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Ninth Annual Meeting

Hilton Lac-Leamy
Gatineau
Quebec

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Saturday, Mar. 21, 2009

Société canadienne du rachis

Neuvième réunion annuelle

Hilton Lac-Leamy
Gatineau
Québec

Du mercredi 18 mars au
samedi 21 mars 2009

Abstracts • Résumés

Canadian Spine Society abstracts presented at the CSS ninth annual meeting 2009

Stimulation of human intervertebral disc cells by immune cytokines creates an inflammatory phenotype. ***Mohammed Shamji,*†* ***Antonia Helbling,†*** ***Liufang Jing,†*** ***Jun Chen,†*** ***Robert Isaacs,†*** ***William Richardson,†*** ***Lori Setton.†*** **From *The Ottawa Hospital, Ottawa, Ont., and †Duke University, Durham, NC.**

Introduction: Pathological intervertebral disc (IVD) cells contain infiltrating macrophages and lymphocytes, with expression of inflammatory cytokines including IL1 and TNF-α. Activated Th17 lymphocytes express IL-17, with known catabolic nitric oxide and IL-6 production in other tissues. While IL-17 activity is regulated by IFN-γ, also expressed by pathological tissue, the effects of such stimulation on IVD cells is uncertain. This study evaluated the phenotype of degenerative IVD cells upon IL-17 and IFN- γ stimulation. **Methods:** Surgical human IVD tissue from patients with degenerative disc disease was isolated by enzymatic digestion. Quadruplicate replicates were treated with media, TNF-α, IL-17, IFN- γ, or both IL-17 and IFN. A broad range of IL-17 concentrations was evaluated for dose–response effects. After 72 hours, supernatant was tested for nitric oxide and IL-6 content, and cell survival was quantified. One-way analysis of variance tested treatment differences at the 0.05 level of significance. **Results:** Stimulation of IVD cells by TNF-α increased production of IL-6 and nitric oxide. Stimulation with IL-17 alone elevated IL-6 production without changing nitric oxide. With the IFN-γ costimulant, IL-17 increased IL-6 production above that of IL-17 or IFN-γ alone and substantially elevated nitric oxide production for both anulus fibrosus and nucleus pulposus cells. Dose–response effects were also observed for IL-17 stimulation. Cell survival was equivalent between groups, with observed effects unlikely to reflect cell death. **Conclusion:** This study demonstrates degenerative human IVD cells to respond to IL-17 stimulation by producing inflammatory mediators, with more robust effects observed in the presence of IFN-gamma. Further investigation will focus on the signalling cascade underlying this synergy and hence the identification of specific inhibitors to antagonize the inflammatory phenotype.

Refinement of the clinical indications for the dynamic neutralisation system for the spine for the treatment of back pain. ***Fras Dakhil-Jerew, John Shepperd*. From the Conquest Hospital, Hastings, United Kingdom.**

Introduction: In this study we report clinical outcomes after dynamic neutralisation system for the spine. Our objectives were to revalidate the most suitable clinical indication(s) of Dynesys in patients with back pain. **Methods:** A prospective cohort study on a consecutive 374 patients who had Dynesys for back pain from Septmber 2000 to the present. The average age of patients was 57 years, and the male-to-female ratio was 40%:60%. Preoperative assessment involved the Oswestry Disability Index, the SF-36 and visual analogue scales for leg and back pain, and the diagnosis was confirmed with physical examination, radiographs, spinal probe and lumbar spine MRI. Regular follow-up was arranged at 2 weeks, 3, 6 and 12 months, then at annual intervals. In our cohort, clinical indications were degenerative disc disease (DDD) (271 patients), spondylolisthesis (55 patients), adjacent segment disease (ASD) (30 patients) and spinal canal stenosis (18 patients). Paired *t* tests were used for comparison between preoperative and postoperative scores, and *p* values were used to show the significance. **Results:** Overall outcome assessment revealed significant improvement in Oswestry, SF-36 and VAS scores in comparison with preoperative status ($p < 0.05$). Improvement was greatest in the DDD group and average for the ASD group. Patients with stenosis performed better when the procedure involved adjunct decompression. Similarly, results of decompression and fusion were better than Dynesys alone in patients with spondylolisthesis. **Discussion and conclusion:** Dynesys successfully controlled symptoms of DDD in the intermediate term. Dynesys can be used as surgical treatment for symptomatic ASD. Dynesys alone in the treatment of spondylolysthesis resulted in a 45% reoperation rate, and we believe it should not be recommended as an indication. Dynesys alone is not recommended as a treatment for symptomatic spinal stenosis.

Lumbar spinal fusion does not equate to discogenic back pain treatment: a Canadian–US survey of orthopedic and neurosurgeons. ***Raja Rampersaud,** Christopher Bono.†* **From the *University of Toronto and the University Health Network, Krembil Neuroscience Program, Toronto, Ont., and the †Department of Orthopaedic Surgery, Brigham and Women's Hospital, Boston, Mass.**

Background: In a time of limited resources, elective spine fusion procedures are under increasing scrutiny. Despite strong evidence supporting good outcomes for surgical management of spinal stenosis or spondylolisthesis, there seems to be a general perception by the media, the public, nonspinal health care providers and policy makers that lumbar fusion does not work and that most elective spine fusions are being performed for back pain. The purpose of this study was to assess surgeons' indications for fusion in the management of discogenic low back pain (DLBP). **Methods:** A web-based survey was created to assess surgeon decision-making regarding lumbar fusion for DLBP. The survey was sent to both orthopedic and neurosurgeons in the United States and Canada through the North American Spine Society and the Canadian Spine Society. A total of 289 responses (n = 57 Canadian, n = 232 US) have been collected to date. **Results:** For Canada versus the United States, the relative mean age (49 v. 48 yr), years in practice (16 v. 15 yr) and the breakdown between orthopedic (82% v. 73%) and neurosurgery (16% v. 26%), respondents were similar. The mean number of yearly lumbar fusions performed was essentially identical (82 v. 83); however, the percentage of fusions performed for DLBP was significantly different between Canadian (10%) and US (25%)

respondents ($p < 0.0001$). Practice type (academic / mixed / private) was very different between Canadian (60%, 19%, 21%) and US (25%, 15%, 60%) respondents. Combining Canadian and US academic versus mixed versus private practice respondents resulted in 11%, 24% and 30% of lumbar fusions being performed for DLBP, respectively. **Conclusion:** The result of this survey demonstrates that the majority of lumbar fusions performed in both Canada and the US are not for DLBP. Overall, a significantly lower percentage of fusions for DLBP are performed in Canada compared with the US. However, this seems to be more related to practice type rather than country of practice.

An updated systematic review of chronic low back pain. ***Greg McIntosh,*[*] *Hamilton Hall.*[*†] From the *CBI Health Research Department and the †University of Toronto, Toronto, Ont.**

Introduction: A systematic review was conducted of randomized controlled trials, observational studies and previous systematic reviews to answer the following question about chronic low back pain (LBP): What are the effects of oral drug treatments, injection therapy and nondrug treatments? **Methods:** Databases searched included MEDLINE, EMBASE, the Cochrane Database of Systematic Reviews, the Cochrane Central Register of Controlled Clinical Trials (2007, issue 2) and other important databases up to May 2007. We included harms alerts from the Food and Drug Administration and the UK Medicines and Healthcare products Regulatory Agency (MHRA). Study inclusion criteria were chronic LBP (> 12 weeks duration), with or without radiation, published in English, at least single blinded, and containing sample sizes of at least 20 subjects with minimum 80% follow-up. There was no minimum length of follow-up required to include studies. Study exclusion criteria were LBP attributed to a recognizable pathology (infection, tumour, osteoporosis, rheumatoid arthritis, fracture, inflammation) or solely addressing sciatica and/or herniated discs. **Results:** We found 74 systematic reviews, randomized controlled trials or observational studies that met our inclusion criteria. The state of evidence for 18 LBP treatments will be presented. **Discussion:** In studies of chronic LBP not attributed to a recognizable pathology, there was insufficient evidence to judge the effectiveness of many LBP treatments. Oral treatments are a trade-off between benefits and harms. Exercise and multidisciplinary treatments appear beneficial, whereas acupuncture, back schools and behaviour therapy offer some evidence of likely benefit.

Preoperative CT imaging of the cross-sectional area of perispinal musculature as a predictor of posterior lumbar fusion surgery outcomes. ***Travis Marion,*[*] *Yangmin Zeng,*[*] *Eugene Wai.*[†] From the *Faculty of Medicine and the †Division of Orthopaedic Surgery, University of Ottawa, Ottawa, Ont.**

Background: Recent research has demonstrated a strong association between preoperative perispinal musculature, adjusted for fatty infiltration and prospective outcomes, and improvements in back pain in patients undergoing lumbar laminectomy without fusion. The purpose of this study was to determine if a similar relation exists in patients undergoing elective posterior lumbar fusion and decompression (PLFD) surgery. **Methods:** A retrospective observational study of prospectively collected outcomes data was conducted; preoperative function and characteristics of patients undergoing PLFD were derived from a functional status questionnaire and medical records. Measurement of the total cross-sectional area and percentage of fatty infiltration of the psoas, multifidus and erector spinae muscles was conducted using preoperative axial CT images. Pre- and postoperative lateral images were evaluated for postoperative adjacent-level degeneration. Follow-up consisted of a functional status questionnaire. Outcomes measured were improvements in back pain, leg pain and Oswestry Disability Index scores. **Results:** Twenty-three patients were analyzed with a mean follow-up of 2 years. Outcomes improved following surgery. There were strong-to-moderate correlations between percentage of fat in the preoperative posterior spinal muscles and improvements in leg pain ($r = 0.63$, $p < 0.001$) and improvements in back pain ($r = 0.41$, $p = 0.05$). There was a moderate trend toward greater adjacent-level degeneration ($r = 0.37$, $p = 0.1$) in patients with a higher percentage of fat in the preoperative posterior spinal muscles. There was a strong relation between greater adjacent-level degeneration and preoperative disability as measured by the Oswestry Disability Index ($r = 0.62$, $p = 0.03$). Results demonstrate a potential relation between preoperative fatty infiltration of posterior perispinal muscles and postoperative outcomes, and adjacent-level degeneration following PLFD surgery. **Discussion:** This suggests that perispinal muscle atrophy and conditioning may play a role in these outcomes. Results may be used for prognostication, surgical candidate selection and interventional strategies.

The selection of posterior rods for pedicle screw instrumented fusions in the thoracic, lumbar and lumbosacral spine: an evidence-based analysis. ***Stephen Kingwell,*[*] *Marcel Dvorak,*[*] *Tim Kuklo,*[†] *Steve Ondra,*[‡] *Larry Lenke,*[†] *Charles Fisher.*[*] From the *Vancouver General Hospital, Vancouver, BC, †Washington University, St. Louis, Miss., and ‡Northwestern University, Chicago, Ill.**

Purpose: To develop a comprehensive, pathology-specific framework for posterior rod selection based on the best available evidence. The primary question was: How does the selection of posterior instrumentation for the purpose of fusion, with particular emphasis on rod parameters as they relate to construct stiffness, affect clinical and radiographic spinal fusion, maintenance of deformity correction and adjacent segment changes? **Methods:** A qualitative systematic review of the literature from 1990 to 2008 was performed. Inclusion and exclusion criteria were determined a priori to reflect both the breadth of the primary question and the anticipated heterogeneity of the literature. A combination of text words and MeSH terms were used to search MEDLINE, EMBASE and the Cochrane Database, and a hand search was subsequently performed. The clinical papers were assigned a quality rating based on their underlying methodology as per Guyatt. **Results:** From the search strategy, 340 potential articles were identified. Based on the review of abstracts, 103 articles were excluded. Overall, 41 studies were accepted for analysis in the systematic review. Of these studies, 19 were clinical studies and 22 were basic science investigations (biomechanical or finite element analysis). No clinical papers were considered high quality: 4 were moderate quality, 8 were low quality and 7 were very low quality. **Conclusion:** For low- and moderate-demand

degenerative lumbar spine applications, the systematic review confirmed the appropriateness of standard 5- to 6-mm titanium rods. A less rigid rod may improve load-sharing and optimize fusion in conjunction with anterior interbody support. There is no evidence that variations in posterior rod stiffness affect adjacent segment changes. There was a tendency to use stiffer rods for deformity correction; however, the quality of clinical evidence to support this practice is very low and should be a focus of further research.

Two-year health-related quality of life following minimally invasive decompression and fusion for low-grade (I–II) spondylolisthesis compared with the normative population. *Raja Rampersaud, Oma Persaud*. From the University of Toronto and the Univeristy Health Network, Krembil Neuroscience Program, Toronto, Ont.

Purpose: The primary objective of this study was to assess the effectiveness of minimal invasive (MIS) lumbar decompression and fusion in restoring health-related quality of life (HRQL) in patients with degenerative or isthmic spondylolishtesis compared with the normative population. **Methods:** Comparison to Canadian normative HRQL data was performed in a series of consecutive patients with prospectively collected SF-36 questionnaires who were at least 2 years post–MIS fusion. The primary outcome measure was the physical (PCS) and mental component scores (MCS) of the SF-36 at 2 years. Comparisons to normative data were age- and sex-matched. **Results:** The mean age of this cohort (n = 42) was 53.5 (26–71) years. There were 16 women and 26 men. Diagnosis was degenerative spondylolisthesis (n = 6) and isthmic spondylolishtesis (n = 36). Grade of listheisis was I (n = 20) and II (n = 22). Before surgery, the mean PCS and MCS were 32.5 and 49.7. Two years postoperatively, they were 48.4 and 54.2. The change in PCS was statistically significant ($p < 0.001$); the change in MCS was also statistically significant ($p = 0.02$) and approached clinical significance. The mean age- and sex-matched Canadian normative SF-36 values (PCS and MCS) were 50.2 and 52.3. At 2 years, the PCS and MCS were neither clinically nor statistically different ($p > 0.05$) from the age- and sex-matched Canadian normative SF-36 values. At 2 years, 81% of patients said they were "Extremely satisfied;" the remaining 19% said they were "Somewhat satisfied" with the results of their spine treatment. When asked, 2 years postoperatively, if they would have the same treatment again if they had the same condition, 81% said "Definitely yes," 11% "Probably yes," and 7% were "Not sure." **Conclusion:** The results of this study demonstrate that MIS decompression and fusion for spondylolisthesis achieves excellent 2-year outcomes with restoration of HRQL comparable to Canadian normative data and is associated with a very high patient satisfaction rate.

Does body habitus affect resource utilization during lumbar spine fusion? A nationwide perspective, 1988–2004. *Mohammed Shamji,[*†] Stephen Parker,[†] Chad Cook,[†] Ricardo Pietrobon,[†] Christopher Brown,[†] Robert Isaacs.[†]* From *The Ottawa Hospital, Ottawa, Ont., and †Duke University, Durham, NC.

