Tinton Falls – *a*
S Ashby Grantham, MD, Englewood – *s*
Robert F Heary, MD, FAANS, Newark – *a*
Ravi K Ponnappan, MD, Marlton – *a*

New York
Todd J Albert, MD, New York – *a*
Frank P Cammisa, Jr, MD, New York – *a*
Andrew Cappuccino, MD, Lockport – *a*
Robert Carras, MD, New York – *s*
Samuel K Cho, MD, New York – *a*
Paul R Cooper, MD, New York – *s*
Nancy Epstein, MD, Mineola – *a*
James C Farmer, MD, New York – *a*
Pierce J Ferriter, MD, New York – *a*
Anthony K Frempong-Boadu, MD, New York – *a*
Francis W Gamache, Jr, MD, Yorktown Hts – *s*
Michael C Gerling, MD, New York – *a*
Franz E Glasauer, MD, Buffalo - *s*
Ronald A Lehman, Jr, MD, New York - *a*
Jeffrey A Goldstein, MD, Rye – *a*
Andrew C Hecht, MD, New York – *a*
Cameron B Huckell, MD, Buffalo – *a*
Alexander P Hughes, MD, New York – *a*
Jeffrey D Klein, MD, New York – *a*
Darren R Lebl, MD, New York – *a*
Addisu Mesfin, MD, Rochester – *a*
Ronald Moskovich, MD, New York – *a*
Patrick F O'Leary, MD, FACS, New York – *s*
Peter G Passias, MD, Brooklyn – *a*
Themistocles S Protopsaltis, MD, New York – *a*
Sheeraz A Qureshi, MD, MBA, New York – *a*
Bernard A Rawlins, MD, New York – *a*
Richard Raynor, MD, New York – *s*
K Daniel Riew, MD, New York – *a*
Edward D Simmons, MD, Buffalo – *a*
Nathaniel L Tindel, MD, New York – *a*
S Murthy Vishnubhakat, MD, Manhasset – *s*
Seth Zeidman, MD, Rochester – *a*

North Carolina
Dahari Brooks, MD, Greensboro – *a*
Bruce V Darden, II, MD, Charlotte – *a*
Gurvinder S Deol, MD, Raleigh – *a*
Ben J Garrido, MD, Mooresville – *a*
Edward N Hanley, Jr, MD, Charlotte – *s*
Mark B Hartman, MD, Cornelius – *a*
Eric B Laxer, MD, Charlotte – *a*
Sergio A Mendoza-Lattes, MD, Durham – *a*
R Alden Milam, IV, MD, Charlotte – *a*
Daniel B Murrey, MD, Charlotte – *a*
Glenn R Rechtine, II, MD, Asheville – *a*
Alfred L Rhyne, MD, Charlotte – *a*
P. Bradley Segebarth, MD, Charlotte – *a*
Leo R Spector, MD, Charlotte – *a*
Paul J Tsahakis, MD, Charlotte – *a*
Christopher G Ullrich, MD, Charlotte – *a*

Ohio
Edward C Benzel, MD, FAANS, Cleveland – *s*
Richard S Brower, MD, Akron – *a*
Hossein K Elgafy, MD, FRCSC, Toledo – *a*
Vijay K Goel, PhD, Toledo – *s*
Timothy A Moore, MD, Cleveland – *a*
Thomas E Mroz, MD, Cleveland – *a*
Jason W Savage, MD, Independence – *a*
Jeffery L Stambough, MD, MBA, Cincinnati – *a*
Michael P Steinmetz, MD, Cleveland – *a*

Oregon
Alexander C Ching, MD, Tualatin – *a*
Robert A Hart, MD, Portland – *a*
Scott H Kitchel, MD, Eugene – *s*
Frederick W Tiley, MD, Salem – *s*
Jung U Yoo, MD, Portland – *a*

Pennsylvania
William F Donaldson, III, MD, Pittsburgh – *a*
Amir H Fayyazi, MD, Allentown – *a*
Peter C Gerszten, MD, MPH, Pittsburgh – *a*
James S Harrop, MD, Philadelphia – *a*
Alan S Hilibrand, MD, Philadelphia – *a*
David R Kraus, MD, Pittsburgh – *s*
Joon Yung Lee, MD, Pittsburgh – *a*
Bruce E Northrup, MD, Newtown Sq – *s*
Kristen E Radcliff, MD, Philadelphia – *a*
Jeffrey A Rihn, MD, Philadelphia – *a*
Richard H Rothman, MD, Philadelphia – *h*
Vincent J Silvaggio, MD, Pittsburgh – *a*
Joseph S Torg, MD, Saint Davids – *s*
Alexander R Vaccaro III, MD, PhD, Philadelphia – *a*
William C Welch, MD, Philadelphia – *a*
F Todd Wetzel, MD, Philadelphia – *a*
Beth A Winkelstein, PhD, Philadelphia – *a*

