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Du mercredi 27 février au samedi 2 mars, 2013

Abstracts • Résumés

Canadian Spine Society abstracts

Podium presentations

Thursday, February 28, 2013

1.1.01

The effect of rib-based distraction surgery on spine growth. ***R. El-Hawary,* M. Vitale,† A. Samdani,‡ J. Heflin,§ M. Smith,¶ J. Wade,¶ J. Klatt,¶ J.T. Smith.¶* From the *IWK Health Centre, Halifax, NS, †Columbia Presbyterian Hospital, New York, NY, ‡Shriner's Hospital, Philadelphia, Pa., §Ogden Regional Hospital, Ogden, Utah, and the ¶Primary Children's Hospital, Salt Lake City, Utah**

Background: For children with spine-based distraction systems, it has been published that T1–S1 length achieved after the initial lengthening procedure decreases with each subsequent lengthening. Our purpose was to evaluate the effect of rib-based distraction on spine growth in children with early onset scoliosis. The hypothesis was that rib-based distraction will improve spine growth; however, these gains may decrease over time and may be related to the normal slowing of T1–S1 growth between the ages of 5 and 10. **Methods:** This was a retrospective, multicentre, radiographic review of patients that have been treated with rib-based distraction surgery for early onset scoliosis. The review included 37 patients with a minimum 5-years follow-up. At initial implantation and at each lengthening, the following radiographic parameters were measured: Coronal Cobb angle, maximum kyphosis, thoracic height and lumbar height. T1–S1 data were calculated and changes in T1–S1 height per lengthening were determined and normalized to expected T1–S1 growth. **Results:** At initial surgery, these patients (mean age of 2.7 yr) had Cobb angle of 59.0° and maximum kyphosis of 39.6°. Three lengthening periods were compared: L1–L5 (n = 72), L6–L10 (n = 102), and L11–15 (n = 51). After a mean of 9.1 lengthenings, Cobb angle remained constant (51.9°, 49.1°, 53.8°), while maximum kyphosis (49.2°, 57.7°, 65.5°), thoracic spine height (13.73 cm, 15.30 cm, 16.46 cm), lumbar spine height (9.39 cm, 10.87 cm, 11.57 cm), and T1–S1 height (22.80 cm, 25.91 cm, 28.03 cm) increased. Change in T1–S1 height/lengthening demonstrated L1–L5 = 0.99 cm/lengthening, L6–L10 = 0.37 cm/lengthening, L11–L15 = 0.38 cm/lengthening, which corresponded to 159.3%, 45.7%, and 47.0% of expected growth. When expressed as a function of age at the time of lengthening, the percent of expected T1–S1 growth decreased (0–5 yr = 173%, 6–10 yr = 32% and 11+ yr = –21%, $p < 0.05$). **Conclusion:** At 5-year follow-up, rib-based distraction maintained scoliosis correction, increased kyphosis, thoracic spine height, lumbar spine height and T1–S1 height.

1.1.02

Responding to neuromonitoring changes in 3-column posterior spinal osteotomies for rigid pediatric spinal deformities. ***J. Jarvis,* S. Strantzas,† L. Holmes,† D. Lebel,† I. Aleem,† S. Lewis.†* From the *Childrens' Hospital of Eastern Ontario, Ottawa, Ont., and the †Hospital for Sick Children, Toronto, Ont.**