Introduction: The United States population trend toward obesity accrues both health risks and surgical morbidity. It is unclear how body habitus affects resource utilization and perioperative complications sustained by patients undergoing lumbar spine fusion surgery. This information could guide patient selection and confirm procedure safety in this population. **Methods:** Data were collected from the Nationwide Inpatient Sample database for 1988–2004, accounting for 244 170 patients undergoing lumbar spine fusion for degenerative disease. Patients were grouped by surgical approach (anterior, lateral, posterior) and body habitus (normal, obese, morbidly obese). We used multivariate logistic regression to evaluate group effects on selected postoperative complications, length of stay, resource utilization and discharge disposition. **Results:** Study groups were heterogeneous for race, geography and number of diseased levels ($p < 0.001$), but multivariate analysis revealed that a higher body mass index was associated with more transfusions (odds ratio [OR] 1.4) and higher need for assisted living (OR 1.4). Furthermore, morbidly obese patients undergoing posterior surgery sustained more wound complications and postoperative infections ($p < 0.001$). That group accrued hospitalization charges 20% higher than the normal group ($p < 0.001$), though equivalent mortality and length of stay were observed. **Conclusion:** This study observes a greater likelihood of inpatient complications among obese patients undergoing lumbar fusion surgery. In addition to more frequent transfusions and wound infections, morbidly obese patients sustain higher hospitalization charges and more frequently require assistance at discharge. This is not because of prolonged length of stay, nor is there any heightened mortality among obese patients, findings that suggest obese patients remain safe candidates for surgery.

Postoperative spine wound infections: risk factors, prevention and treatment strategies. *Christian DiPaola, John Street, Michael Boyd, Charles Fisher, Brian Kwon, Scott Paquette, Marcel Dvorak*. From the University of British Columbia, Vancouver, BC.

Background: Postoperative spine infection rates have been reported to range from 2% to 20%. Surveillance methods are used to identify risk factors and target potential preventive and treatment strategies. The sequelae of postoperative spine wound infections are multifactorial and generate physiologic risk to the patient, risk to spinal stability and wound healing complications. There is also an economic burden to hospital systems and society. The purpose of this study was to evaluate postoperative spinal wound infections, risk factors and treatment strategies in our quaternary referral centre, which treats complex spinal problems. **Methods:** Data regarding patient wound complications and infections were prospectively collected over an 8-month period during weekly spine unit rounds using a standardized adverse events form that was developed in conjunction with the Canadian Spine Society. All patients discharged between February and September of 2008 who were identified as having deep or superficial wound infection, wound drainage or wound dehiscence were identified. Patients who had irrigation and débridement (I&D) were identified. Patient factors, infection and treatment characteristics were identified. **Results:** There were 598 patient discharges. Patient diagnoses included trauma, degenerative conditions, deformity and tumours. There were 53 (8.9%) patients with deep or superficial wound infection, wound dehiscence or wound drainage. Twenty-three (3.8%) patients with deep or

superficial wound infection required I&D. Eighteen (78%) were instrumented. Eight (35%) patients required multiple I&Ds. Multiple–I&D patients often had methicillin-resistant *Staphylococcus aureus* (MRSA) or polymicrobial cultures and were often treated with adjunct treatments such as vacuum-assisted closure and/or plastic surgery wound coverage. **Discussion:** This study demonstrates the utility of using a standardized prospectively collected adverse events form to identify patients with postoperative spine infections. MRSA colonization–prevention strategies and treatment algorithms including the use of vacuum-assisted closure and plastic surgery for wounds that may require multiple I&D may be useful in postsurgical spine infection prevention and treatment.

The use of vacuum-assisted closure in postoperative spinal wound infections. *Christian DiPaola, John Street, Michael Boyd, Charles Fisher, Brian Kwon, Scott Paquette, Marcel Dvorak*. From the University of British Columbia, Vancouver, BC.

Background: Vacuum-assisted closure (VAC) dressings have gained great favour as a component of complex surgical wound management in recent years. There are limited yet successful reports on the use of the VAC in surgical spine wounds. To date there have been no reported series of patients treated with VAC for spine surgical wounds in Canadian spine centres. Our goal was to report on our experience of VAC use for patients with spine surgical infections and to describe patient factors and the general characteristics of their treatment. **Methods:** All patients over the past 2 years who were treated with a VAC dressing for spine wound care were identified by the dedicated wound care nurse. Computerized patient records were retrospectively reviewed to identify medical/infection risk comorbidities, surgical history, infection/wound treatment and microbiology history. **Results:** A total of 220 patients of 1700 (13%) who were treated at our quaternary spine referral centre during the past 2 years were treated for spinal wound infection. Eighteen of the 220 (8%) patients with confirmed wound infection were treated with VAC dressings. Their average age was 58 years. Regarding comorbidities, 5 of 18 patient had a spinal cord injury (SCI), 4 of 18 had diabetes, 2 of 18 were intravenous drug users and 2 of 18 were smokers. All 3 cancer patients had received previous radiation treatment. Six of 18 patients had undergone surgery before the most recent infected surgical procedure. There were 3 patients with dural tears, and 7 of 18 had an estimated blood loss greater than 500 mL. Postoperative infection occurred an average of 2.1 weeks from initial surgery. Six patients required irrigation and debridement (I&D) more than twice. Of the 18 patients, 10 had identifiable duration of VAC treatment that averaged 5.6 weeks. Sex wounds eventually required flap coverage: 2 had delayed primary closure and 1 required a split-thickness skin graft. The longer the duration of treatment or greater the number of I&Ds, the more likely the infections were to be polymicrobial. **Discussion:** Our series represents a heterogeneous mix of postoperative spinal wound infections treated with vacuum-assisted closure in a busy spine centre. Common infection risk factors were characterized. Successful VAC treatment can be used for definitive wound management after I&D or as part of a staged plan with plastic surgery reconstruction. Our series demonstrates that VAC dressings can be used with success for more than 6 weeks in spinal wounds as part of a multimodal treatment plan.

Morbidity associated with decompression, fusion and instrumentation of the lower thoracic spine to the pelvis for degenerative disc disease in the elderly. *Edward Abraham, Neil Manson, Donna Eastwood*. From the Saint John Regional Hospital, Saint John, NB.

Introduction: Thoracolumbar arthrodesis (T10–pelvis) with instrumentation is necessary to address spinal stenosis associated with sagittal and coronal plane deformities of the lumbar spine in an effort to re-establish overall trunk balance and prevent adjacent segment degeneration. Because this is a complex undertaking, comorbidities need to be considered in this older age group population. The purpose of this study was to look at the overall improvement and complication rate for T10–pelvis surgery and to identify risk factors for poor results. **Methods:** Fifty participants who required T10–pelvis surgery during the period 2003–2008 were identified from a prospective database. Surgeries were performed by 2 surgeons at one Canadian institution. Data collected in the preoperative, operative and postoperative period included clinical and radiological assessments, SF-36 and Oswestry Disability Index (ODI) scores. In addition, operative and postoperative data included complications that occurred early and late. Follow-up for the majority of patients reached the 2-year point. **Results:** All 50 participants underwent T10–pelvis surgery to address deformities associated with spinal stenosis. The average age at the index operation was 71 years. Preoperative ODI scores averaged 54, with an average improvement of 24% noted on final follow-up. Operative complications included incidental durotomies (41%), blood loss ranging from 300 mL to 3600 mL (33% of patients required intraoperative transfusion of packed red blood cells in addition to autologous transfusion via cell saver). The perioperative mortality rate was noted to be 4% (1 deceased during index surgery hospital stay, 2nd deceased 1 year post–index surgery). Overall, the complication rate was greater than 50%. Fifty-four percent of these index surgeries were performed as revision procedures, and 26% went on to require further revision surgery, many for adjacent segment deterioration. **Conclusion:** Preoperative comorbidities, including poor mobility status and diabetes, were common factors leading to a higher incidence of postoperative complications.

The comparison of the cervical sagittal balance between horizontal MRI and upright x-ray for patients with surgical degenerative cervical stenosis. *Nicolas Marcotte, Michel Lacroix, Jerome Paquet*. From Laval University, Québec City, Que.

Introduction: Sagittal balance is known to be an important factor involved in surgical decision-making for degenerative cervical stenosis. A particular sagittal balance (kyphosis, straight or lordosis) will have a tendency to influence the type of surgical approach (anterior v. posterior) adopted. With the widespread availability of magnetic resonance imaging, routine upright cervical spine x-ray has become less common. It was noted on some occasions that the sagittal balance observed on MRI and upright x-ray was different. The hypothesis of this study is that the sagittal balance between horizontal MRI and upright x-ray differs significantly. **Methods:** This study is a retrospective comparative analysis of the sagittal balance measured between horizontal MRI and upright cervical x-ray. Sagittal angulations were systematically

quantified using the Cobb method from C2 to C7 in all patients undergoing surgery for degenerative spinal stenosis with myelopathy. Semiquantitative measurement of the type of curvature (kyphosis, straight or lordosis) was also considered. Statistical analysis was done using the Student *t* test. **Results:** Over 13 months, 38 surgeries were done for degenerative spinal stenosis with myelopathy by one neurosurgeon at our institution. Thirty-five patients had both an MRI and upright x-ray done before the surgery. The mean angulations of the sagittal balance using Cobb's method was 5.3° on the horizontal MRI and 13.6° on the upright x-ray ($p = 0.0007$). Semiquantitative measurement showed a significant shift toward a straight or kyphotic spine on horizontal MRI. **Conclusion:** This study demonstrates a significant difference in the sagittal balance between horizontal MRI and upright x-ray for patients undergoing surgery for degenerative spine stenosis with myelopathy. Upright x-ray probably reflects a more accurate measurement of the cervical spinal curvature. This difference in sagittal balance could potentially have an impact on decision-making with respect to the type of surgical approach adopted.

Improvements in neck pain following cervical fusion in degenerative cervical spondylotic disease. Review of 148 cases of cervical arthrodesis. ***Babak Arvin, Michael Fehlings, Raj Rampersaud, David Mercier, Eric Massicotte*. From Toronto Western Hospital, Toronto, Ont.**

Background: Neck pain is a major source of disability in patients affected by degenerative spondylosis. Generally, the role of surgery, as explained to the patient, is to stabilize any neurologic deficit and improve radiculopathy while downplaying expectations of improvement in disability caused by neck pain. **Aim:** The aim of this study was to measure any improvements in Neck Disability Index (NDI) scores after fusion for cervical radiculopathy or myelopathy and to compare anterior versus posterior techniques. **Methods:** In this reterospective study, we looked at a cohort of 148 patients from a single institution who had undergone fusion by the anterior or posterior route between 2005 and 2008. We measured NDI scores preoperatively and 6 months postoperatively and calculated any improvements. Indices including smoking, sex and age were considered confounding factors. **Results:** There were 148 patients: 61% men, 39% women. Seventy-eight percent of the patients were younger than 65 years. Sixty-five percent of patients had anterior surgery compared with 35% posterior. Seventy percent of patients in the anterior group had improved scores on the NDI (of at least 4%, 2 questions) compared with 55% in posterior group. Smokers only improved 18% and 60% in the posterior and anterior groups, respectively. There was no significant difference in improvements in the anterior group between 1 level, more than 1 level or corpectomy subgroups (72%, 72% and 82%, respectively). **Conclusion:** A significant number of patients achieved improvements in their NDI scores after surgery for degenerative cervical disease. Anterior surgery leads to significantly better improvements on the NDI. Smokers fare badly in NDI improvements. We suggest that improvements in neck disability indices should be addressed as one of the possible goals of surgery, in particular in the anterior approach. Smokers should be warned of less satisfactory results. Only 3 questions on the NDI address neck pain exclusively, and an analysis of this subgroup will be further analyzed.

CerviCore disc replacement versus fusion for single-level cervical radiculopathy: one-year outcomes from 4 study sites in a prospective randomized controlled trial. ***J.J. Abitbol,[*] Jim A. Youssef,[†] Neill M. Wright[‡], Nevan G. Baldwin.[§]* **From *California Spine, San Diego, Calif., †Durango Orthopedic Associates, Durango, Colo., ‡Washington University School of Medicine, St. Louis, Miss., and §Neurosurgical Associates, Lubbock, Tex.**

Introduction: Anterior cervical discectomy and fusion (ACDF) is a highly successful procedure for radiculopathy, but it reduces motion and may accelerate adjacent–segment level degeneration. This study compares CerviCore to the gold standard of ACDF, for single-level treatment of cervical radicular symptoms, C3–C7. **Methods:** Functionality was assessed with the Neck Disability Index (NDI), and neck pain was measured with visual analogue scales (VAS). At our 4 sites, data were available for 39 CerviCore patients and 41 ACDF patients at baseline and 34 CerviCore and 25 ACDF patients at 12 months. A signed-rank test and a Kruskal–Wallis test were used to test for statistical differences. **Results:** For CerviCore versus fusion, the mean (SD) NDI scores were 51 (15.6) versus 52 (13.4) preoperatively, 29 (15.6) versus 30 (19.0) at 6 weeks, 22 (16.7) versus 27 (17.3) at 3 months, 18 (17.9) versus 19 (17.5) at 6 months and 16 (17.3) versus 20 (21.5) at 12 months. The mean (SD) VAS scores were 56 (25.8) versus 61 (25.9) preoperatively, 23 (22.2) versus 23 (22.4) at 6 weeks, 21 (28.0) versus 24 (24.4) at 3 months, 19 (24.0) versus 18 (20.6) at 6 months and 21 (26.9) versus 19 (26.7) at 12 months. **Conclusion:** Results were similar for both treatment groups according to both VAS and NDI measurements. Within each treatment group, the mean VAS and NDI results were significantly different from preoperative scores at all visits up to 12 months. There were no significant differences between treatment groups. These preliminary results suggest that CerviCore may be an alternative treatment for radiculopathy.

An updated systematic review of acute low back pain. ***Greg McIntosh,[*] Hamilton Hall.[*†]* **From the *CBI Health Research Department and the †University of Toronto, Toronto, Ont.**

Introduction: A systematic review was conducted of randomized controlled trials, observational studies and previous systematic reviews to answer the following question about acute low back pain (LBP): What are the effects of oral drug treatments, local injections and nondrug treatments? **Methods:** Databases searched: MEDLINE, EMBASE, the Cochrane Database of Systematic Reviews, the Cochrane Central Register of Controlled Clinical Trials (2007, issue 2) and other important databases up to May 2007. We included harms alerts from the Food and Drug Administration and the UK Medicines and Healthcare products Regulatory Agency (MHRA). Study inclusion criteria were acute LBP (< 12 weeks duration), with or without radiation, published in English, at least single blinded, and containing sample sizes of at least 20 subjects with minimum 80% follow-up. There was no minimum length of follow-up required to include studies. Study exclusion criteria were LBP attributed to a recognizable pathology (infection, tumour, osteoporosis, rheumatoid arthritis, fracture, inflammation) or solely addressing sciatica and/or herniated discs. **Results:** We found 28 systematic reviews, randomized

controlled trials or observational studies that met our inclusion criteria. Evidence for 18 treatments will be presented. **Discussion:** In studies of acute LBP not attributed to a recognizable pathology, there was insufficient evidence to judge the effectiveness of most LBP treatments. Oral treatments reviewed do not offer any benefits. Bed rest remains the most harmful treatment, whereas advice to stay active and manipulation offer some evidence of likely benefit.