South Carolina
John A Glaser, MD, Charleston – *a*
Charles A Reitman, MD, Charleston – *a*
Barton L Sachs, MD, MBA, Charleston – *a*

Tennessee
Clinton J Devin, MD, Nashville – *a*
Denis J DiAngelo, PhD, Memphis – *a*
Jason C Eck, DO, MS, Chattanooga – *a*
Kevin T Foley, MD, FAANS, Memphis – *a*
Scott D Hodges, DO, Chattanooga – *a*

Texas
Theodore A Belanger, MD, Sachse – *a*
Michael J Bolesta, MD, Addison – *s*
Christopher D Chaput, MD, Temple – *a*
Randall F Dryer, MD, Austin – *a*
Matthew J Geck, MD, Austin – *a*
Kevin Gill, MD, Dallas – *a*
Richard D Guyer, MD, Plano – *a*
Alan E Heilman, MD, Houston – *s*
Ronald W Lindsey, MD, Galveston – *a*
Rex A W Marco, MD, Houston – *a*
Mark L Prasarn, MD, Houston – *a*
Eeric Truumees, MD, Austin – *a*
William C Watters, III, MD, Houston – *s*
Jack E Zigler, MD, Dallas – *a*

Utah
Ronald I Apfelbaum, MD, Salt Lake City – *s*
Darrel S Brodke, MD, Salt Lake City – *a*
Andrew T Dailey, MD, Salt Lake City – *a*
Brandon D Lawrence, MD, Salt Lake City – *a*

Vermont
Martin H Krag, MD, Burlington – *a*

Virginia
Steven S Hughes, MD, Vienna – *a*
Tushar C Patel, MD, McLean – *a*
Christopher I Shaffrey, MD, Charlottesville – *a*
Francis H Shen, MD, Charlottesville – *a*
J Michael Simpson, MD, Richmond – *a*
Justin S Smith, MD, PhD, Charlottesville – *a*

Washington
Carlo Bellabarba, MD, Seattle – *a*
Jens R Chapman, MD, Seattle – *a*
Branko Kopjar, MD, PhD, MS, Seattle – *a*

West Virginia
Scott D Daffner, MD, Morgantown – *a*
Sanford E Emery, MD, MBA, Morgantown – *a*
John C France, MD, Morgantown - *a*

Wisconsin
Paul A Anderson, MD, Madison – *a*
Jamie L Baisden, MD, FAANS, Milwaukee – *a*
Joseph F Cusick, MD, FAANS, Milwaukee – *s*
Donald R Gore, MD, Sheboygan – *s*
Brian D Stemper, PhD, Milwaukee – *a*
Clifford B Tribus, MD, Madison – *a*
Narayan Yoganandan, PhD, Milwaukee – *a*
Thomas A Zdeblick, MD, Madison – *a*

Australia
Ian D Farey, MBBS, FRACS, Sydney – *c*
Richard Ferch, MD, Hamilton – *e*

Austria
Ernst Sim, MD, Vienna – *e*

Belgium
Jan Goffin, MD, PhD, Leuven – *e*
Bart Poffyn, MD, Gent – *e*

Brazil
Jose Luis Bordas Sales, MD, Petropolis – *e*

Canada
Alun Ackery, MSc, Vancouver – *e*
Marcel F Dvorak, MD, Vancouver – *a*
Brian K Kwon, MD, PhD, Vancouver – *a*
Neil Duggal, MD, MSc, London – *a*
Michael G Fehlings, MD, PhD, Toronto – *a*

China
Yong Hu, MD, Ningbo City – *c*
Hongxing Shen, MD, Yanpu, Shanghai – *c*
Yu Sun, MD, PhD, Beijing – *c*
Shenglin Wang, MD, Beijing – *c*
Wen Yuan, MD, Shanghai – *c*
Feifei Zhou, MD, Beijing – *c*