Background: Three column spinal osteotomies have allowed for significant correction in severe, rigid spinal deformities. Such correction can be associated with spinal cord stretching and ischemia with resultant electrophysiological changes. We sought to highlight high-risk steps and to describe actions taken to avert major neurologic injury during performance of 3 column osteotomies. **Methods:** A retrospective review was performed on neuromonitoring changes recorded during a consecutive series of cord level 3-column osteotomies between 2005 and 2011. A decrease in somatosensory-evoked potentials (SSEP) and transcranial motor-evoked potentials (MEP) greater than 50% of baseline was considered an alert. Alerts were classified chronologically as type I: before decompression, type II: occurring during decompression and bone resection, type III: occurring following osteotomy closure. **Results:** Thirty-six 3-column, cord level spinal osteotomies were performed in 29 patients. Mean age was 14.4 years. The SSEP alerts occurred in 3 patients, all of whom had significant MEP alerts. There were 4 type I, 12 type II, and 6 type III MEP alerts. Increasing blood pressure improved MEP in all with the exception of 5 type II and 4 type III alerts. The unresponsive 5 type II alerts were treated with osteotomy closure. The unresponsive 4 type III alerts all responded to reopening, manipulation, and subsequent reclosure of the osteotomy either with a cage or less correction. There were 6 immediate transient postoperative motor deficits that all resolved completely. No patients had permanent deficit. **Conclusion:** Significant MEP changes are common during the performance of 3-column, cord-level posterior spinal osteotomies in children. Type II changes unresponsive to increasing blood pressure responded well to osteotomy closure. Unresponsive type III changes were treated successfully with opening the osteotomy, cage adjustment and less correction. Real time intraoperative information provided by the MEP provided the necessary information to direct key surgical decisions.

1.1.03

Intraoperative skull femoral traction (ISFT) in posterior instrumentation for adolescent idiopathic scoliosis: safety and effect on perioperative care. ***S. Alsayegh, J. LaMothe, M. Letal, D. Parsons, F. Ferri-de-Barros.* From the University of Calgary, Calgary, Alta.**

Background: Several reports show the effect of the use of intraoperative traction in the treatment of spinal deformities in adolescent idiopathic scoliosis (AIS) or neuromuscular scoliosis. No studies looked for the benefits of intraoperative skull-femoral traction in terms of blood loss, blood transfusion requirement and operative time. **Methods:** We reviewed the charts and radiographs of all patients who had posterior superior iliac for AIS from January 2008 to December 2011 in a single institution. Two groups of patients were compared: group A had no intraoperative skull femoral traction (ISFT) and group B had ISFT. We

excluded patients who had 1 or more of the following: other causes of scoliosis, anterior approach, revision surgery, systemic diseases, incomplete data on charts or preoperative donation of blood. We compared relevant demographic, clinical and radiographic data for both groups, with a particular interest in traction related complications, which have been monitored since we began using ISFT in 2010. Our primary outcome measures were blood loss and operative time. We calculated blood loss with a previously validated formula. Operative time was measured from skin incision to skin closure for group A, and from traction application to skin closure for group B. **Results:** Seventy-three patients met the inclusion criteria, 28 for group A and 45 for group B. The groups were comparable with regards to age, body weight, gender and distribution of curve types, major curve magnitude, number of levels fused and type of anesthetic (no statistical difference). The mean blood loss for group A was 2083 mL versus 1485 mL for group B (p = 0.027). The operative time was 447.6 minutes for group A versus 375.6 minutes for group B (p = 0.0001). Sixty-four percent of group A patients required blood transfusion versus 33% of group B (p = 0.01). There was no significant difference in the percentage of curve correction (58.1% v. 62.5%). There were no traction related complications that were significant to patients or that required any treatment. Two patients had transient changes in spinal cord monitoring (motor evoked potentials), 1 from each group. No neurologic deficits occurred. **Conclusion:** Intraoperative skull-femoral traction in posterior spinal instrumentation for AIS is safe, and may contribute to reduction in blood loss, blood transfusion requirements and operative time.