An autoimmune hypothesis for gait abnormalities and sensory changes in radiculopathy. ***Mohammed Shamji,*†* ***Kyle Allen,†* ***Stephen So,†* ***Liufang Jing,†* ***Samuel Adams,†* ***Reinhard Schuh,*‡* ***Janet Huebner,†* ***Virgnia Kraus,†* ***Lori Setton,†* ***William Richardson.†* **From *The Ottawa Hospital, Ottawa, Ont., †Duke University, Durham, NC and the ‡Gait Analysis Laboratory, Foot and Ankle Center, Vienna, Austria.**

Objective: This study evaluated gait and behavioural changes in an animal model of disc herniation radiculopathy. A second goal was to observe evidence of neuroinflammation and autoreactive lymphocyte immune activation. **Methods:** The animal model of radiculopathy involved harvesting autologous nucleus pulposus (NP) from a tail intervertebral disc and exposing the L5 dorsal root ganglia (DRG) by hemilaminectomy and partial facetectomy. Experimental animals (n = 16) received NP placement on the exposed DRG, and control animals (n = 16) underwent exposure only. Animals were evaluated weekly for mechanical allodynia by Von Frey testing and for gait symmetry by digitized video analysis. At sacrifice, serum inflammatory cytokine content was tested. Immunohistochemistry was performed on the L5 DRG for mediators of inflammation and immune activation. Statistical analyses were at the 0.05 level of significance, with Bonferroni corrections for multiple comparisons. **Results:** Persistent mechanical allodynia occurred in NP-treated rats compared with the sham group (Von Frey, $p < 0.01$). Gait analysis reflected a functional consequence of this altered sensation with marked asymmetry and a preference for placing load on the contralateral limb ($p < 0.01$). Serum cytokine expression was equivalent between groups, reaffirming that the sensation and behavioural changes observed in these animals result primarily from local inflammatory changes. Immunohistochemical analysis of the sectioned DRGs after sacrifice revealed equivalent postsurgical inflammatory activation (IL23, $p = 0.47$) but substantial immune activation in the NP group (IL17, $p = 0.01$). **Conclusion:** This study provides evidence of gait abnormality in animals receiving noncompressive placement of NP tissue. Immune cytokine activation in those animals represents a target pathway for specific treatment, with asymmetric gait being a novel functional parameter to evaluate treatment efficacy.

Preoperative predictors for postoperative clinical outcome in lumbar discectomy. ***Yangmin Zeng, Travis Marion, Pamela Leece, Melanie Chin, Eugene Wai.* From the University of Ottawa, Ottawa, Ont.**

Background: Persistent radiculopathy secondary to lumbar disc herniation is a common problem that greatly compromises quality of life. In North America, lumbar discectomies are among the most common elective surgical procedures performed. There is still much debate about when conservative or surgical treatments should be offered to patients. Although the related literature is comprehensive, there are limited systematic reviews on the prognostic factors predicting the outcome of lumbar discectomy. The purpose of this review was to define the preoperative factors predicting clinical outcome after lumbar discectomy. **Methods:** We conducted a computerized literature search using Ovid's MEDLINE and the Cochrane Central Register of Controlled Trials. We included randomized controlled trials and prospective studies dealing with lumbar disc surgery. The preoperative predictors had to be clearly identified and correlated with outcome measures. We assessed the articles as high- or low-quality studies and summarized the results of the high-quality studies. **Results:** We found 39 articles that met our criteria. The 2 most prominent negative predictors were Workers' Compensation status and depression, according to 6 studies. Poor predictors reported in 4 articles were female sex, increasing age and prolonged duration of leg or back pain. A positive Lasègue sign was a positive predictor in 7 articles. Absence of back pain, positive patient expectations and higher income were good prognostic factors in 3 studies. Patients with contained herniations did worse than those who had uncontained disc extrusions and sequestrations according to 4 studies. The level of herniation was not a predictive factor in 7 studies. Workers' Compensation, depression, greater back versus leg pain, increasing age, female sex, contained herniations and prolonged symptoms predict unfavourable postoperative outcomes. Positive Lasègue sign, higher income, uncontained herniations and positive patient expectations predict favourable postoperative outcomes. **Discussion:** The results of this review provide a preliminary framework for patient selection for lumbar disc surgery.

Differences in back pain outcomes by symptom duration and pain disorder. ***Greg McIntosh,* Hamilton Hall.*†* **From the *CBI Health Research Department and the †University of Toronto, Toronto, Ont.**

Introduction: The purpose of this study was to assess outcomes in low back pain (LBP) rehabilitation based on symptom duration, stratified for those with or without a pain disorder. **Methods:** This was a prospective observational cohort study of mechanical LBP cases (n = 1256) conservatively treated at 29 spine care rehabilitation clinics in Ontario between January 2006 and August 2008. All patients were not working at the time of first assessment. Analysis was based on symptom duration (acute was defined as < 90 days postinjury, n = 820; chronic was defined as > 90 days postinjury, n = 436) and stratified based on pain disorder (present/absent), assessed via clinical examination and using a previously validated pain disorder questionnaire. **Results:** The mean age of the cohort was 41.1 (SD 9.9, range 18–60) years, with 63.5% men. Nonstratified analysis revealed that for symptom duration only, acute patients had statistically significant more pain reduction ($p < 0.05$) and functional improvement ($p < 0.05$) compared with chronic patients; for pain disorder status only, the no–pain disorder group had significantly more functional improvement ($p < 0.05$) than the pain disorder group, but there was no statistically significant difference in pain reduction. Stratified analysis provided more clinically relevant information: acute patients with no identified pain disorder had the most pain reduction and functional improvement ($p < 0.05$). Patients with chronic

disease did not have any statistically significant improvements in pain or function, regardless of pain disorder status. Patients with acute disease with an identified pain disorder had more pain reduction and functional improvement than patients with chronic disease with no pain disorder ($p < 0.05$). **Discussion:** Screening for a pain disorder is an important component of an initial assessment, regardless of symptom duration. In the absence of a pain disorder, emphasis should remain on a mechanical response to pain using an approach that emphasizes pain control and function, regardless of the symptom duration, because even those with long histories of back pain can respond favourably to mechanical treatment.

MRI investigation of nanoparticle-doped PLGA channels for spinal cord regeneration. ***Xuefen Yang,*[*] *Harrison Westwick,*[*†] *Arturo Cárdenas-Blanco,*[*] *Xudong Cao,*[†] *Eve C. Tsai.*[*†‡] **From the *Ottawa Health Research Institute, the †University of Ottawa and ‡The Ottawa Hospital, Ottawa, Ont.***

Traumatic spinal cord injury is a widespread clinical condition with no currently available cure. A variety of strategies have been investigated for the treatment of spinal cord injury, but the use of hollow polymer channel scaffolds as a component of combination therapy for the regeneration of spinal cord tissue has shown tremendous potential. These channels can act as a template for tissue regeneration and can be used to contain and release therapeutic factors to enhance spinal cord regeneration. There is currently, however, no method available to noninvasively monitor the extent of channel degradation and therapeutic factor release in vivo in animal models. Here, we report the development of a novel, biodegradable, biocompatible polymer channel composed of poly(lactate-co-glycolate) (PLGA) with imbedded iron oxide nanoparticles to enable visualization of the channel by magnetic resonance imaging (MRI). Channels were evaluated in Sprague Dawley rat complete transaction models at the eighth thoracic level for a survival time of up to 6 months. Both channels with and without nanoparticles were studied with a 1.5-T Siemens Symphony whole-body MRI scanner. Channels containing iron oxide nanoparticles exhibited no adverse effects on weight, survival or locomotor scores compared with both bare PLGA channels without nanoparticles and transaction controls alone. The channels containing iron oxide nanoparticles were detectable with MRI and enabled the evaluation of channel degradation noninvasively. Thus, iron oxide nanoparticle PLGA channels hold promise as a component of therapy for spinal cord injury that enables noninvasive monitoring of channel degradation.

Motor recovery and health-related quality of life in patients with a thoracolumbar spine injury. Relation to neural axis level of injury: spinal cord, conus medullaris and cauda equina. ***Stephen Kingwell,*[*] *Vanessa Noonan,*[*] *Doug Graeb,*[*] *Charles Fisher,*[*] *Ory Keynan,*[†] *Marcel Dvorak.*[*] **From the *University of British Columbia, Vancouver, BC, and †Tel Aviv University, Tel Aviv, Israel.***

Purpose: To determine whether neural axis level of injury is related to American Spinal Injury Association motor score (AMS) improvement in patients with a thoracolumbar (T11–L3) spine injury. **Methods:** Fifty-three patients who sustained a neurologic deficit secondary to a thoracolumbar spine injury from 1995 to 2003 had their AMS collected prospectively. Independent evaluation determined follow-up AMS and SF-36 generic health-related quality of life (HRQL) at a mean of 6.6 (SD 2.5) years postinjury. A spine surgeon and neuroradiologist reviewed all MRIs to determine the location of the conus medullaris and the precise level of neural axis injury. **Results:** Nineteen patients (36%) had an SCI, 20 (38%) had a conus medullaris injury (CMI) and 12 (23%) had a cauda equina injury (CEI). Patients with SCI improved their AMS by a mean of 7.0 (SD 9.8); CMI improved 11.9 (SD 11.8); and CEI improved 16.8 (SD 16.0). This trend was not statistically significant ($p = 0.09$). Multivariate analyses demonstrated that initially the AMS had a significant interaction with neural axis level of injury with respect to AMS improvement. Specifically, CEIs showed the greatest improvement in AMS only when the initial AMS was less than 75. Absence of initial anal sensation, a fracture-dislocation injury type and increasing time to surgery were all statistically associated with less improvement in AMS. The mean follow-up SF-36 physical component score (PCS) was 37.3 (SD 10.1), and the mean mental component score (MCS) was 51.4 (SD 11.8). For varying levels of neural axis injury, the mean PCS and MCS were not statistically different. **Conclusion:** Patients with a CEI demonstrated the most improvement in AMS, whereas absent anal sensation, a fracture dislocation and surgical delay were poor prognostic indicators overall for motor recovery. The results of this study assist in determining a prognosis for patients who sustain these common injuries provided the clinician evaluates the precise level of neural axis injury on MRI.

Age at the time of injury as a key determinant of disability following traumatic spinal cord injury: analysis of the Third National Acute SCI Study (NASCIS-3) database. ***Julio Furlan,*[*] *Michael Bracken,*[†] *Michael Fehlings.*[‡] **From the *Toronto Western Research Institute, University Health Network, Toronto, Ont., †Yale University, New Haven, Conn., and the ‡Krembil Neuroscience Centre, Toronto Western Hospital, University of Toronto, Toronto, Ont.***

Introduction: Given the increasing incidence of spinal cord injury (SCI) in the elderly (≥ 65 yr), we sought to examine whether age is a key determinant of functional recovery after acute traumatic SCI. **Methods:** Functional recovery was assessed at 6 weeks, 6 months and 1 year afer SCI using the Functional Independence Measure (FIM). Data analysis was performed using Fisher's exact test, the Mann–Whitney *U* test and multiple linear regression. All patients who were enrolled in the Third National Acute SCI Study (NASCIS-3) trial were included. **Results:** There were 499 patients (423 male, 76 female; ages 14–92 yr with a mean of 35.7 yr) who received 24-hour methylprednisolone, 48-hour methylprednisolone or 48-hour tirilazad mesylate. Both younger ($n = 455$) and elderly groups ($n = 44$) were comparable regarding ethnicity, weight, Glasgow Coma Scale score (GCS) and drug protocol, but significantly different regarding sex, cause, severity and level of SCI. Whereas increasing age was significantly correlated with lower FIM scores at 6 weeks after SCI ($p = 0.025$), there were no significant correlations between age and FIM scores at 6 months ($p = 0.289$) and at 1 year ($p = 0.61$) in the unadjusted models and after controlling for major potential

confounders (sex, ethnic group, GCS, alcohol level, drug protocol, cause of SCI, level and severity of SCI). **Conclusion:** Age at time of injury was not significantly correlated with functional recovery in the chronic stage after SCI. With the rising incidence of SCI in the elderly, our results suggest that a more proactive therapeutic approach should be considered in this patient population.

Timing of surgery and radiotherapy in the management of metastatic spine disease: a systematic review. ***Eyal Itshayek,[*] Josh Yamada,[†] James Harrop,[‡] Peter Gerszten,[§] Michael Fehlings,[¶] Meic Schmidt,[**] Charles Fisher.[*]*** **From the *University of British Columbia, Vancouver, BC, the †Memorial Sloan-Kettering Cancer Center, New York, NY, ‡Thomas Jefferson University, Philadelphia, Pa., the §University of Pittsburgh, Pittsburgh, Pa., the ¶University of Toronto, Toronto, Ont., and the **University of Utah, Salt Lake City, Utah.**

Introduction: The last decade has witnessed a dramatic change in the management of metastatic spine disease with an increased role for surgery. Surgical advances have occurred concurrent with growth in the field of radiation therapy. These advances have been synergistic, with more frequent multimodality therapy using both radiotherapy and surgical strategies in combination. This shift presents both spine surgeons and radiation oncologists with 2 clinical scenarios: (1) patients with spinal metastases treated with radiotherapy who then require surgical treatment and (2) patients who had spinal operations who then require radiotherapy. The purpose of this study was to determine the optimal interval between surgery and radiotherapy to minimize wound complications while maximizing timing of the adjuvant oncolytic effects of these therapies. **Methods:** A formal systematic review with search of MEDLINE, EMBASE, Paper First, Web of Science, Google Scholar and the Cochrane Database of Systematic Reviews was undertaken. Included reports described adult patients with primary or metastatic disease of the spine who underwent posterior spine surgery, preceded or followed by radiotherapy. Postoperative wound complication data were extracted. Two blinded, independent reviewers used a standardized study selection worksheet. **Results:** Forty-six reports were identified in which patients underwent radiotherapy before surgery. These reports, along with expert opinion, suggest that surgery within 7 days of radiation increases the risk of postoperative wound complications. Regarding radiotherapy after surgery, 51 reports were identified. One study did not find postoperative radiotherapy to be a significant risk factor for wound complications. Nine studies reported the radiotherapy–surgery time interval (5–21 d). Eight studies reported a total of 9 wound complications in 122 patients. Qualitative analysis favoured waiting at least 1 week after surgery before commencing radiation. **Discussion:** Based on best available evidence, we suggest that the radiotherapy–surgery/surgery–radiotherapy time interval should be at least 1 week to minimize wound-related complications.

A prospective, multicentre trial to evaluate the role and timing of decompression in patients with cervical spinal cord injury: one-year results of the STASCIS study. ***Michael Fehlings,[*] Alexander Vaccaro,[†] Bizhan Aarabi,[‡] Christopher Shaffrey,[§] Marcel Dvorak,[¶] Charles Fisher,[¶] Eric Massicotte,[*] Stephen Lewis,[*] Raja Rampersaud.[*]*** **From the *University of Toronto, Toronto, Ont., †Thomas Jefferson University, Philadelphia, Pa., the ‡University of Maryland, Baltimore, Md., the §University of Virginia, Charlottesville, Va., and the ¶University of British Columbia, Vancouver, BC.**

Background: The role and timing of decompression in patients with spinal cord injury (SCI) remains controversial. Accordingly, we sought to evaluate the role and timing of decompressive surgery on neurologic outcome in a consecutive series of patients with cervical SCI. **Methods:** Patients with a cervical SCI (American Spinal Injury Association [ASIA] level A–D) and imaging evidence of cord compression were entered into a prospective, multicentre, cohort study at 10 centres in North America. Decompression was achieved by either traction and/or surgical decompression. Patients were stratified into "early" (< 24 h) or "delayed" (> 24 h) groups based on the time to decompression. Outcomes were assessed using the standardized ASIA system at 6 months and 1 year postinjury. **Results:** To date, 219 patients (mean age 42.5, SD 17.5; 75.3% male, 24.7% female) have been entered into the trial. The distribution of SCI severity was as follows: ASIA A (42%), B–D (58%). There were no significant differences between sex, ASIA level or Injury Severity Score (ISS) between the early and delayed groups. Patients in the early group were slightly younger (mean 40.2, SD 17.2) than the late group (45.5, SD 17.5). To date, 6-month and 1-year follow-up has been obtained in 134 and 95 cases, respectively. At 1-year follow-up, 27.3% of the patients in the early decompression group had at least a 2-grade improvement in the ASIA score compared with 7.5% in the delayed group ($p = 0.015$). Moreover, rates of complication were lower in the patients treated with early decompression than delayed intervention (34.5% v. 47%, $p = 0.059$). **Conclusion:** The results from the ongoing Surgical Treatment for Acute Spinal Cord Injury Study (STASCIS) suggest that decompression within 24 hours in patients with an isolated cervical SCI may be associated with improved neurologic recovery and reduced rates of complication at 1-year follow-up. Further recruitment of patients with long-term follow-up is underway to validate these promising results.