Denmark
Soren Peter Eiskjaer, MD, Aalborg – *e*

France
Yves Allieu, MD, Montpellier – *e*
Philippe Bancel, MD, Paris – *e*
Pierre Bernard, MD, Merignac – *e*
Yves Dirheimer, MD, Strasbourg – *e*
Vincent Fiere, MD, Lyon – *e*
Jean-Marc Fuentes, MD, Montpellier – *e*
Pierre Kehr, MD, Strasbourg – *e*
Prof Rene Louis, Marseille – *e*
Christian Mazel, MD, Paris – *e*
Vincent Pointillart, MD, PhD, Bordeaux - *e*
Jean-Marc Vital, MD, Bordeaux – *e*

Germany
Eva Maria Buchholz, MD, Gladbach – *e*
Juergen Harms, MD, Karlsbad – *e*
Patrick Kluger, MD, Erbach – *e*
Heiko Koller, PhD, MD, Waldeck – *e*
Ralph Kothe, MD, Dortmund – *e*
Klaus Liebig, MD, Erlangen – *e*
Robert P Melcher, MD,
Karlsbad-Langensteinbach – *e*
Marcus Richter, MD – *e*
Prof Udo Rodegerdts, Hamburg – *e*
Johannes Schroeder, MD, PhD,
Osnabrueck – *e*
Christoph Ulrich, MD, Owen – *e*
Andreas Weidner, MD, PhD, Osnabruck – *e*

Greece
George Sapkas, MD, N. Faliro – *e*
Zahariou Konstantinos, MD, Athens – *e*
Demetre S Korres, MD, Athens – *e*
Panayiotis Papagelopoulos, MD, Athens – *e*
Spiros G Pneumaticos, MD, PhD,
Politia Athens – *e*

Iceland
Halldor Jonsson, Jr, MD, Reykjavik – *e*
Bjorn Zoega, MD, PhD, Reykjavik – *e*

India
Atul Goel, MD, PhD, Parel – *c*

Indonesia
Bambang Prijambodo, MD, Surabaya – *e*

Ireland
Ciaran Bolger, MD, Dublin – *e*

Israel
Nahshon Rand, MD, Tel-Aviv – *c*

Italy
Stefano Astolfi, MD, Rome – *e*
Prof Vicenzo Denaro, Rome – *e*
Giosue Gargiulo, MD, Torino – *e*
Carlo Logroscino, MD, Roma – *e*
Roberto Assietti, MD, Milano – *e*
Mauro Costaglioli, MD, PhD, Capoterra – *e*
Massimo Laus, MD, Bologna – *e*
Antonio Solini, MD, Torino – *e*

Japan
Kuniyoshi Abumi, MD, Sapporo - *c*
Takashi Asazuma, MD, PhD, Tokyo – *c*
Hiromi Ataka, MD, Matsudo – *e*
Kazuhiro Chiba, MD, PhD, Saitama – *c*
Yoshinori Fujimoto, MD, PhD, Hiroshima – *c*
Sumio Goto, MD, Chiba – *c*
Iizuka Haku, MD, Maebashi Gunma – *e*
Kiyoshi Hirabayashi, MD, Tokyo – *c*
Takashi Hirai, MD, PhD, Tokyo – *c*
Masatake Ino, MD, Takasaki Gunma – *e*
Ken Ishii, MD, PhD, Tokyo – *c*
Manabu Ito, MD, PhD, Sapporo – *c*
Tatsuo Itoh, MD, Chiba – *c*
Dr Takashi Kaito, Suita – *c*
Shuichi Kaneyama, MD, PhD, Kobe Hyogo – *c*
Mamoru Kawakami, MD, PhD, Wakayama – *c*
Hideki Kitagawa, MD, Toyama City – *c*
Kazuya Kitamura, MD, PhD, Kanagawa – *c*
Kenichi Kitaoka, MD, Kochi – *e*
Masao Koda, MD, PhD, Chiba – *c*
Masaaki Machino, MD, Nagoya – *c*
Morio Matsumoto, MD, PhD, Tokyo – *c*
Shunji Matsunaga, MD, Kagoshima – *c*
Yukihiro Matsuyama, MD, PhD,
Hamamatsu – *c*
Hisanori Mihara, MD, Yokohama – *c*
Akihito Minamide, MD, PhD, Wakayama – *c*
Jun Mizutani, MD, PhD, Nagoya – *c*
Narihito Nagoshi, MD, PhD, Tokyo – *c*
Masaya Nakamura, MD, PhD, Tokyo – *c*
Kazuyoshi Nakanishi, MD, PhD, Tokyo – *c*
Hiroaki Nakashima, MD, Nagoya Aichi – *c*
Yasushi Oshima, MD, PhD, Tokyo – *c*
Kazuhiko Satomi, MD, Tokyo – *c*
Takachika Shimizu, MD, Takasaki, Gunma – *c*
Kenichi Shinomiya, MD, PhD, Yokohama – *c*
Tateru Shiraishi, MD, PhD, Chiba – *c*
Kota Suda, MD, Bibai – *c*
Masatoshi Sumi, MD, PhD, Kobe Hyogo – *c*
Toshihiko Taguchi, MD, PhD, Ube – *c*
Masahiko Takahata, MD, PhD, Tokyo – *c*
Katsushi Takeshita, MD, PhD, Tochigi – *c*
Nobuhiro Tanaka, MD, Hiroshima – *c*
Tetsu Tanouchi, MD, Takasaki Gunma – *e*
Ryoji Tauchi, MD, Nagoya – *c*
Kazuo Terayama, MD, Matsumoto – *sc*
Yoshiaki Toyama, MD, Tokyo – *c*
Eiji Wada, MD, Matsuyama Ehime – *c*
Akiyoshi Yamazaki, MD, PhD, Niigata – *e*
Masashi Yamazaki, MD, PhD, Ibaraki – *c*
Toru Yokoyama, MD, Hirosaki – *e*
Kazunori Yone, MD, Kagoshima – *c*
Kazuo Yonenobu, MD, DMSC, Osaka – *c*