1.1.04

Comparison between X-ray and MRI in the measurement of sagittal spinopelvic parameters in children with late onset scoliosis. ***A. Raizah, W. Kishta, A. Spurway, R. El-Hawary*. From the IWK Health Centre, Halifax, NS**

Background: Spinopelvic parameters (pelvic incidence, pelvic tilt and sacral slope) are helpful to describe the orientation, shape and morphology of the spine and pelvis. We have identified variability in these measurements for children with early onset scoliosis. This is likely due to difficulty identifying landmarks for measurement on the immature sacral end plate. It is hypothesized that MRI may be useful for identifying these landmarks and for measuring these parameters in the immature population. As a first step toward this, the goal of this study was to validate this technique by comparing X-ray and MRI spinopelvic parameters in patients with late onset scoliosis (i.e., more mature sacrum). We hypothesize that there will be no significant difference between X-ray and MRI measurements in children with late onset scoliosis. In particular, pelvic incidence which is not position dependent should be the same for this population. **Methods:** Thirteen patients with untreated late onset scoliosis who presented to a tertiary children hospital were enrolled in the study. Standing lateral radiographs were evaluated and MRI was performed for these patients. Sagittal spinopelvic parameters were measured on standing lateral radiographs and on MRI images. The Surgimap program was used to obtain the X-ray measurements. An MRI spinopelvic balance program was developed and used to do the MRI measurements, which were compared and analyzed. **Results:** Average age was 14.5 years. The average pelvic tilt was 6.6° in X-ray and 7.2° in MRI. The average sacral slope was 42.2° for X-ray and 37.2° for MRI. The average pelvic incidence was 48.5° for X-ray and 44.4° for MRI. Paired t test showed significant difference in sacral slope and pelvic incidence between X-ray and MRI. **Conclusion:** This study demonstrated that X-ray and MRI are not comparable in measuring spinopelvic parameters in this population. This includes pelvic incidence, which should not be position dependent.

1.2.05

Impact of global sagittal alignment on health-related quality of life in lumbosacral spondylolisthesis. ***A. Harroud,* H. Labelle,* J. Joncas,* J.-M. Mac-Thiong*.*† From the *Division of Orthopeadic Surgery, CHU Sainte-Justine, Montréal, Que., and the †Division of Orthopeadic Surgery, Hôpital du Sacré-Coeur de Montréal, Montréal, Que.**

Background: Many surgeons believe that global sagittal alignment is an important aspect in the management of spondylolisthesis, but the data establishing its clinical impact is poor. Previous studies reported significant correlation between global sagittal alignment and health-related quality of life (HRQOL) in patients with adult spinal deformity, but none has investigated this relationship in adolescent spondylolisthesis. The purpose of this paper is to determine if global sagittal alignment parameters are clinically relevant and have an impact on health status in adolescent spondylolisthesis. **Methods:** This is a retrospective study of 149 consecutive unoperated patients presenting with lumbosacral adolescent spondylolisthesis at a single pediatric institution (117 low-grade and 32 high-grade). Two global sagittal alignment parameters were measured on full spine standing radiographs: spinal tilt and C7 plumbline deviation (C7P deviation). All patients completed the SRS-22 questionnaire to assess HRQOL. Pearson correlations were calculated between each radiological parameter and HRQOL. Multiple regression analyses were also undertaken to account for slip percentage and lumbosacral kyphosis (LSK). **Results:** Both global sagittal alignment parameters were related to SRS-22. When grouped based on slip percentage, the correlation was absent in low-grade patients but remained significant in high-grade patients (r = 0.35 for spinal tilt; r = –0.35 for C7P deviation). The relation was strengthened when considering high-grade patients with a C7P deviation in front of the posterior corner of the upper sacral end plate and was also positive for the SRS-22 pain and appearance domains. Correlations for these patients remained significant when controlling for slip percentage and LSK in multiple regression analyses. **Conclusion:** In high-grade patients, an increase in positive sagittal alignment was independently related to a poorer health status. Global sagittal alignment should be assessed in the clinical evaluation of high-grade patients with spondylolisthesis. This study may support reduction in the surgical management of high-grade patients.

1.2.06

Ending spinal fusion at l5 versus S1 in adult patients with lumbar scoliosis: a review. ***Z. Sardar, M. Weber, P. Jarzem, J.Ouellet*. From the McGill Scoliosis & Spine Centre, McGill University Health Centre, Montréal, Que.**

Background: Adult lumbar scoliosis is a common disorder with reported prevalence that increases steadily after the age of 50.