The impact of duration of symptoms on outcomes in patients undergoing surgical treatment for cervical spondylotic myelopathy: analysis of a prospective multicentre study in 294 patients with one year follow-up. ***Michael Fehlings,[*] Branko Kopjar,[†] Tim Yoon,[‡] Paul Arnold,[§] Alexander Vaccaro,[¶] Eric Woodward,[**] Darrel Brodke,[††] Jens Chapman,[†] Christopher Shaffrey,[‡‡] Michael Jannsen,[§§] Rick Sasso,[¶¶] Eric Massicotte.[*]*** **From the *University of Toronto, Toronto, Ont., the †University of Washington, Seattle, Wash., ‡Emery University, Atlanta, Ga., the §University of Kansas, Kansas City, Kan., ¶Thomas Jefferson University, Philadelphia, Pa., the **Boston Spine Group, Boston, Mass., the ††University of Utah, Salt Lake City, Utah, the ‡‡University of Virginia, Charlottesville, Va., the §§Spine Education and Research Institute, Denver, Colo., and the ¶¶Indianapolis Spine Group, Indianapolis, Ind.**

Introduction: The impact of the duration of neurologic symptoms on treatment outcomes in patients with cervical spondylotic

myelopathy (CSM) is unclear. We hypothesized that the duration of symptoms of myelopathy affects the reversibility of neurologic deficits of CSM. **Methods:** We used data from a large multicentre prospective clinical study of 285 prospectively enrolled patients at 13 sites across North America. We applied stepwise multiple regression to model associations between the changes in key outcome variables (modified Japanese Orthopaedic Association [mJOA], Neck Disability Index [NDI], Nurick score and SF-36) and self-reported duration of myelopathic symptoms while adjusting for important baseline characteristics. **Results:** Complete 1-year follow-up data were obtained in 252 (88.4%) subjects and demonstrated a strongly positive overall impact of either anterior or posterior surgery on mJOA, Nurick, NDI and SF-36 scores ($p < 0.001$). The median reported duration of the myelopathic symptoms was 12 (range 1–432) months. After adjusting for covariates, we found a significant negative association between the duration of myelopathic symptoms and the degree of recovery in mJOA, Nurick scores and the SF-36 physical component score. No association was found between the duration of symptoms and NDI, SF-36 mental component score and walking speed. Patients with symptoms less than 6 months in duration experienced significantly greater improvement in the mJOA, Nurick score and SF-36 PCS scores than patients with symptoms exceeding 2 years. **Conclusion:** The data from this large prospective clinical study suggest that the chronicity of myelopathic symptoms negatively affects outcomes following surgical treatment. The best outcomes of surgical treatment were observed in patients whose reported duration of symptoms was shorter than 6 months.

Cost-effectiveness in spinal surgery: a systematic review. ***Eugene Wai,*† Maher Khan.*** **From the *University of Ottawa Spine Unit and the †Division of Orthopedic Surgery, University of Ottawa, Ottawa, Ont.**

Background: With rapidly advancing technologies and limited healthcare resources, the evidence of cost-effectiveness of spine surgery as a treatment for back pain is still divisive. **Methods:** A MEDLINE, EMBASE as well as a manual search of *Spine*, from 1996 to 2008, was performed to identify studies evaluating cost-effectiveness of spine surgeries and revealed 13 published articles. Each article was scored based on methodological criteria previously presented by Blackmore, as well as a modified economic evaluation initially published by Drummond. Standardized data abstraction was performed by 2 independent reviewers. **Results:** The 13 articles appeared in 4 different journals, including 12 articles in 3 surgical journals. Seven of the 13 articles compared lumbar surgery to conservative therapy, and the remaining compared lumbar surgery to other surgical therapy. Most of the manuscripts that were studied had met most of the methodological standards. **Conclusion:** In general, conclusions of these studies are that for carefully selected patients with lower back pathology, short-term quality of life is improved considerably with surgical versus medical treatment alone. Surgical treatment of spine was in general less cost-effective in the interim compared with conservative therapy, but further research is required for long-term cost-effectiveness. Common methodological limitations will be discussed.

A look at an interdependent practice model for the nurse practitioner in spine. ***Angela Sarro, Raja Rampersaud, Stephen Lewis.*** **From the University of Toronto and University Health Network, Krembil Neuroscience Program, Toronto, Ont.**

Background: Frequently, nurse practitioners (NP) are linked to particular patient populations or specific surgeons within an acute care setting. Through advanced education, development of clinical expertise and surgeon mentorship, the NP is able to effectively perform nonsurgical clinical roles previously relegated to the "physician" and provide excellent advanced levels of care within the holistic paradigm of nursing. An NP–led ambulatory clinic has been implemented in our spinal program since January 2008. Confident in their clinical expertise, and supported by the staff surgeon, the nurse practitioner assesses diagnoses and manages all (nonsurgical) aspects of care for selected referrals. **Purpose:** The purpose of this study was to validate this model from a patient and surgeon perspective. **Results:** To date, 150 patients referred to 2 spinal surgeons have been assessed and evaluated by the NP. The patient population consisted of individuals diagnosed with acute disc herniations, spinal stenosis and degenerative disc disease. Diagnoses and management plans were reviewed with the respective surgeons. There was excellent agreement with clinical working diagnosis (100%) and management options (95%). Patients were asked to complete a satisfaction questionnaire of their consult appointment with the NP. Results show that patients were satisfied with the consultation (97%), felt that they better understanding of their condition (92%) and that the examination was thorough (94%). Preference for direct consultation with the surgeon was minimal (26%). The patients being assessed are seen in a timely manner, usually within 11.5 weeks of referral, addressing the patient's presenting condition and concerns. **Conclusion:** Earlier assessment, matched with the nurse practitioner skill set may facilitate diagnosis specific management and recovery in a timelier manner. At the very least, this model enables a more efficient surgeon-specific triage method and provides improved patient education.

Response shift bias in patients outcome measures following lumbar spine surgery. ***Joel Finkelstein, Helen Razmjou, Aimee Gallant, Raphael Lotan, Aileen Davis.*** **From the Sunnybrook Health Sciences Centre, Toronto, Ont.**

Background: Most quality of life (QoL) measures assume that patients have the same perspective of their disease and QoL throughout the recovery process. Response shift is a psychological construct that refers to perceptual alteration of one's QoL following health status changes. Due to response shift, self-report outcome measures used in prospective studies may not always track objective changes. **Purpose:** To examine for response shift in patients following spinal surgery. **Methods:** Oswestry Disability Index (ODI) questionnaires were collected preoperatively and at 6 weeks and 3 months postoperatively. At the follow-up, patients also filled out a second questionnaire with instruction to complete this by providing a renewed judgment of their preoperative condition ("Then" test). Since the "Then" test is performed at the same time as the follow-up visit, it is assumed that the patient is using the same frame of reference for both. Response shift is the difference between the "Then" test and the baseline pretest. An adjusted treatment effect which accounts for

any response shift bias is calculated by the difference between the "Then" test and preoperative scores. **Results:** A total of 62 consecutive patients undergoing decompression were included. Average age was 50.5 years; 67% were male. The preoperative mean ODI score was 47.7 with treatment effects of 24.8 and 24.0 at 6 weeks and at 3 months, respectively ($p < 0.05$). When response shift was measured by the "Then" test, the mean adjusted treatment effects improved to 29.5 and 30.4. Over versus underestimation of their previous disability was 50% versus 25%. There was no response shift in 25% when minimal detectable change was accounted for. Agreement between response shift direction between 6 weeks and 3 months was high ($\kappa = 0.77$). **Conclusion:** Patients undergo a response shift following spinal surgery. This has implications in our routine measurements of outcome, and this potential bias needs further exploration.

Understanding patient and physician preferences for surgery on the degenerative lumbar spine. ***S. Samuel Bederman,*†** ***Nizar N. Mahomed,*** ***Hans J. Kreder,*** ***Warren J. McIsaac,*** ***Peter C. Coyte,*** ***James G. Wright.*** **From the *University of Toronto, Toronto, Ont., and the †University of California at San Francisco, San Francisco, Calif.**

Surgery for the degenerative lumbar spine (DLS) offers significant benefit for patients with moderate/severe symptoms failing nonoperative treatment. There is little appreciation among family physicians (FPs) on factors that identify ideal surgical candidates. Differences in preferences between patients and physicians leads to wide variation in referrals and impedes the shared decision-making process. Our purpose was to identify the dominant clinical factors influencing patient, FP and surgeon preferences for DLS surgery. We used a mailed survey to all orthopedic and neurosurgeons, a random sample of FPs and patients in Ontario to determine the importance that respondents place on decisions for DLS surgery. We presented 16 hypothetical vignettes to participants, who rated their preference for surgery. Data were analyzed using random-effects ordered probit regression models, and the relative importance was calculated. We obtained responses from 131 surgeons, 202 FPs and 164 patients. Surgeons placed the highest importance on the pain location (34%), severity (19%) and walking tolerance (19%). Family physicians considered neurologic symptoms (23%), walking tolerance (20%), severity (20%) and typical onset (16%) to be all of similar importance. Severity (29%), walking tolerance (29%) and duration (28%) were the most important factors for patients. Orthopedic (over neurosurgical) specialty was associated with a lower preference for surgery ($p < 0.047$). Older patients ($p < 0.03$) and previous surgical consultation ($p < 0.03$) were both associated with greater patient preference for considering surgery. Different preferences for surgery exist between patients and physicians. Family physicians may reduce over- and under-referrals by appreciating surgeons' importance on pain location (leg v. back). Surgeons and FPs may improve the shared decision-making process by understanding that patients place high importance on duration and severity of pain, and walking tolerance.

Surgical outcome of cervical spondylotic myelopathy: a systematic review. ***David Mercier, Babak Arvin, Michael Fehlings*****. From the Toronto Western Hospital, Toronto, Ont.**

Background and objectives: Although cervical spondylotic myelopathy (CSM) is recognized to cause progressive spinal cord impairment, there is uncertainty in the literature (based on a Cochrane review of only 2 published studies) as to whether surgery is effective in treating this condition. Given that the Cochrane methodology relies solely on randomized controlled trials, we sought to undertake a systematic review (using the GRADE system) of the entire literature to address the question of which treatments are most effective for CSM. **Methods:** A systematic search for articles published from 1966 to 2008 was undertaken with the MeSH term "cervical myelopathy" using the MEDLINE (1960–June 2008) and EMBASE (1980–June 2008) databases. The papers included were limited to those reporting on prospective clinical studies with a minimum of 1 year follow-up and at least 30 patients. Two reviewers independently scrutinized studies for inclusion criteria and quality using the Downs and Black criteria. The GRADE methodology was used to assign strength of recommendations and level of evidence. **Results:** A total of 648 studies were identified and scanned for inclusion/exclusion criteria: 26 prospective studies, encompassing 1597 patients and including a broad range of surgical and nonsurgical treatments met the predetermined criteria. The studies reported that surgical treatment was associated with significant improvement in neurologic outcomes. However, there was no clear benefit of surgery over conservative treatment in subjects with mild cervical myelopathy based on a randomized controlled trial. Nonetheless, several case series and cohort studies showed that patients with early myelopathy require close observation due to continued clinical progression. **Conclusion:** Our systematic review of literature on CSM supports a strong recommendation based on low- to moderate-quality evidence for a benefit of surgery over observation/conservative management in patients with moderate and severe CSM.

Magnetic resonance changes in spinal cord tissue due to the application of load: a preliminary study. ***Arturo Cárdenas-Blanco,*†** ***Harrison Westwick,*†** ***Xuefen Yang,†*** ***Eve C. Tsai.*†‡** **From the *Ottawa Health Research Institute, the †University of Ottawa and ‡The Ottawa Hospital, Ottawa, Ont.**

Magnetic resonance imaging has been widely used because it can measure quantitative parameters such as water molecular diffusion noninvasively. To improve our knowledge of spinal cord tissue and its response to traumatic injuries, we have designed a novel experimental model to measure the ex vivo response of rat spinal cord tissue to the application of pressure. The experiments were carried out in an 11.7-T Bruker AVANCE 500 magnet that allowed us to achieve an in-plane resolution of 50×100 microns. The measurement of diffusion was done by acquiring axial images using a stimulated echo spin echo diffusion-weighted sequence with the diffusion gradient applied along the slice direction. Loads of first 4.94 (SD 0.05) Atm and then 5.92 (SD 0.05) Atm were applied to the dorsal aspect of the spinal cord. The images were acquired before and after the application of the first and second loads, and after the release of all load. There was a statistically significant reduction of the white matter diffusion values along the spinal cord due to the application of the load. These values decreased again after the application of a second load and showed recovery to preload values after the release of all load.

These results suggest that magnetic resonance diffusion measurements are sensitive enough to detect the changes produced in tissue due to the application of pressure. This new model can provide a means of evaluating the response of the central nervous system to compression injury and treatment.

Surgical treatment for cervical spondylotic myelopathy: 1-year outcomes of a multicentre prospective study of 294 patients. ***Michael Fehlings,*[*] *Branko Kopjar,*[†] *Tim Yoon,*[‡] *Paul Arnold,*[§] *Alexander Vaccaro,*[¶] *Eric Woodard,*[**] *Darrel Brodke,*[††] *Jens Chapman,*[†] *Christopher Shaffrey,*[‡‡] *Michael Jannsen,*[§§] *Rick Sasso,*[¶¶] *Eric Massicotte.*[*] **From the *University of Toronto, Toronto, Ont., the †University of Washington, Seattle, Wash., ‡Emory University, Atlanta, Ga., the §University of Kansas, Kansas City, Kan., ¶Thomas Jefferson University, Philadelphia, Pa., the **Boston Spine Group, Boston, Mass., the ††University of Utah, Salt Lake City, Utah, the ‡‡University of Virginia, Charlottesville, Va., the §§Spine Education Research Institute, Denver, Colo., and the ¶¶Indianapolis Spine Group, Inadianapolis, Ind.**

Introduction: There is a paucity of valid outcomes data about surgical intervention in cervical spondylotic myelopathy (CSM). We conducted a multicentre, prospective cohort study to assess the outcomes of operative intervention in patients with CSM. **Methods:** Study enrollment was completed in October 2007 with 294 subjects enrolled at 13 sites across the United States and Canada. To date, a total of 235 patients have 1-year follow-up data available (40% female; average age 57 [SD 12] yr) Outcomes assessments included the modified Japanese Orthopaedic Association (mJOA), Neck Disability Index (NDI), Nurick score, quantitative assessments of walking speed, SF-36 and complications. **Results:** Overall, 59% of the subjects received anterior surgery, 36% posterior and 6% combined "360" approach. There has been a statistically ($p < 0.01$) and clinically significant improvement from baseline values to 12 months in all measured outcome parameters. Modified JOA scores improved from 13.0 (SD 2.8) preoperatively to 15.5 (SD 2.8). The NDI scores improved from 41.8 (SD 20.8) to 30.4 (SD 22.8). The average Nurick scores improved from 4.1 (SD 1.0) to 2.7 (SD 1.6). The 30-metre walk test improved from 29 seconds (SD 18) to 25 (SD 14). The SF-36 physical component scores improved from 35 (SD 9) to 39 (SD 12) and the SF-36 mental component scores improved from 41 (SD 15) to 47 (SD 14). **Conclusion:** One-year outcomes of this large prospective clinical study show significant improvements in surgically treated patients with CSM based on the generic and specific patient-relevant outcome measures.