Japan *(continued)*
Ikuho Yonezawa, MD, PhD, Tokyo – *e*
Munehito Yoshida, MD, PhD, Wakayama – *c*
Toshitaka Yoshii, MD, PhD, Tokyo – *c*
Yasutsugu Yukawa, MD, PhD, Nagoya – *c*
Takashi Yurube, MD, PhD, Kobe – *c*

Republic of Korea
Koang H Bak, MD, PHD, Seoul - *c*
Bong-Soon Chang, MD, Seoul - *c*
Han Chang, MD, PhD, Busan – *c*
Dong-Kyu Chin, MD, Seoul – *c*
Dae-Chul Cho, MD, PhD, Daegu - *c*
Kyoung-Suok Cho, MD, PhD, Seoul - *c*
Eun Seok Choi, MD, PhD, DAEGU - *c*
Jae Taek Hong, MD, PHD, Suwon - *c*
Jae-Young Hong, MD, Ansan - *c*
Jin-Hwan Kim, MD, PhD, Gyeonggido – *c*
Seok-Woo Kim, MD, PhD,
Anyang-Si, Gyeonggi-Do - *c*
Sung Uk Kuh, MD, PhD, Seoul – *c*
Dong-Ho Lee, MD, PhD, Seoul – *c*
Jae-Chul Lee, MD, PhD, Seoul - *c*
Jung Sub Lee, MD, PhD, Busan – *c*
Kwang-Bok Lee, MD, PhD, Jeonju – *c*
Sang-Hun Lee, MD, PhD, Seoul - *c*
Eun-Su Moon, MD, Kwangju City – *c*
Jong-Beom Park, MD, PhD, Uijongbu-si - *c*
Moon-Soo Park, MD, PHD,
Anyang Gyunggi - *c*
Yung Park, MD, Goyang - *c*
Hyun-Chul Shin, MD, PhD, Seoul – *c*
Won-Han Shin, MD, Bucheon – *c*
Kwang-Sup Song, MD, Seoul - *c*
Kyung-Jin Song, MD, PhD, Jeonju - *c*
Kyung-Soo Suk, MD, PhD, Seoul – *c*
Jin Sup Yeom, MD, PhD, Sungnam City – *c*
Do-Heum Yoon, MD, Seoul – *c*

Malaysia
Eugene Wong, MD, Selangor – *c*

Netherlands
Ronald HMA Bartels, MD, PhD, Nijmegen – *e*
Peter C G Hubach, MD, Alkmaar – *e*
Willem F Luitjes, MD, Amsterdam – *e*
Paul W Pavlov, MD, PhD, Nijmegen - *e*
Wilco Peul, MD, PhD, Leiden – *e*
Jasper F C Wolfs, PhD, The Hague – *e*

Russian Federation
Yuri A Shulev, MD, Saint Petersburg – *e*

Singapore
Hwan Tak Hee, MD, Singapore – *c*
Gabriel K P Liu, MSc, FRCS (ORTHO) Singapore – *c*
Wai Mun Yue, MD, Singapore – *c*

Spain
Jose M Casamitjana, MD, Barcelona – *c*
Antonio Martin-Benlloch, MD, PhD, Valencia – *e*
Prof Carlos Villas Tome, Pamplona – *e*