Studies have favoured operative versus nonoperative treatment for symptomatic patients with adult scoliosis. For patients requiring long fusion to the lumbar spine, the question remains whether to stop the fusion at L5 or to extend the fusion to S1 and the pelvis. The objective of this review is to compare the relevant literature for the benefits of stopping a fusion at L5 versus S1. **Methods:** A systematic review of the English literature published from 1983 through June 2012 was undertaken on PubMed. Inclusion criteria were 1) lumbar fusion for adult scoliosis to L5 versus S1 and 2) assessment of lumbar fusion outcomes to L5 versus S1. Outcomes included surgical time; blood loss; functional status, pseudarthrosis rate, revision rate, loss of deformity correction, degeneration at L5–S1, rate of hip/sacroiliac joint degeneration and other medical complications. **Results:** We identified 8 studies to be included in this review. There was a higher rate of perioperative complications in patients fused to the sacrum versus those fused to L5. One study reported a statistically significant loss of correction of lumbar lordosis in the L5 group compared with the sacrum/pelvis fusion group. Several studies reported a high (58%–69%) incidence of subsequent advanced disc degeneration at L5–S1 after long fusion to L5, which was not related to the level of degeneration present at L5–S1 preoperatively. One study reported that this degeneration is more likely in patients with preoperative sagittal imbalance (> 5 cm) and lumbar hypolordosis (< 30°). However, L5–S1 disc degeneration was not found to be associated with need for revision surgery. For patients with extension of fusion to S1, development of pseudarthrosis is a major complication with rates between 19%–40%. The studies show that there is a significant revision rate in both groups. However, no studies report a higher revision rate for the L5 group even with a known high rate of subsequent L5–S1 degeneration. **Conclusion:** The review highlights the importance of involving the patient in the decision to stop a fusion at L5 versus S1 and to share with the patient the high risks for revision surgery in both surgeries. Stopping the fusion at L5 spares a single motion segment and is not associated with a greater revision surgery rate when compared with S1 but may not allow for the treatment of the fractional curve and resultant deformity.

1.2.07

A novel surface topography technique to evaluate torso asymmetry in adolescent idiopathic scoliosis. ***A. Komeili,*[*] *L. Westover,*[†] *E. Parent,*[*†] *M. Moreau,*[*†] *M. El-Rich,*[*] *S. Adeeb.*[*] **From the *University of Alberta, Edmonton, Alta., and †Alberta Health Services, Edmonton, Alta.**

Background: Surface topography (ST) is investigated as a noninvasive tool to replace or supplement radiographic monitoring of adolescent idiopathic scoliosis (AIS). Previous ST approaches are limited because they extract 2-dimensional measurements rather than utilize the full 3-dimensional (3D) data and rely on manually placed markers. This study aimed to introduce a novel, 3D markerless analysis for assessing torso asymmetry in AIS and determine the intra/inter-rater and test-retest reliability and face validity of a classification based on asymmetry maps. **Methods:** Full torso ST scans of 46 patients with AIS (Cobb angle: 34.1° ± 15.3°; curve types: Lenke 1, 3 and 5) and 5 healthy participants were used for analysis. A second baseline scan and 1-year follow-up scan were analyzed for 15 participants. The best plane of symmetry, dividing the torso into left and right, was calculated for each scan. Asymmetry across this plane was displayed as a deviation contour map. The patterns of torso asymmetry maps were classified into 3 main groups to facilitate the development of deformity measures specific to each group. The intra/inter-observer and test-retest reliability of the classification was assessed using 4 raters. The contour deviation map was visually compared with the corresponding radiograph for all participants. **Results:** The mean κ coefficient for intraobserver reliability was 0.85 (range 0.68–0.92) indicating good to excellent reliability. The intraobserver test-retest reliability using the first and second baseline scans showed 85% agreement (range 80%–93%), with a mean κ value of 0.83 (range 0.70–0.92). Excellent correspondence was observed between ST contour maps and radiographs in terms of the location of curve apex, severity of curvature and the number of the spinal curves. **Conclusion:** The classification system showed good reliability. The technique shows promise as a noninvasive tool for assessment and monitoring of AIS. Asymmetry measurements for each group will be proposed and their reliability and validity assessed in a future study.