Cervical spondylotic myelopathy: functional outcome measures and prognostic indications based on imaging. A prospective and blinded study. ***Babak Arvin, Sukhvinder Kalsi-Ryan, David Mercier, Julio Furlan, Eric Massicotte, Michael Fehlings*. From the Toronto Western Hospital, Toronto, Ont.**

Introduction: Cervical spondylotic myelopathy (CSM) has major health and social implications. Traditional methods of assessing CSM patients are now being reinforced with practical functional modalities such as testing balance, walking and hand function. The changes on MRI associated with CSM are a further tool to scrutinize patient selection and prognosis. These latter 2 indices have not yet been compared. This study is designed to correlate changes observed on MRI with outcomes-based measures. **Methods:** Thirty CSM patients treated surgically were prospectively enrolled and imaged by MRI pre- and postoperatively. MRI scans were quantitatively and blindly analyzed for T_1 low signal, area and extent of T_2 signal change, segmentation in T_2 signal, maximal cord compromise (MCC) and maximal spinal cord compression (MSCC). Nurick grading, modified Japanese Orthopaedic Association (mJOA), Berg Balance Scale (BBS), 30-metre walk test (30MWT quality and time), Grip and Pinch Dynamometry (GPD) were measured preoperatively and 1 year postoperatively. Data were analyzed using Spearman's correlation coefficient and paired t test. **Results:** There were 21 male and 9 female patients with ages from 32 to 78 years (mean 56.1 yr). Duration of symptoms varied from 1 to 120 months (mean 29.2 mo). Nurick grade and mJOA had a mean difference improvement of 1 and 2.8, respectively ($p < 0.05$). The BBS, GPD and 30MWT showed mean improvements of 5.5, 6.4 Kg/F and 16.2 seconds, respectively ($p < 0.05$). There was a significant correlation between the presence of T_1 low signal and BBS ($R^2 = 0.33$, $p = 0.009$) and WT ($R^2 = 0.26$, $p = 0.004$). The area of T_2 signal change postoperatively correlated weakly with WT ($R^2 = 0.12$, $p = 0.061$).The longitudinal extent of T_2 signal change was correlated to BBS and WT ($R^2 = 0.21$, $p = 0.012$ and $R^2 = 0.18$, $p = 0.018$. Preoperative MCC and postoperative MSCC correlated to WT and BBS ($R^2 = 0.17$ $p = 0.021$). **Conclusion:** Changes observed on MRI in CSM correlate with patients' functional changes on objectives assessments of walking and balance. Moreover, the presence of low signal T_1 signal preoperatively and diffuse T_2 signal changes postoperatively are indicators of poorer functional outcome.

Pressure on the spinal cord: a pressure versus displacement model of burst fracture. ***Peter Jarzem, Jerod Hines, Mahdi Bassi, Rudy Reindl*. From the McGill University Health Centre, Montréal, Que.**

Introduction: Spinal trauma can injure the spinal cord through 2 mechanisms: 1) direct injury from displaced bone/disc at the time of injury/impact and 2) residual pressure on the spinal cord (SC) from ongoing spinal canal compromise. This paper describes a model of traumatic residual SC compression. **Methods:** Six porcine spinal sections, 6 thoracic and 6 lumbar were harvested from 30-kg pigs. Myelographic dye was then injected in the subarachnoid space. A plunger with a pressure sensing port was then advanced through the vertebral body into the spinal canal through a previously prepared hole. Anteroposterior and lateral fluoroscopic images were obtained to determine the extent of canal compromise. The plunger was advanced in 0.25-mm increments at a rate of 0.25 mm/2 minutes. Pressure was measured at each increment. Pressure versus displacement curves were then determined. **Results:** Initial cord compromise does not lead to significant pressure elevation. After an initial low-pressure plateau, pressure rises rapidly to high levels that can cause cord damage. This elevation in cord pressure occurs when 60% of the canal has been compromised and rises abruptly with little further canal transgression. **Conclusion:** These pressure displacement relations demonstrate that the spinal canal can initially sustain

60% reductions in canal volume before having abrupt and dangerous spinal cord pressure elevations. Further work needs to be done to determine if stress relaxation will occur (and reduce cord pressure) and to determine if the same pressure displacement relations exist in live animal models and human cadaver specimens.

A comparative analysis of the results of vertebroplasty and kyphoplasty in osteoporotic veterbral compression fractures. ***Krishna Kumar, Rita Nguyen, Sharon Bishop.*** **From the Regina General Hospital, University of Saskatchewan, Regina, Sask.**

Objective: Our goal was to perform a prospective comparative evaluation of improvement in pain, functional disability and quality of life following the treatment of osteoporotic vertebral compression fractures using kyphoplasty or vertebroplasty. To the best of our knowledge, this is the first long-term study comparing these 2 treatment modalities using pain, functional disability and quality of life as outcome measures. **Methods:** The study population included 28 patients in the vertebroplasty group and 24 patients in the kyphoplasty group. There were 46 fractures treated by vertebroplasty and 39 fractures treated by kyphoplasty, with a mean follow-up period of 42.2 weeks in the vertebroplasty group and 42.3 weeks in the kyphoplasty group. Outcomes were measured pre- and postoperatively using a visual analogue scale (VAS), the Oswestry Disability Index (ODI), the EuroQol 5-D (EQ-5D) questionnaire and the Short-Form 36 Health Survey (SF-36). A comparative analysis was then performed to compare the outcomes between the treatment options. **Results:** In the vertebroplasty group, VAS scores improved from a mean of 8.0 to 5.5 at last follow-up ($p = 0.001$). Preoperatively, the ODI was 57.6, which reduced to 38.4 postoperatively ($p = 0.006$). The EQ-5D score preoperatively was 0.157 and improved postoperatively to 0.504 ($p = 0.001$). SF-36 showed greatest improvements in the areas of physical health, role physical, body pain and vitality. In the kyphoplasty group, VAS scores improved from a mean of 7.5 preoperatively to 2.5 postoperatively ($p = 0.000001$). The mean ODI preoperatively was 50.7 and postoperatively declined to 28.8 ($p = 0.002$). The EQ-5D score improved from a mean of 0.234 preoperatively to 0.749 postoperatively ($p = 0.00004$). SF-36 showed greatest improvement in the areas of physical health, physical functioning, role physical, body pain and social functioning. **Conclusion:** Both vertebroplasty and kyphoplasty are effective at improving pain, functional disability and quality of life; however, kyphoplasty provides better results, which are maintained over the long-term follow-up.

Epidemiology and demographics of acute traumatic spinal cord injury in British Columbia. A prospective cohort analysis of 10 years. ***Brian Lenehan, John Street, Hongbin Zhang, Vanessa Noonan, Michael Boyd, Charles Fisher, Brian Kwon, Scott Paquette, Peter Wing, Marcel Dvorak.*** **From the Combined Neurosurgical and Orthopaedic Spine Program, Vancouver General Hospital and University of British Columbia, Vancouver, BC.**

Objective: The annual incidence of acute traumatic spinal cord injury (ATSCI) in developed countries varies from 11 to 55 per million population. Etiology, demographics and pattern of injury have many unique regional differences. Regional population-based surveillance is fundamental to strategic healthcare provision. This prospective observational population study describes the incidence, demographics and pattern of ATSCI within the unique socio-geographic climate of British Columbia, Canada, from 1995 to 2004. **Methods:** Systematic analysis of prospectively collected spine registry data (Vertebase) at the provincial quaternary referral unit from 1995 to 2004. **Results:** During the 10-year study period, 938 patients were admitted with a traumatic spinal cord injury. The annual population-standardized incidences ranged from 19.94 to 27.27 per million, with a median incidence of 23.34 per million, with no significant change over the study period. The mean age was 39.7 years (34.73 in 1995 and 42.1 in 2004, $p < 0.05$) with a range of 16–92 years. Patients were predominantly male (79.74%), and 48.2% had an American Spinal Injury Association (ASIA) score of A on admission. Forty-eight patients were quadraparetic. The most common levels of spinal cord injury were C5 (17.3%), C6 (10%), T1 (9.4%) and T12 (5.8%). The mean ASIA score was 50.22 (range 0–100). A total of 19.8% of patients had a Glasgow Coma Scale score of 13 or less. The mean Injury Severity Score was 26.02 (range 0–75). Motor vehicle collisions and falls were responsible for 59%% and 30% of admissions, respectively. Mean length of in-hospital stay was 34 days, ranging from 1 to 275 days. The in-hospital mortality rate was 2.9%. ASIA grade, level of injury and total motor score correlated directly with length of stay ($p < 0.0001$). **Conclusion:** The incidence of ATSCI in British Columbia is comparable to worldwide reports. The annual population-standardized incidence remained unchanged over the study period. This information now allows us to rationalize strategies for prevention and management of these devastating injuries.

A novel approach to define instability in patients with spine tumours: validity and inter-rater reliability of the Spinal Instability Neoplastic Score (SINS). ***Daryl Fourney,* Timothy Ryken,† Charles Fisher.‡*** **From the *University of Saskatchewan, Saskatoon, Sask., the †University of Iowa, Iowa City, Iowa, and the ‡University of British Columbia, Vancouver, BC**

Introduction: A major goal of spine surgery for tumours is the preservation or achievement of spinal stability; however, there is currently no evidence-based classification for tumour-related instability. The Spine Oncology Study Group (SOSG) developed the Spinal Instability Neoplastic Score (SINS) by a systematic review of the literature and expert consensus opinion. The SINS assesses tumour location, pain, bone quality and radiographic criteria to provide a numerical score of instability. The purpose of this study was to assess the validity of SINS against a reference standard of expert opinion. Inter-rater reliability of SINS was also assessed. **Methods:** Relevant clinical and radiographic data from 24 de-identified cases of spinal tumour were assessed by 24 SOSG members. Raters were first asked to categorize each case as "stable," "potentially unstable" and "unstable." Each rater later scored each case using the SINS. Each numerical score was converted to a 3-category data field, with 0–5 as "stable," 6–10 as "potentially unstable" and 11+ as "unstable." **Results:** Validity was assessed via the calculation of a Kappa coefficient by comparing numerical scores provided by each rater for each case to the reference standard. Overall Kappa was 0.442, which is moderate agreement, as per Landis and Koch. Inter-rater reliability of the

total score was assessed by interclass correlation (ICC.) The overall ICC for individual numeric scores was 0.761, which is excellent agreement, as per Fleiss. **Conclusion:** In this initial analysis, SINS appears to be a reliable and valid classification system for spine instability due to tumour. SINS was designed to be able to be scored by nonsurgeons. Further validity and reliability testing will need to be performed using radiation and medical oncologist raters. Hopefully, further refinement and prospective application of SINS will improve referral patterns to spine surgery and help to standardize the therapeutic approach.

Surgical management of primary bone tumours of the spine using the Enneking principle: a multicentre cohort study. ***Davor Saravanja,*† Marcel Dvorak,*† Michael Boyd,† Raj Rampresaud,‡ Paul Clarkson,*† Hongbin Zhang,*† Stephen Lewis,‡ John Hurlbert,§ Richard Fox,¶ Charles Fisher.*** **From the *Combined Neurosurgical and Orthopaedic Spine Program, Vancouver General Hospital, the †University of British Columbia, Vancouver, BC, ‡Toronto Western, Toronto, Ont., the §University of Calgary, Calgary, and the ¶University of Alberta, Edmonton, Alta.**

Introduction: Oncologic management of primary bone tumours of the spine is open to individual interpretation. Tumour margin violation appears to increase local recurrence and mortality in case series, but has never been shown in a cohort study. We report on the largest multicentre cohort of primary bone tumours of the spine (PBTS) to determine the influence of surgical margin on local recurrence and mortality. **Methods:** Patients surgically treated for PBTS between January 1994 and January 2008 at 4 tertiary care centres were prospectively followed. Exclusion criteria were known metastases and previous surgery on the same tumour. Baseline demographics, Enneking grade, operative details and histological margins were recorded. An experienced musculoskeletal sarcoma pathologist determined final histological margin as intralesional, marginal or wide, as defined by Enneking. Primary outcomes were local recurrence and mortality. Group differences were tested using t tests on continuous variables and χ^2 tests on categorical variables. Significance was decided by p value less than 0.05. When the time to event was analyzed, Kaplan–Meier survival curves were produced and log-rank tests performed. **Results:** A total of 150 patients (ages 8–83 yr) with PBTS were evaluated. Diagnoses were chondrosarcoma (35), chordoma (55), Ewing sarcoma (17), osteosarcoma (12), giant cell tumour (7) and other (24). Surgical margins were wide or marginal in 66 cases and intralesional in 84 cases. Between the two groups, there was no statistical difference in age, sex or mortality. A decrease in local recurrence ($p = 0.0001$) was observed in favour of wide or marginal resection. In patients with local recurrence there was increased risk of mortality ($p < 0.0001$). **Discussion:** This large multicentre cohort shows that applying Enneking's prescribed surgical margins when managing PBTS results in a significant reduction in local recurrence and a trend for decreased mortality. Patients with local recurrence had a statistically higher risk of mortality. Surgical margins based on Enneking's principles are validated and should be the standard of care when treating PBTS.

Decision-making in the surgical treatment of cervical spine metastases — a systematic review of the literature. ***Michael Fehlings,* Kenny David,* Luiz Vialle,† Emiliano Vialle,† Frank Vrionis,‡ Mathias Setzer.‡*** **From the *Toronto Western Hospital, Toronto, Ont., the †Hospital Universitario Cajuru, Curitiba, Brazil, and the ‡H. Lee Moffitt Cancer Center, Tampa, Fla.**

Introduction: The objective of this study was to determine whether surgical indications and techniques are influenced by the region of the cervical spine (occipito-cervical, midcervical, cervicothoracic junction) involved. **Methods:** The two primary research questions were determined through consensus among a panel of experts: 1) Is the decision to operate influenced by the anatomic region of the cervical spine? 2) Is the operative technique (approach) influenced by the anatomic region of the cervical spine? A systematic review of the literature was designed to answer the 2 research questions. **Results:** The literature search yielded a total of 1140 abstracts, and 35 articles were found to fulfill all the criteria specified above, which were then studied in detail. No level-1 or level-2 studies were found in this search. There were 29 level-3 studies (retrospective case series) and 6 level-4 articles (review articles/expert opinion articles). There were 16 articles with information about the C0–C2 region, 7 articles with information about the C3–C6 region, and 10 articles with data pertaining to the C7–T2 region. With respect to question 1, there was evidence in the literature that junctional pathology (C0–C2, C7–T2) or subaxial disease with collapse/kyphosis influences the decision to operate (weak evidence, strong recommendation). With respect to question 2, in the C0–2 region, the most common surgical approach adopted was posterior; for the C3–6 region, the majority of patients underwent anterior procedures; and for the C7–T2 region, anterior as well as posterior approaches have been used (with the anterior approach favoured more often), but the rate of anterior-posterior procedures was the highest in this group. **Conclusion:** The location of cervical metastatic involvement influences both the decision to operate as well as the surgical approach used. The preference of the approach used may reflect the anatomic as well as unique biomechanical properties of each specific region.