Sweden
Rune L Hedlund, MD, Gothenburg – *e*
Bengt I Lind, MD, PhD, Vastra Frolunda – *e*
Hans Moller, MD, Stockholm – *e*
Claes Olerud, MD, PhD, Uppsala – *e*
Wolfgang Rauschning, MD, PhD, Uppsala – *se*
Yohan Robinson, MD, Uppsala – *e*
Martin Skeppholm, MD, PhD, Lowenstromska Sjukuset – *c*

Switzerland
Max Aebi, MD, DHC, FRCSC, Bern – *c*
John M Duff, MD, La Croix-sur-Lutry – *e*
Jean Pierre Elsig, MD, Kusnacht – *e*
Dieter Grob, MD, Zurich – *se*
Lalso Husag, MD, Erlinsbach – *e*
Bernard Jeanneret, MD, Basel – *e*
Professor Friederich Magerl, St Gallen – *e*
Constantin Schizas, MD, Lauusanne – *e*

Thailand
Tapanut Chuntarapas, MD, Bangkok – *c*
Chaiwat Piyaskulkaew, MD, Bangkok – *c*
Thanut Valleenukul, MD, Bangkok – *c*

Turkey
Sait Naderi, MD, Izmir – *e*
Ali Fahir Ozer, MD, Istanbul – *e*
Mehmet Zileli, MD, Izmir – *c*

Ukraine
Alexander Barysh, MD, Kharkiv – *e*

United Kingdom
Thomas Cadoux-Hudson, MD, Oxford – *e*
H Alan Crockard, MD, FRCS, London – *e*
John Dove, FRCS, Stoke-on-Trent – *e*
Andre Jackowski, MD, Birmingham – *e*
Jesus Lafuente Baraza, MD, London – *e*
Hossein Mehdian, MD, Nottingham – *e*

Viet Nam
Vo Van Thanh, MD, Ho Chi Minh – *c*

Pledge Form

CERVICAL SPINE RESEARCH SOCIETY
FOUNDED 1973

Since its inception, the CSRS mission has always been to exchange and develop ideas and philosophy regarding the diagnosis and treatment of cervical spine injury and disease. The goal of our fundraising campaign is to broaden the scope of CSRS educational opportunities as well as increase CSRS peer reviewed research funding.
Won't you consider a donation to help us carry out these objectives?
Donate online at www.csrs.org/research/donors/

☐ YES! I would like to support CSRS!

FIRST NAME _____ LAST NAME _____ DEGREE(S) _____

ADDRESS _____

CITY _____ STATE/PROVINCE _____ POSTAL CODE _____ COUNTRY _____

TELEPHONE _____ E-MAIL _____

PLEDGE (CHECK ONE)

☐ Titanium Sponsor **$5,000 PER YEAR FOR 5 YEARS**
☐ Gold Sponsor **$2,500 PER YEAR FOR 5 YEARS**
☐ Bronze Sponsor **$500 PER YEAR FOR 5 YEARS**
☐ Benefactor **$500**
☐ Platinum Sponsor **$4,000 PER YEAR FOR 5 YEARS**
☐ Silver Sponsor **$1,000 PER YEAR FOR 5 YEARS**
☐ Iron Donor **$1,000**
☐ Merit Sponsor **OTHER**

DONATION

☐ I would like to make a donation in the amount of $ _____.

METHOD OF PAYMENT

PLEASE COMPLETE THE INFORMATION BELOW AND RETURN TO THE CSRS ONSITE REGISTRATION DESK

OR MAIL TO: CSRS at 9400 W Higgins Rd, Suite 500 Rosemont, IL 60018-4976

☐ **CHECK** (make check payable to CSRS in US Dollars drawn on US bank)

☐ **CREDIT CARD** ☐ VISA ☐ MasterCard ☐ American Express

CARD NUMBER _____ EXP. DATE _____ CCV# _____

NAME (AS IT APPEARS ON CARD) _____

SIGNATURE (I AGREE TO PAY ACCORDING TO THE CREDIT CARD ISSUER AGREEMENT) _____ DATE _____

Your donation is tax deductible

Notes:

DISCLAIMER

Some pharmaceuticals and/or medical devices demonstrated at this course may not have been cleared by the FDA or have been cleared by the FDA for specific purposes only. The FDA has stated that it is the responsibility of the program participant to determine the FDA clearance status of each pharmaceuticals and/or medical device he or she wishes to demonstrate at our educational activities.