1.3.08

Anterior versus posterior surgical approaches to treat cervical spondylotic myelopathy: outcomes of the prospective multicentre AOSpine North America cervical spondylotic myelopathy (CSM) study in 278 patients. ***M. Fehlings,*[*] *S. Barry,*[*] *B. Kopjar,*[†] *S.T. Yoon,*[‡] *P. Arnold,*[§] *E. Massicotte,*[*] *A. Vaccaro,*[¶] *D. Brodke,*[**] *C. Shaffrey,*[††] *J. Smith,*[††] *E. Woodard,*[‡‡] *R. Banco,*[§§] *J. Chapman,*[†] *M. Janssen,*[¶¶] *C. Bono,*[***] *R. Sasso,*[†††] *M. Dekutoski,*[‡‡‡] *Z. Gokaslan.*[§§§] **From the *University of Toronto, Toronto, Ont., †University of Washington, Seattle, Wash., ‡Emory University, Atlanta, Ga., §University of Kansas, Kansas City, Mo., ¶Thomas Jefferson University, Philidelphia, Pa., **University of Utah, Salt Lake City, Utah, ††University of Virginia, Charlottesville, Va., ‡‡New England Baptist Hospital, Boston, Mass., §§Boston Spine Group, Newton, Mass., ¶¶Spine Education and Research Institute, Denver, Colo., ***Brigham and Woman's Hospital, Boston, Mass., †††Indiana Spine Group, Indianapolis, Ill., ‡‡‡Mayo Clinic, Rochester, Minn., and §§§Johns Hopkins University, Baltimore, Md.**

Background: The optimal surgical approach to treat cervical spondylotic myelopathy (CSM) remains debated with varying opinions favouring anterior versus posterior surgical approaches. We present an analysis of a prospective observational multicentre study examining outcomes of surgical treatment for CSM. **Methods:** Two hundred and seventy-eight patients from 12 sites in North America received anterior/posterior or combined surgery at the discretion of the surgeon. This study focused on patients who had either anterior or posterior surgery (n = 264, 87% follow-up rate). Outcome measures included the Modified Japanese Orthopedic Assessment Scale (mJOA), the Nurick Scale, the neck disability index (NDI) and the SF36v2 physical (PCS) and mental component scores (MCS). **Results:** One hundred and sixty-nine patients were treated anteriorly while 95 received posterior surgery. Anterior surgical cases were younger and had less severe myelopathy as assessed by mJOA and Nurick scores. There were no baseline differences in NDI or SF36 between the anterior and posterior cases. Improvement in the mJOA was significantly lower in the anterior group when compared with posterior group

(2.47 v. 3.62, respectively; $p < 0.01$), although the groups started at different levels of baseline impairment. The extent of improvement in the Nurick, NDI, SF36v2 PCS, SF36v2 MCS scores did not differ between groups. **Conclusion:** Patients with CSM show significant improvements in several health-related outcome measures with either anterior or posterior surgery. Importantly, patients treated with anterior techniques were younger, with less severe impairment and more focal pathology. We demonstrate for the first time that, when patient and disease factors are controlled for, anterior and posterior surgical techniques have equivalent efficacy in the treatment of CSM.