Surgical management of cervical spine tumours in neurofibromatosis type 1 (NF-1): 22 cases with clinical and radiological follow-up. ***Faisal Taleb,* Abhijit Guha,* M.G. Fehlings,* E.M. Massicotte,* Paul M. Arnold.†*** **From the *University of Toronto, Toronto, Ont., and the †University of Kansas, Kansas City, Kan.**

Patients with NF-1 at the cervical spine present significant challenges owing to neural compression, multiplicity of tumours and complex spinal deformities. The focus of this study was to understand the indications of stabilization in this specific group of patients. Iatrogenic instability following resection of tumours is underappreciated in the literature. We conducted a retrospective review of 22 NF-1 patients with symptomatic cervical spine neurofibromas. There were 13 men and 9 women with a median age of 42.5 years. Median age at initial diagnosis of NF-1 was 30 (range 8–74) years. The median follow-up period was 7 (range 1–32) years. Progressive myelopathy was the main presenting symptom. Complete removal of the symptomatic tumours was performed in 11 patients. Ten patients underwent instrumented

fusion during their first surgery. Four out of these 10 patients needed second surgery and instrumented fusion. Out of the 12 patients who did not receive instrumented fusion on their first surgery, 5 needed a second surgery and instrumented fusion. Progressive deformity and neurologic deterioration was the cause of second surgery in 3 patients. The other 2 patients underwent the second surgery and instrumented fixation for progressive myelopathy and tumour compressing the spinal cord. Four patients needed a third operation and instrumented fixation. Stabilization of the neurologic status was seen in all patients. There was no further progression of deformity in all patients based on serial radiographs. Instrumented fusion should be strongly recommended in the initial management of cervical complications of NF-1 patients, particularly in the presence of multiple levels of involvement, resection of lateral masses or facets or pre-existing deformity.

Current trends in the surgical treatment of neuromuscular scoliosis in Canada. ***Ron El-Hawary,*†* ***Peter Jarzem,*‡* ***Reinhard Zeller,*§* ***Douglas Hedden,*¶* ***Stephen Lewis.*§***
From the *Canadian Pediatric Spinal Deformity Study Group, †Dalhousie Univeristy, Halifax, NS, ‡McGill Univeristy, Montréal, Que., the §University of Toronto, Toronto, Ont., and the ¶University of Alberta, Edmonton, Alta.

Introduction: It is believed that variation exists in the care of patients with neuromuscular scoliosis. Members of the Canadian Pediatric Spinal Deformity Study Group (CPSDSG) designed a questionnaire to determine current trends and areas of controversy in the care of this patient population. **Purpose:** Determine areas of controversy that are amenable to multicentred study. **Methods:** Seventeen surgeons from the CPSDSG completed the questionnaire. Answers were graded from 0 to 3 (0 = never, 1 = rare, 2 = frequent, 3 = always). A "current trend" was defined as being graded greater than 88% "always" or "frequent use" or greater than 88% "never" or "rare use," as long as "never" or "always" were graded greater than 67%. "Areas of controversy" were defined as "users" (1+2+3) or "occasional users" (1+2) between 35% and 67%. **Results:** Grafting: current trends included not using bone morphogenic proteins, rib or iliac crest; areas of controversy included allograft. Blood conservation: current trends included the use of cell saver and not using erthropoeitin; areas of controversy included blood donation, transexemic acid and hypotensive anesthesia. Fusion preparation: current trends included facet decortication, thoracic transverse process decortication and no thoracoplasty; areas of controversy included lumbar tranverse process decortication. Instrumentation: current trends included not using 5.0- or 6.35-mm rods and not using lumbar hooks; areas of controversy included rod material, 5.5- or 6.0-mm rod diameter, thoracic fixation, sublaminar wires and Lucque rods. Pelvic fixation: current trends included not using S2 pedicle screws, alar screws, iliosacral screws or Dunn–McCarthy rods; areas of controversy included S1 pedicle screws, Galveston fixation and iliac screws. Postoperative: current trends included not bracing; areas of controversy included the use of drains. Monitoring: current trends included not using the wake-up test; areas of controversy included the use of spinal cord monitoring. Perioperative traction is an area of controversy. **Discussion:** This questionnaire provides useful information from the practices of surgeons treating neuromuscular scoliosis. While it is useful to know the current trends in the country, several areas of controversy also provide potential for multicentred study: the use of allograft, the use of transexemic acid, instrumentation material and pelvic fixation.

Psychiatric disorders associated with scoliosis: a prevalence study. ***Christopher Reilly,*** ***Darin Davidson,*** ***Angeliki Perdios,*** ***Simon Davidson.†***
From the *University of British Columbia, Vancouver, BC, and the †University of Ottawa, Ottawa, Ont.

Purpose: In children and youth, the prevalence of psychiatric disorder associated with chronic medical illness approximates 30%. The objective of this study was to estimate the prevalence of mental health disorders in patients with adolescent idiopathic scoliosis (AIS). **Methods:** Adolescents being treated for AIS completed the Achenbach Youth Self Report and one parent completed the Achenbach Child Behaviour Checklist. Both measures are validated for screening of mental health disorders. The prevalence of mental health disorder in this population was estimated on the basis of the proportion that screened positive. Univariate analysis and logistic regression analysis was conducted to estimate the association between variables. A sensitivity analysis was performed to estimate the robustness of the results. **Results:** Between October 2006 and February 2008, 61 of 126 adolescents completed the study (48%). Of the 61 subjects, 18 were treated with observation, 26 with bracing and 17 with surgical intervention. Overall, 41 adolescents screened positive (67%). Sensitivity analysis demonstrated that, of those who did not return the questionnaire, the prevalence of a positive screen would have had to have been less than 0.1% in order to decrease the overall prevalence to 30%. There was a statistically significant difference in the magnitude of the scoliosis between those who screened positive (mean curve 39°) compared with those who screened negative (mean curve 30.6°) (p = 0.03). **Conclusion and significance:** The estimated prevalence of a mental health disorder using the Achenbach questionnaires in patients with AIS is 67%. This is substantially higher than the anticipated prevalence in either the healthy population or those with a chronic illness. The results of this study provide evidence of the high burden of mental health illness among those with AIS. The sensitivity analysis demonstrated that the results are robust despite the relatively low response rate.

Combined anterior/posterior spinal fusion compared with posterior fusion with intraoperative traction in the correction of scoliosis curves greater than 75°. ***Sarah Bacon,*** ***Subir Jhaveri,†*** ***Omprakash Sharma,†*** ***Elise Halpern,*** ***Douglas Hedden,†*** ***Andrew Howard,†*** ***Stephen Lewis.†***
From *Queen's University, Kingston, and †The Hospital for Sick Children, Toronto, Ont.

Background and objectives: Intraoperative skull–skeletal traction has been used to facilitate correction of large scoliotic deformities. This study aims to conduct a retrospective review of patients with adolescent idiopathic scoliosis (AIS) with curves greater than 75° treated with either a combined anterior/posterior spinal fusion or posterior fusion alone with intraoperative traction. The objective is to compare the results of patients

treated with these 2 surgical techniques to determine whether traction would obviate the need for anterior release and its associated morbidity without sacrificing the curve correction. **Methods:** Retrospective radiographic and chart review of 20 consecutive AIS patients undergoing anterior/posterior corrections were compared with 20 consecutive patients treated with intraoperative traction and posterior-only correction. Clinical outcome, radiographic correction and perioperative complications were analyzed. **Results:** Patients were comparable between age, weight and preoperative curve (85.2° v. 85.6°). The anterior/posterior group had significantly increased levels fused (12.6 v. 11.5), hospital stay (35.3 v. 6.4 d), number of procedures (2.6 v. 1.1), duration of surgery (15.4 v. 6.0 h), need for nonautologous transfusions (85% v. 20%), quantity of autologous blood transfusions (808 v. 480 mL) and major complications. Postoperative Cobb angle was 28.1 in the anterior/posterior group versus 32.2 in the traction group ($p = 0.30$). **Conclusion:** Anterior/posterior correction is associated with significantly more morbidity, hospital resources and need for transfusions than traction-assisted posterior fusion for severe scoliosis, without benefiting final correction. Intraoperative skull–skeletal traction facilitated curve correction, obviating the need for anterior release in pediatric AIS cases greater than 75°.

A responsiveness study of a novel approach to quantitatively assess the extent of canal stenosis and spinal cord compression using CT scan and MRI in patients with C-spine trauma. *Julio Furlan,[*] Ahilan Kailaya-Vasan,[†] Bizhan Aarabi,[‡] Michael Fehlings.[§]* From the *Toronto Western Research Institute, University Health Network, Toronto, Ont., †University College London, London, United Kingdom, the ‡University of Maryland, Baltimore, Md., and the §Krembil Neuroscience Centre, Toronto Western Hospital, University of Toronto, Toronto, Ont.

Introduction: We have recently described a novel technique to assess cervical maximum spinal cord compression (MSCC) and maximum spinal compromise (MCC). This study examines the discriminating properties of this outcome measure in patients with different degrees of subaxial (C3–T1) spine trauma. **Methods:** Severity of injury on admission was classified using the American Spinal Injury Association Impairment Scale (ASIA). CT and MRI scans were assessed in a blinded manner to clinical data. MCC and MSCC were estimated at the level of injury in patients with a spinal cord injury (ASIA A–D). The same parameters from C3–T1 levels were estimated in patients with ASIA E. Data were analyzed using Fisher exact test, 1-way analysis of variance with Bonferroni's test and receiver operating characteristic (ROC) curve. **Results:** There were 78 male and 22 female patients with a mean age of 45 (17–82) years. Most patients had a complete (ASIA A: 25, B: 9) or incomplete (ASIA C: 19, D: 24) spinal cord injury. There were no significant differences among the patients with ASIA A–E regarding age ($p = 0.156$), sex ($p = 0.292$) and cause of injury ($p = 0.791$). Among patients with ASIA E, there were no significant differences for CT-MCC and MRI-MSCC among all levels from C3 to T1 ($p = 0.166$ and $p = 0.206$, respectively). Most comparisons using MRI-MCC between levels were comparable but not between C3 and C7 ($R^2 = 0.21$, $p = 0.017$). ROC curve analyses comparing patients with ASIA D and patients with ASIA E showed a greater area under curve (AUC) for MSCC (AUC = 0.972), in comparison with MRI-MCC (AUC = 0.824) and CT-MCC (AUC = 0.726). Comparisons between patients with ASIA A–D and patients with ASIA E indicated that MSCC (AUC = 0.851) and MRI-MCC (AUC = 0.914) has higher discriminative indices than CT-MCC (AUC = 0.626). **Discussion:** Our results indicate that the degree of spinal cord compression assessed by MRI has the best performance in the discrimination between patients with spine trauma and patients with different degrees of spinal cord injury. We strongly recommend that MRI routinely be used in the clinical management of patients with acute cervical spinal cord injury.

An anatomic study of the interspinous space of the lumbosacral spine: suitability of an interspinous spacer. *Christopher S. Bailey, John S. Albietz, Kevin R. Gurr, Stewart I. Bailey, Jennifer Fleming.* From the University of Western Ontario, London, Ont.

Introduction: Lumbar interspinous spacers are gaining popularity for use in degenerative conditions of spinal stenosis, segmental instability and back pain. Variability in both soft tissue and bony posterior spinal anatomy may limit the implantation of these devices in the lower lumbar spine. To our knowledge, the anatomic space available for these implants in the lower lumbar and lumbosacral spine has not been reported. **Objective:** To evaluate the osseous interspinous anatomy at the L4/5 and L5/S1 levels. **Methods:** One hundred reconstructed computer tomography scans of the lumbosacral spine were reviewed by 2 separate assessors. Data were collected from the midline sagittal reconstructed image at the L4/5 and L5/S1 levels. Measurements taken at each level included the Cobb angle, anterior and posterior disc height and maximum interspinous space in both the anterior–posterior (height) and cephalad–caudal (length) direction. **Results:** The mean age of the patients reviewed was 47 (16–88) years. We found no correlation between the L4–5 or L5–S1 interspinous space with the disc height, Cobb angle or age. The mean length and height of the L4–5 interspinous space was 13 mm (SD 3.2, range 3–22 mm) and 6.3 mm (SD 3, range 1–13 mm), respectively. At the L5–S1 level, the mean length and height was 9 mm (SD 3.4, range 1–20 mm) and 6.8 mm (SD 3.1, range 2–18 mm), respectively. The maximum implant height was too small for only 2% at the L5/S1 level and was large enough to fill all available space at the L4/5 level. **Conclusion:** The osseous interspinous space available, as defined by computer tomography, at the L5/S1 level, is less able to accommodate some interspinous devices compared with the adjacent L4/5 level. The vast majority of our study population was unable to accept an implant at the L5/S1 level due to osseous limitation in the anterior–posterior dimension.

Apical vertebra pedicle morphology in scoliosis. *Christopher Reilly, Firoz Miyanji, Renjit Verghese, Denise MacKay, Davor Saravanja.* From the University of British Columbia, Vancouver, BC.

Purpose: The purpose was to determine the reliability of measurement of various parameters of vertebral morphology in idiopathic scoliosis. **Methods:** Ten patients with adolescent idiopathic scoliosis (AIS) were investigated with standardized

low-dose multislice helical CT. Axial reconstructions in the plane of the T8 (apical) vertebra were performed prone, as per Jamieson and colleagues (2008). Anteroposterior canal diameter, left and right pedicle width, canal width, left and right midpoint to medial pedicle length, left and right pedicle length, and cord length, left and right transverse angles, and left and right canal area were measured by our spine surgeons and spine surgery fellow. Statistical analysis for intraclass coefficients (ICC) for intra- and interobserver reliability was then performed. **Results:** Intraobserver reliability was excellent, with a mean ICC of 0.930 (range 0.608–0.996), across all 14 variables. Interobserver reliability was very good with a mean ICC of 0.890 (range 0.360–0.987), across all variables. There was poor interobserver reliability for measurement of the transverse pedicle angles (0.360–0.446). The intraobserver reliability for transverse pedicle angles, while good (0.608–0.861), was worse than any of the other intraobserver reliabilities. **Conclusion:** We demonstrated excellent intra- and interobserver reliability for measurement of apical vertebrae morphology in AIS. This tool can be used in the further study of pedicle dysplasia. Measurement of the transverse pedicle angle was less reliable than any of the other measurement variables. A standardized measurement of the morphology of vertebral canal, pedicles and vertebral body morphology is reliable both within individual observers and across a group of observers. A standardized measure for further investigation has been validated that will enable study of the evolution of pedicle dysplasia over time. This will lead to a better understanding of the etiology of pedicle dysplasia in scoliosis.