CSRS policy provides that "off label" uses of a device or pharmaceutical may be described in the CSRS' CME activities so long as the "off-label" status of the device or pharmaceutical is also specifically disclosed (i.e. that the FDA has not approved labeling the device for the described purpose). Any device or pharmaceutical is being used "off label" if the described use is not set forth on the product's approved label.

- Indicates those faculty presentations in which the FDA has not cleared the pharmaceuticals and/or medical devices for the use described in their presentation. (i.e., * indicates pharmaceuticals and/or medical devices are being discussed for an off-label use).

FINANCIAL DISCLOSURE

The names of authors presenting papers are printed in **boldface**. All presenters, secondary authors, and any other participant in the Annual Meeting have been asked to disclose if he/she, or a member of his/her immediate family has a financial interest in or other relationship with a commercial company or institution within the last twelve months.

An indication of the participant's disclosure as well as the commercial company or institution that provided the support appears in the disclosure index on page 40.

The CSRS does not view the existence of these disclosed interests or commitments as necessarily implying bias or decreasing the value of their participation in this activity.

We apologize for any oversight, deletion or misspelling. Any such occurrences were unintentional. – CSRS Staff

Daily Schedule

Tues, Dec 1, 2015

12:00–7:00 pm	Technical Exhibit Set-up	*Seaport Ballroom ABCD*
3:00–7:00 pm	Early Registration	*Seaport Foyer*

Wed, Dec 2, 2015–Board of Directors Meeting

12:30–6:00 pm	Board of Directors Meeting	*LaJolla AB*

Wed, Dec 2, 2015–Instructional Course

6:00 am–7:00 pm	Registration	*Seaport Foyer*
6:30 am–6:00 pm	Technical Exhibits	*Seaport Ballrooms ABCD*
6:30–8:00 am	Continental Breakfast	*Seaport Ballrooms ABCD*
7:20 am–4:30 pm	CSRS 20th Instructional Course	*Seaport Ballrooms FGH*
9:30–10:00 am	Break	*Seaport Ballrooms ABCD*
11:45 am–12:45 pm	Lunch	*Seaport Ballrooms ABCD*
3:00–3:30 pm	Break	*Seaport Ballrooms ABCD*
4:30 pm	Instructional Course Adjourns	
4:30–6:00 pm	Networking Reception	*Seaport Ballrooms ABCD*

Thurs, Dec 3, 2015–Annual Meeting

6:00 am–6:00 pm	Registration	*Seaport Foyer*
6:30 am–7:20 pm	Technical Exhibits	*Seaport Ballrooms ABCD*
6:30 –8:00 am	Continental Breakfast	*Seaport Ballrooms ABCD*
7:00 am–5:16 pm	43rd Annual Meeting Scientific Session	*Seaport Ballrooms FGH*
9:38–10:03 am	Break	*Seaport Ballrooms ABCD*
12:11–1:11 pm	Member Lunch & Business Meeting	*Balboa ABC*
12:11–1:11 pm	Non-member Lunch	*Seaport Ballrooms ABCD*
2:55–3:25 pm	Break	*Seaport Ballrooms ABCD*
5:20–7:20 pm	Welcome Reception	*Seaport Ballrooms ABCD*

Fri, Dec 4, 2015–Annual Meeting

6:00 am–1:30 pm	Registration	*Seaport Foyer*
6:30–10:00 am	Technical Exhibits	*Seaport Ballrooms ABCD*
6:30–8:00 am	Continental Breakfast	*Seaport Ballrooms ABCD*
7:00 am–12:01 pm	Annual Meeting Scientific Session	*Seaport Ballrooms FGH*
9:26–9:56 am	Break	*Seaport Ballrooms ABCD*
12:30–2:30 pm	Myelopathy "Ask the Experts"	*Seaport Ballroom E*
	Lunch Symposium*	**(optional)*
6:00–8:15 pm	Deformity "Ask the Experts"	*Seaport Ballroom E*
	Dinner Symposium *	**(optional)*

Sat, Dec 5, 2015–Annual Meeting

6:00 am–12:30 pm	Registration	*Seaport Foyer*
6:30–8:00 am	Continental Breakfast	*Seaport Foyer*
7:00 am–12:17 pm	Annual Meeting Scientific Session	*Seaport Ballrooms FGH*
9:56–10:11 am	Break	*Seaport Foyer*
12:17 pm	Annual Meeting Adjourns	

See you next year in Toronto
Nov 30–Dec 3, 2016!