1.3.09

A clinical prediction rule to determine outcomes in patients with cervical spondylotic myelopathy (CSM) undergoing surgical treatment: data from the prospective, multicentre AOspine North America CSM study. ***L. Tetreault,*** [*] ***B. Kopjar,*** [†] ***A. Vaccaro,*** [‡] ***S. Yoon,*** [§] ***P. Arnold,*** [¶] ***E. Massicotte,*** [**] ***M. Fehlings.*** [*] **From the *University of Toronto, Toronto, Ont., †University of Washington, Seattle, Wash., ‡Thomas Jefferson University, Philadelphia, Pa., §Emory University, Atlanta, Ga., ¶University of Kansas, Kansas City, Mo., and **Toronto Western Hospital, Toronto, Ont.**

Background: Cervical spondylotic myelopathy (CSM) is a degenerative spine disease and the most common cause of spinal cord dysfunction worldwide. Surgery is an effective and common treatment option for mild to severe CSM. The objective of this study is to develop a clinical prediction rule relating a combination of clinical and imaging variables to surgical outcome in patients with CSM, based on data from a large multicentre prospective study. **Methods:** Two hundred and seventy-eight patients diagnosed with cervical myelopathy treated surgically were enrolled in the CSM North American multicentre trial. Patients were consented at 12 sites from December 2005 to September 2007. Univariate analyses were performed to evaluate the relationship between outcome, assessed by the modified Japanese Orthopaedic Association (mJOA) score and various clinical and imaging predictors. A set of important variables for the final model was selected based on author consensus and statistical findings. Logistic regression was used to formulate the final prediction model and assess the impact of each variable on outcome. **Results:** The dependent variable, mJOA at 1 year, was dichotomized for logistic regression: a "successful" outcome was defined as a final mJOA greater than or equal to 16 and a "failed" outcome was a score less than 16. The final model included age ($p = 0.0017$), duration of symptoms ($p = 0.048$), smoking status ($p = 0.043$), impairment of gait ($p = 0.020$), psychological comorbidities ($p = 0.0035$), baseline severity score ($p = 0.0084$) and transverse area of the cord on MRI ($p = 0.19$). The area under the receiver operator curve was 0.79, indicating excellent model prediction. **Conclusion:** Based on this study, we have identified a list of the most important predictors of surgical outcome for CSM. This model will allow clinicians to estimate the likely outcome of surgery, provide this valuable prognostic information to their patients and implement appropriate treatment programs.

1.3.10

Influence of graft height on anterior cervical discectomy, fusion and plating (ACDFP) for an in vitro unilateral facet injury model. ***R. Yao, S. McLachlin, P. Rasoulinejad, K. Gurr, C. Dunning, C. Bailey.*** **From Western University, London, Ont.**

Background: Anterior cervical discectomy, fusion and plating (ACDFP) is standard commonly employed treatment for unilateral facet injuries; however, there is no consensus as to optimal graft height. This study examined the influence of graft height on biomechanical stability in ACDFP for unilateral facet injuries with or without facet fracture. We hypothesize that over sizing the graft will reduce the buttress effect of the facets due to over-distraction, and under sizing the graft will impair soft tissue tensioning; both states will lead to a decreased construct stability. **Methods:** Seven spine segments from C4–C7 were tested in a custom spine simulator. Flexibility testing was performed in axial rotation (AR), lateral bend (LB), and flexion-extension (FE). The testing sequence was as follows: intact specimens, unilateral facet perch injury at C5–C6, ACDFP with graft size equal to 1) CT-measured disc space height, 2) height minus 2.5 mm, then 3) height plus 2.5 mm, ACDFP after ipsilateral facet fracture, and ACDFP after a simulated bilateral facet dislocation injury (BFD). Range of motion (ROM) at C5–C6 for each motion was analyzed using repeated-measured analysis of variance. **Results:** In all motions, regardless of graft size, ACDFP reduced ROM from all injury states. Regarding graft size, the oversized graft decreased FE ROM compared with both the measured size and undersized grafts $p < 0.05$). In LB and AR, the undersized graft decreased ROM compared with the other grafts ($p < 0.05$); however, for AR this was significant for the BFD injury only. **Conclusion:** Our results demonstrate that graft size does affect biomechanical stability; undersizing the graft resulted in both facet overlap and locking of the uncovertebral joints, providing greater stability in LB and AR, while oversizing the graft provided more stability in FE. Although multiple factors must be considered in graft selection, these results will help guide the clinician's decision when choosing the appropriate graft size.