Comparison of 1- and 2-level decompression and fusion performed using a minimally invasive or conventional open posterior technique in patients with spondylolisthesis. ***Randolph Gray, Oma Persaud, Michael Fehlings, Stephen Lewis, Eric Massicotte, Raja Rampersaud.*** **From the University Health Network, University of Toronto, Toronto, Ont.**

Background: The utility of minimally invasive surgery (MIS) fusion remains a controversial issue. The objective of this study was to directly compare the acute postoperative outcomes for 1- or 2-level primary decompression and fusions for degenerative or isthmic spondylolisthesis using an MIS versus a conventional open technique. **Methods:** A retrospective cohort study was performed using prospective data from 79 consecutive patients (MIS: n = 37, 1 surgeon; open: n = 41, 3 surgeons) between 2005 and 2008. Independent review was performed. **Results:** The groups were comparable in age, sex, ASA score and body mass index. The MIS group had a mean of 1.22 levels fused, whereas the open group had a mean of 1.49 levels fused (p = 0.04). However, all MIS patients had an interbody cage(s) compared with only 14 in the open group. The mean operative time for the MIS patients was 3.70 hours and 3.79 hours for the open group (p = 0.65). The mean blood loss was 201 mL in the MIS group and 797.7 mL in the open group (p = 0.0001). The length of stay (LOS) was 6.08 days for the MIS group and 8.41 days for the open group (p = 0.01). The mean drop in preoperative hemoglobin at discharge was 25.17 mg/dL in the MIS patients and 38.34 mg/dL in the open group (p = 0.0002). There were no transfusions in the MIS group, whereas there was a 17% transfusion rate in the open group (n = 7 patients; 14 units of blood). There was no difference in the rate of intraoperative adverse events. Direct cost comparison is pending. **Conclusion:** This cohort study demonstrates reduced blood loss, transfusion and LOS following MIS fusion compared with open surgery. In a homogenous (diagnostic, demographic and institutional) spine population, treated by surgeons who are mature in their surgical technique, this study also refutes concerns regarding preclusive operative times or safety when considering MIS fusion as a viable alternative to open surgery.

Functional and radiological outcome of posterior fixation of the cervicothoracic junction using screws and rod system. ***Fawzi Mazek, Michael Goytan, Michael Johnson.*** **From the University of Manitoba, Winnipeg, Man.**

Objective: To asses the functional and radiological outcome of the posterior fixation and fusion of the cervicothorax using the screws and rod system. **Outcome measure:** Clinical outcome using the neurologic scale of Frankel, and radiological outcome using CT and plan radiographic evaluation 6/52, 3/12, 6/12, 1 year and then annually. **Methods:** Between May 2000 and August 2007, a total of 590 screws were implanted in 37 patients undergoing posterior instrumentation and fusion of the cervicothoracic junction for different diagnoses. **Results:** Bony fusion was recorded in all cases on CT evaluation. One mechanical failure of anterior fixation of C7–T1 bilateral jumped facet treated with anterior fixation and C6–T2 posterior fixation required revision anterior fixation. No infections and no hardware failures have been observed. The length of stay in the hospital was from 10 to 14 days with an average of 12 days. The operation time was from 3 to 11 hours with an average of 7 hours. The estimated blood loss was from 300 to 1500 mL with an average of 900 mL. Complete or partial neurologic recovery was observed in 19 of 22 patients. The initial neurologic status of these patients was Frankel B, C or D. Eight of the 14 patients with Frankel A show 1-level root improvement, and 6 patients failed to show any neurologic improvement. **Conclusion:** The high rate of fusion observed in these patients justified posterior fixation with the screws and rod system. Considering the few mechanical failures observed the choice of the posterior approach using the screws and rod system was appropriate for fixation at the cervicothoracic junction for different pathology. Insertion of a pedicle screw in the upper thoracic portion T1–T3 requires a careful technique and knowledge of the posterior projection points of the pedicle and their orientation. However, it is a very reproducible and safe technique with excellent results.

How do primary care surgical referral practices compare with stated preferences and consensus interpretation of guidelines for degenerative lumbar spinal patients? ***S. Samuel Bederman,*† Warren J. McIsaac,* Peter C. Coyte,* Hans J. Kreder,* Nizar N. Mahomed,* James G. Wright.**** **From the *University of Toronto, Toronto, Ont., and the †University of California at San Francisco, San Francisco, Calif.**

Degenerative disease of the lumbar spine (DDLS) is a common condition that presents to family physicians (FPs). Poor adherence to clinical practice guidelines (CPGs) leads to wide variation in referrals. Our purpose was to understand how CPGs

recommend surgical referral for patients with DDLS and to determine the agreement between CPG and individual FP preferences for referral with actual referral practices. We used a Delphi consensus process consisting of 4 FPs, 2 rheumatologists, 2 orthopedic and 2 neurosurgeons. We developed 16 vignettes based on 6 clinical factors. The panel was asked to rate the appropriateness of surgical referral based entirely on their interpretation of the CPGs. By mailed survey, FPs were similarly asked to rate their preferences. Patients with DDLS rated their clinical symptoms and indicated prior surgical referral. Random-effects ordered probit regression was employed to determine the most important clinical factors, and predicted likelihood of referral was compared with actual referral. Receiver operating characteristic (ROC) curves were constructed, and area under the curve (AUC) was measured. Our panel reached consensus after 2 iterations (Cronbach's $\alpha = 0.96$). All clinical factors were found to be statistically significant ($p < 0.0004$); however, the panel considered the duration of pain (26%) and the dominant location of pain (22%) to be the most important factors as interpreted by the CPGs. We obtained 164 patient responses with complete clinical data. There was poor concordance (AUC 0.57, 95% CI 0.49–0.67) for FP prediction and only modest concordance (AUC 0.64, 95% CI 0.53–0.74) for the panel–CPG prediction. Referral practices may be more similar to CPGs than to individual FP preferences based on clinical factors alone. Nonclinical factors may be more influential in guiding FPs' referral practices. Understanding these other factors may be important in reducing variation in referrals and improving the process of care.

Instrumented posterolateral fusion with rhBMP-2: long-term (4-year) follow-up. ***Edward Abraham,[*] Stewart Bailey,[†] David Alexander,[*] Robert McBroom,[‡] James Mahood,[§] Charles Fisher,[¶] Alain Jodoin,[**] R. John Hurlbert.[††]*** **From *Dalhousie University, Halifax, NS, the †University of Western Ontario, London, the ‡University of Toronto, Toronto, Ont., the §University of Alberta, Edmonton, Alta., the ¶University of British Columbia, Vancouver, BC, the **Université de Montréal, Montréal, Que., and the ††University of Calgary, Calgary, Alta.**

Background: A prospective randomized controlled trial comparing fusion rates between patients receiving rhBMP-2 versus autograft was undertaken in 1999. We report long-term (4-yr) follow-up results. **Methods:** From 1999 to 2003, across 8 Canadian institutions, 97 patients undergoing either 1- or 2-level posterolateral instrumented lumbar fusions were randomized to either the control (autograft) or investigational treatment (rhBMP-2) groups. Patients were followed pre- and postoperatively with a variety of outcome measures including the Oswestry Disability Index, SF-36, plain radiographs and thin-slice CT scans. Fusion was assessed by 2 independent, blinded radiologists. For comparing success rates, Fisher's exact test was performed. Analysis of covariance with preoperative score as the covariate was used for comparing score improvement between the treatment groups, while the score improvement from presurgery within each group was assessed with a paired t test. **Results:** There were no differences in patient demographics among the 2 groups. Operative time, blood loss and hospital stay were similar. Seventy-three percent of rhBMP-2 patients and 80% of control patients were available for 4-year follow-up. Both groups improved significantly compared with their preoperative clinical status as measured by Oswestry and SF-36 instruments. This improvement persisted to 4 years; there was no statistical difference between the groups. At 4 years, 69% of autograft patients demonstrated solid bony union compared with 94% of rhBMP-2 patients ($p = 0.007$). **Conclusion:** Although clinical outcomes are similar, rhBMP-2 provides statistically higher fusion rates in patients undergoing 1- and 2-level posterolateral instrumented lumbar fusions. rhBMP-2 should be considered instead of autograft in surgeries involving lumbar instrumentation where the primary long-term goal is fusion.

Is epilepsy a contraindication to neuromonitoring during spinal surgery? ***Jonathan Norton*. From the University of Alberta, Edmonton, Alta.**

Neurophysiological monitoring during spinal surgery is rapidly gaining popularity in Canada. It is widely believed that this form of neurophysiological monitoring, including both sensory and motor evoked potentials (MEPs), offers an increased level of safety for the patient and decreases the risk of permanent neurologic deficit following surgery. However, epilepsy, or seizures, is usually indicated as a relative contraindication to neuromonitoring with MEPs. This is because of a theoretical risk of inducing an epileptic seizure during the electrical stimulation to evoke an MEP. Many children with neuromuscular conditions who require spinal surgery may have a previous history of epilepsy and/or other skull surgery. In this review of our experience over the last 2 years in Edmonton, we reviewed 200 neuromonitored cases. In these cases, we did not find any incidence of an epileptic seizure being generated as a result of the electrical stimulation required to generate an MEP. Within these cases, 10 patients had a history of epilepsy, including 2 who had Lennox–Gastaut syndrome, one of whom had also previously had vagal nerve stimulation and a corpus callasotomy in an attempt to control the seizures. The lack of seizures evoked by the stimulus indicates that in most patients, generation of MEPs is a safe and prudent procedure. We would caution, however, that in patients for whom a seizure is an increased risk, i.e., those with a previous history of epilepsy, a propofol-based anesthetic regime is of increased importance because of the antiepileptic effects of propofol.

Kyphoplasty and vertebroplasty in spinal tumours: a systematic review of the literature. ***Jeff Golan, Ehud Mendel*. From Ohio State University, Columbus, Ohio.**

Introduction: Vertebral augmentation procedures have been used in the last 20 years to treat axial pain and pathological fractures in patients with spinal tumours. There are no randomized studies to support their usefulness. We sought to evaluate the safety and effectiveness of these procedures. **Methods:** A systematic review of the English literature was performed using PubMed between Sept. 3 and 30, 2008, using the following keywords: (1) cancer, tumour; (2) vertebroplasty, kyphoplasty, vertebral augmentation; and (3) outcome, safety, pain, quality of life. Articles were included if they were original and included at least 10 patients with spinal tumours. **Results:** A total of 1396 abstracts were identified using the various keywords. All abstracts were reviewed. Twenty-eight articles using vertebroplasty

reported on 877 patients and 1599 treated levels. Medical and neurologic complications varied from 0% to 7.1% and 0% to 8.1%, respectively. Symptomatic cement extravasations occurred in 0–13.5%. Eleven articles using kyphoplasty reported on 315 patients and 459 treated levels. Medical complication rates varied from 0% to 0.5%. No neurologic complications or symptomatic cement extravasations were reported. Pain and functional outcomes were universally successful using either technique. **Conclusion:** Vertebral augmentation procedures are effective in treating axial pain and improving functional outcome in patients with spinal tumours. Kyphoplasty appears to be safer than vertebroplasty, although fewer patients have been treated using this technique.

Lumbar decompression results in a decrease in the conduction slowing in the large corticospinal fibres. *Jonathan Norton, Richard Fox*. University of Alberta, Edmonton, Alta.

Patient H.J. suffered an L4 burst fracture as a result of a motor vehicle collision. He extricated himself from the vehicle and walked to the emergency department of a remote hospital. The patient was neurologically intact, but a full neurologic examination was not possible due to his agitated state. Imaging studies of the spine showed a burst fracture at the L4 level with canal compromise of approximately 75%. Significant compression arose posteriorly due to laminar fracture with a dorsolateral dural breach found. Somatosensory and motor evoked potentials (MEPs) were used during a decompression surgery. Motor evoked potentials were recordable in all of the studied muscles; however, they were significantly delayed in the legs with a conduction time to the tibialis anterior muscle of 53 ms. Based upon the subject's height, this was around 20 ms longer than what would have been expected. Immediately following decompression of the canal, there was an 8-ms reduction in the latency of the MEP to the tibialis anterior. There was no increase in the amplitude. As the case progressed, there was a further reduction of 2–3 ms in latency of the MEPs. Therefore, at the conclusion of this surgical procedure, this patient had approximately halved his deficit in terms of the latency of the MEPs. The patient awoke from the anesthetic with the same, intact, neurologic sensation and function that he had before the surgery. The changes in MEP latency did not result in any changes in neurologic function. Studies during carpal tunnel surgery have documented a rapid increase in the conduction velocity following the removal of the compression. This case illustrates that subtle deficits may be detected with MEPs and that decompression appears to have a favourable electrophysioologic effect on the cauda equina which is qualitatively similar to peripheral nerve.

Mini diaphragm incision to approach thoracolumbar spine anteriorly. *Zubair Wali, David Yen*. From Queen's University, Kingston, Ont.

Purpose: The aim of this study was to introduce a new technique in releasing the diaphragm to approach T12 and L1 anteriorly for decompression and fusion with instrumentation. **Methods:** A retrospective case series of 5 patients treated with anterior spinal decompression, fusion and instrumentation using a mini approach to release the diaphragm between June 2004 and January 2008 was performed. **Results:** The ages of the patients ranged from 26 to 68 years, with a mean of 47.6 years. All patients had an anterior spinal decompression with fusion and instrumentation. The procedure was successfully completed in all patients without major morbidity and no mortality. The mean length of chest tube drainage was 3.4 days and hospitalization was 7 days. Four out of 5 were extubated immediately after the surgery. **Conclusion:** The mini release of diaphragm as an approaching technique for anterior decompression and fusion with instrumentation of thoracolumbar spine is a safe procedure and facilitates patient recovery.

Neuromonitoring of scoliosis surgery in children with neuromuscular scoliosis. *Jonathan Norton*. From the University of Alberta, Edmonton, Alta.

Neuromonitoring of spinal deformity surgery in children is recommended by the Canadian Pediatric Spinal Deformities Study Group. While most of the spinal deformity surgery is on children with idiopathic scoliosis, a significant minority takes place on individuals with scoliosis that is neuromuscular in origin. These include children with muscular dystrophy, cerebral palsy or spinal injuries. In these instances, neuromonitoring may be more challenging but is still worthwhile. For instance, children who are wheelchair-bound may still have bladder and bowel control, and preserving these functions becomes critically important for them. Cerebral palsy may lead to a reorganization of the cortical map so that the sensory and motor cortices are not in the usual positions. Corticospinal transmission may be impaired as well as spinocortical transmission, and the muscles themselves may be atrophied. Furthermore, children with spasticity may experience abnormal responses to either peripheral nerve stimulation or the central stimulation for a motor evoked potential. For instance, we have noted in 3 out of 15 children with cerebral palsy large reflex responses following peripheral nerve stimulation to generate sensory evoked potentials. For these patients, a preoperative visit with the neurophysiologist responsible for the neuromonitoring becomes essential. In this preoperative visit, the neurophysiologist is able to map the sensory motor cortices using transcranial magnetic stimulation. He is also able to determine the best location for placing the sensory evoked potential recording electrodes on the scalp. Concurrently, he can assess the functionality of the corticospinal tract and the patient's spasticity and determine which may interfere with the neuromonitoring during the scoliosis surgery. In summary, neuromonitoring of children with neuromuscular scoliosis is as important as monitoring of children with idiopathic scoliosis but requires a skilled approach and forward planning on behalf of the neuromonitoring team in consultation with the surgeons.

Occupational physical activities in low back pain: a systematic review with critical appraisal of causal relations. *Eugene K. Wai,* Simon Dagenais,* Paul Bishop,† Brian Kwan.†* From the *Univerisity of Ottawa Spine Unit, Ottawa, Ont., and the †University of British Columbia, Vancouver, BC.

Background: Identifying causal relations between occupational physical activities and low back pain (LBP) may be potentially helpful both to reduce exposure to activities deemed harmful, and to help adjudicate claims of occupational LBP. Due to the

multiple known or suspected risk factors, determining causality requires a methodologically rigorous approach. **Methods:** We conducted a systematic review focused on the relation between specific occupational physical activities and LBP. A search of the MEDLINE, EMBASE, CINAHL, the Cochrane Library and OSHROM databases was supplemented by searching grey literature, hand-searching relevant journals, examining bibliographies and soliciting additional studies from experts. The methodological quality was assessed using a modified Ottawa–Newcastle scale for observational studies. Data were summarized into 20 categories of physical activities and further subclassified into specific types. Causality was assessed by evaluating the level of evidence supporting association, dose–response, temporality, experiment and biological plausibility, based on high-quality studies using multivariate analyses. **Results:** This search yielded 2766 citations, of which 281 were potentially relevant and retrieved for full-text review. From this, 99 studies were included for analysis. Strong evidence was found that there is no causality for LBP and assisting patients, carrying or sitting. Moderate-to-strong evidence was found for both association and temporality between LBP and twisting/bending, as well as bending (trunk flexion > 45°). Moderate evidence was found for both association and temporality between LBP and driving (transit vehicle). All other categories and subtypes of physical activities uncovered did not rise above a limited or conflicting level of evidence supporting their causality for LBP. **Conclusion:** Despite uncovering a large number of studies related to physical activities and LBP, few conclusions could be made regarding causality. Several methodological weaknesses in the identified studies were commonly noted during this review. Future studies related to this topic should attempt to overcome some of these weaknesses to shed light on this topic.

Pressure on the spinal cord: a pressure versus displacement model of burst fracture. *Peter Jarzem, Jean Ouellet, Marco Ferrone*. From the McGill University Health Centre, Montréal, Que.

Introduction: Vertebrectomy and vertebral body replacement (VBR) are proven techniques in the treatment of patients with malignant spinal cord compression. Currently there is no vertebral body device designed for the posterior or posterolateral approach to the spine. **Methods:** A cylindrical accordion side wall was attached to 2 textured stainless steel round end plates and the intervening space between the end plates, and the side wall was filled with polymethylmethacrylate (PMMA) by puncturing the side wall with a vertebroplasty cannula and then pumping in PMMA cement. Measurements of the most compressed and expanded states were carried out. The VBR was filled with silicon oil of a similar viscosity to freshly mixed PMMA cement and then subjected to loads at various degrees of kyphosis and lordosis. The VBR was also tested with and without air evacuation holes to determine percent fill. Finally, a simple finite element analysis model was carried out to determine compressive load limits for the device. **Results:** In its most collapsed state, the VBR measured 15 mm high with a diameter of 37 mm; expanded, the VBR measured 85 mm in height. The diameter of the end plates was 37 mm. The cage sidewalls failed with silicon oil when loads reached 300 N and the end plates were angled 30°. No failures were noted with lower loads or with straight end plates. End plate angulations of 30° could be easily accommodated at loads below 300 N. The addition of microscopic air evacuation holes permitted the air to exit the cage without extravasations outside the VBR. Finite analysis modelling indicates that the VBR should be able to resist loads of 20 000 N before failing. This is well above the maximum anticipated loads. **Conclusion:** A novel, highly expandable VBR design has been described that can resist loads equivalent to available expandable cages. It design permits end plate angulations without special adapters. The lift force generated by the cage is similar to that of commercially available devices. Air evacuation is effectively carried out using multiple microscopic holes. This device is suitable for vertebral body replacement using a minimally invasive posterolateral approach.

A prospective randomized clinical trial of posterolateral lumbosacral spinal fusion with BMP-2 and titanium pedicle screw instrumentation versus BMP-2 alone: preliminary 6-month results. *David Alexander, William Oxner, Alex Soroceanu, Adrienne Kelly, Donna Shakespeare*. From Dalhousie University, Halifax, NS

Introduction: Recombinant human bone morphogenic protein (BMP-2) is used in spinal arthrodesis to induce bone growth. Several studies have demonstrated that it achieves similar or superior fusion rates compared with autlogous iliac crest bone graft when used in instrumented fusions. Our study aims at evaluating the requirement for instrumentation in 1- and 2-level spinal arthrodesis when BMP-2 is used in conjunction with local bone to achieve fusion. **Methods:** A total of 50 patients were recruited for the study and randomized to instrumented versus noninstrumented spinal arthrodesis. BMP-2 with autologous local bone was used in all patients. Patients are evaluated at 3 months, 6 months, 12 months and 24 months postoperatively with questionnaires to assess clinical outcome (Oswestry Disability Index [ODI], visual analogue scale [VAS] and validated SF-36). Posteroanterior and lateral radiographs of the spine are reviewed using the Lenke score to assess radiographic fusion. At 24 months, a thin-cut (1-mm) CT scan will be performed to further evaluate fusion. **Results:** Six months of data are available on 30 patients. At 6 months postoperatively, there were no statistically significant difference seen between the 2 groups based on the clinical outcomes measured. Average ODI values were 25.43 (SD 5.01) for the instrumented group versus 30.00 (SD 4.35) for the noninstrumented group ($p > 0.1$). The average back VAS for pain for the instrumented group was 2.35 (SD 0.80) versus 3.21 (SD 0.94) for the noninstrumented group ($p > 0.1$). The SF-36 (physical component) score was 64.65 (SD 6.77) for the instrumented group versus 53.99 (SD 5.38) for the study group ($p > 0.1$). The operating time was 103 (SD 4.7) minutes for the instrumented group versus 88.8 (SD 4.6) minutes for the noninstrumented group ($p = 0.036$). Average calculated blood loss was 342.1 (SD 47.49) mL for the instrumented group versus 267.5 (SD 36.68) mL for the noninstrumented group ($p = 0.1$). Preliminary 12-month data will be presented at the meeting. **Conclusion:** At 6 months follow-up, the BMP-2 graft demonstrated functionally equivalent clinical outcomes when used with or without instrumentation in lumbar spinal fusions while offering potential reduction in operative time and blood loss.

Regional variation in rates of surgery for the degenerative lumbar spine and the influence of patient

and physician enthusiasm. ***S. Samuel Bederman,*† *Peter C. Coyte,** *Hans J. Kreder,** *Nizar N. Mahomed,** *Warren J. McIsaac,** *James G. Wright.*** **From the *University of Toronto, Toronto, Ont., and the †University of California at San Francisco, San Francisco, Calif.**

Rates of surgery for the degenerative lumbar spine (DLS) have been steadily increasing. Significant regional variation has been observed, and it is thought that the enthusiasm for surgery of patients and physicians contributes to this variation. Although the "ideal rate" cannot be known, there may be an overall unmet need. Our purpose was to understand how regional rates of surgery for DLS vary across Ontario and to understand how the enthusiasm of patients, family physicians (FPs) and surgeons may influence them. Using administrative databases, we obtained the utilization rates of all surgery for DLS in Ontario for patients aged 50 years or older from 2002–2006. Patient and physician enthusiasm was measured across Ontario counties using responses to 16 clinical vignettes from a mailed survey. Using direct standardization, we calculated measures of small area variation and used random-effects over-dispersion Poisson regression controlling for demographics, socio-economic measures, prevalence of back pain and community resources (supply of surgeons, FPs and MRI scans). We identified 10 318 surgical discharges for DLS (mean age 65 yr, 50.6% female). No significant overall change over time was observed. Surgical rates increased for patients up to their 70s then declined for those aged 80 and above. We observed significant variation and found that DLS surgery was more variable than hip and knee replacement. Counties with higher rates of surgery had older ($p < 0.0001$) male patients ($p < 0.0001$), lower income ($p < 0.002$), higher rates of official language ($p < 0.004$) and higher surgeon enthusiasm ($p < 0.008$). Although patients and FPs have variable enthusiasm for surgery, surgeon enthusiasm may be the dominant modifiable factor influencing surgical rates. Prevalence of back pain and regional resources do not appear to be related to surgical rates. Strategies targeting surgeon practices may reduce regional variation in care and improve access disparities.

Should we rethink the natural history of the nonspecific symptom of low back pain? ***Greg McIntosh,** *Hamilton Hall.*†* **From the *CBI Health Research Department and the †University of Toronto, Toronto, Ont.**

Background: Knowing the natural history of any medical disorder is essential to understanding its impact, outcomes and guiding diagnostic and therapeutic decisions. Recurrent episodes are a common feature in the natural history of low back pain (LBP). But not all episodes are the same. This pilot study was intended to determine if recurrent episodes progressively worsen and how often patients report certain patterns of changing pain location during their episodes. **Methods:** Patients with LBP seeking care in 15 North American and European clinical practices completed a self-administered questionnaire. The survey focused on changes in patients' pain location within episodes and, for those with an episodic history, queried original versus most recent episodes based on 5 criteria: pain intensity, interference with leisure and work activities, duration of episodes and distal-most extent of pain. **Results:** Of 279 respondents, 84.9% reported having a recurrence, 40.9% recalled at least 10 and 24.7% over 50 previous episodes. There were 27% who reported at least 5 episodes each year. Seventy-eight percent (78%) of those with recurrences reported that at least 1 of the 5 criteria of a worsening episode was worse during their most recent compared with their original episodes ($p < 0.01$). Of the responding sample, 73.5% reported that their pain location changed during episodes, and 76.1% of that group reported that their initial pain spread distally during their episodes before retreating proximally as their pain abolished during recovery. There was a strong trend toward those reporting worsening episodes also reporting proximal-to-distal-to-proximal changes in pain location during their episodes ($r = 0.132$, $p < 0.06$). **Conclusion:** Recurrent LBP episodes are common and numerous. In these data, recurrences often worsened over time, while the pain within each episode usually started in the back, then spread distally, only to then centralize to the low back before disappearing as part of episode recovery.

The efficacy of intraoperative skull–skeletal traction in patients with adult idiopathic scoliosis undergoing surgical management. ***Andy Van Houwelingen, Elise Halpern, Subir Jhaveri, Stephen Lewis.*** **From Toronto Western Hospital, Toronto, Ont.**

Background and objectives: Intraoperative skull–skeletal traction improves correction and facilities implant insertion in scoliosis surgery. It is considered that scoliosis surgically corrected in childhood would have greater correction than that achieved in adulthood. This project aimed to determine if intraoperative skeletal traction can help achieve comparable scoliosis correction in adults as seen in children. **Methods:** Following research ethics board approval, we conducted a retrospective radiographic and chart review of 44 consecutive scoliosis patients (27 adults and 17 adolescents) undergoing surgical correction using intraoperative skeletal traction. Standard anteroposterior and lateral radiographs and patient charts were analyzed. The adult group was divided into 2 groups: those with degenerative listhesis and those without. Statistical analysis comparing the data of 2 experimental groups and 1 control group was done using a 2-sample t test, assuming unequal variance. **Results:** Patients with adolescent idiopathic scoliosis were used in the control group. Listhesis patients were significantly greater in age (mean 59 yr) than both nonlisthesis (mean 30 yr) and adolescent groups (mean 15 yr). Correction of sagittal balance was equal in all groups. Scoliosis corrections as measured by the Cobb angles in traction were similar between all groups (mean 46%) as well as postoperative angle correction (mean 59%). Listhesis patients achieved significant correction in their deformity with a reduction in angle of over 50%. The overall complication rate was low. **Conclusion:** The use of intraoperative skeletal traction facilitated scoliosis correction in our series providing older patients, even those with degenerative listhesis, with correction comparable to young adults and adolescents. There were no major complications associated with the use of intraoperative skeletal traction. We found intraoperative traction to be safe and effective in our series.

The role of pelvic incidence in degenerative spondylolisthesis. ***Kenny David, B. Ravi, Raja Rampersaud.*** **From the University Health Network, University of Toronto, Toronto, Ont.**

Background: The causative factors leading to development of

degenerative spondylolisthesis (DS) remain unproven. The role of pelvic incidence in DS and associated instability has not been previously studied. The purpose of this study was to determine if increased pelvic incidence was associated with a higher likelihood of DS being present in a cohort of surgical spinal stenosis patients and if a higher pelvic incidence was associated with a greater likelihood of loading translation (LT = increase in degree of anterolisthesis on standing v. recumbent imaging). **Methods:** A single surgeon's database was reviewed to identify all patients who underwent surgical treatment for spinal stenosis, with or without spondylolisthesis. Standing lateral radiographs and supine MRI scans of all patients were studied to quantify the following: pelvic incidence, sagittal translation and facet angle (FA). **Results:** A total of 135 consecutive patients were assessed. This included 83 patients with (group A) and 52 patients without (group B) concomitant spondylolisthesis. The mean pelvic incidence was 62.04° (36°–90°) in group A and 51.23° (19°–82°) in group B ($p < 0.001$). The mean FA was 31.8° (3°–67°) in group A and 39.7° (18°–56°) in group B ($p = 0.0013$). A 5% or more increase in the amount of LT was seen in 41% of patients in group A; these individuals had a higher mean pelvic incidence (63.6° v. 54.8°, $p = 0.019$) compared with those with less than 5% LT; there was no difference in FA for this subgroup. **Conclusion:** Given the wide range of radiographic findings, the development of DS is obviously multifactorial. However, a higher pelvic incidence seems to be associated with DS, particularly in those with LT. The high incidence of LT strongly suggests that preoperative standing radiographs to assess for LT are required in the spinal stenosis patient population. A large-scale study that includes a nonsurgical cohort is ongoing.

Thoracoscopic anterior instrumentation and fusion as a treatment for adolescent idiopathic scoliosis: a systematic review of the literature. ***Ron El Hawary, David Russell, Alex Soroceanu, Coleen O'Connell.*** **From Dalhousie University, Halifax, NS**

Introduction: The traditional surgical treatments for adolescent idiopathic scoliosis (AIS) include open anterior thoracotomy with instrumentation and posterior spinal fusion and instrumentation. Thoracoscopic instrumentation is a newer technique whose role remains controversial. This systematic review of the literature aims to better understand thoracoscopic instrumentation as a treatment for AIS and to discuss it in the context of the alternative techniques currently used. **Methods:** The most commonly used medical databases (PubMed, MEDLINE, EMBASE, Cinahl and the Cochrane Library) were searched up to April 2008 using the search terms "VATS," "thoracoscopic scoliosis" and "thoracoscopic scoliosis instrumentation." Two reviewers performed the literature search independently. There were no language restrictions. **Results:** Eleven studies met the strict inclusion criteria for the systematic review, of which the majority contained level-III and -IV evidence. A total of 445 cases have been reported, 80% of them female, with the vast majority having a diagnosis of AIS. Similar surgical techniques were used and had a mean operative time of 355 minutes, a mean blood loss of 444 mL and a mean hospital stay of 5.1 days. The mean preoperative curve magnitude was 47.9°, and the postoperative curve magnitude was 16.3°, with a correction of 62%. The number of levels instrumented was 6.3. Pulmonary function tests returned to preoperative values by 2 years postoperative, and the complication rate was 21.6%, including a pulmonary complication rate of 9.2%. Scoliosis Research Society questionnaires revealed that patients were satisfied. **Conclusion:** The major drawbacks of the thoracoscopic approach are the operative time and incidence of early pulmonary complications. Advantages include its minimally invasive approach, low blood loss, short hospital stay, excellent curve correction, few levels fused, good patient satisfaction and lack of long-term effect on pulmonary function. With appropriate surgeon training, careful patient selection and precise surgical technique, this technique can offer an acceptable alternative to the more traditional procedures.