1.3.11

Silicate-substituted calcium phosphate ceramic bone graft replacement for spinal fusion procedures. ***V. Nagineni,*** [*] ***A. James,*** [*] ***M. Alimi,*** [*] ***C. Hofstetter,*** [*] ***B. Shin,*** [*] ***I. Njoku,*** [*] ***J. Tsiouris,*** [†] ***R. Härtl.*** [*] **From the *Department of Neurological Surgery, Weill Cornell Medical College, New York, NY, and the †Department of Clinical Radiology, Weill Cornell Medical College, New York, NY**

Background: SiCaP is a newer generation synthetic ceramic designed to maximize osteoinduction and osteoconduction. **Methods:** This is a retrospective analysis of a prospectively collected patient database including 108 patients with 204 individual spinal levels. Different surgical procedures performed included 25 anterior cervical discectomy and fusions, 17 posterior cervical fusions, 7 combined anterior and posterior cervical fusions, 10 thoracic fusion surgeries, 18 transforaminal lumbar interbody fusions with 12 axial lumbar interbody fusions, 11 transpsoas disc ectomy and fusions, and 8 combined thoracolumbar fusion procedures. SiCaP was used as bone extender without any additional graft material, bone marrow aspirate, or bone morphogenetic protein. Clinical outcomes were assessed using the visual analogue scale (VAS), Oswestry Disability Index (ODI), and neck disability

index (NDI). Fusion was determined by the presence of bony bridging on 2 consecutive sections in at least 2 planes on computed tomographic imaging. **Results:** At a follow-up of 12 (± 4.7) months, 90% of all patients demonstrated radiographical fusion. Fusion rates were highest in the cervical spine (97%) followed by thoracic and lumbar spines (86% and 81%, respectively). There were significant improvements in all clinical outcome measures (ODI: 11.1 [± 10.2] and NDI: 9.0 [± 11.4]; VAS-back: 3.1 [± 3.0], VAS-leg: 3.5 [± 3.6], VAS-neck: 3.7 [± 2.5], and VAS-arm: 4.0 [± 3.2]). There was no radiographical loosening of instrumentation due to infection or nonunion in this series, and no subsequent revisions for nonunion were required. **Conclusion:** SiCaP is an alternative to autogenous bone graft in spinal arthrodesis procedures. At 12-month follow-up, we detected high levels of bony fusion using SiCaP in combination with various surgical spinal techniques.

1.4.12

A novel scientific model for rare and often neglected neoplastic conditions. ***C. Fisher,[*] T. Goldschlager,[*] S. Boriani,[†] P. Varga,[‡] M. Fehlings,[§] M. Bilsky,[¶] M. Dekutoski,[**] A. Luzzati,[††] R. Williams,[‡‡] S. Berven,[§] D. Chou,[§] N. Quraishi,[¶¶] L. Rhines,[***] C. Bettegowda,[†††] Z. Gokaslan.[†††]***

From the *University of British Columbia, Vancouver, BC, †Istituto Ortopedico Rizzoli, Bologna, Italy, ‡Buda Health Center, Budapest, Hungary, §University Health Network, Toronto, Ont., ¶Sloan-Kettering Institute for Cancer Research, New York, NY, **Mayo Clinic, Rochester, NY, ††Istituto Ortopedico Galeazzi, Milan, Italy, ‡‡Brisbane Spine Research Centre, Brisbane, Australia, §§University of California, San Francisco, Calif., ¶¶Nottingham University Hospitals, Nottingham, UK, ***MD Anderson Cancer Center, Houston, Tex., and †††John Hopkins University, Baltimore, Md.

Background: The treatment of rare neoplastic conditions is challenging especially because studies providing high levels of evidence are often lacking. Such is the case with primary tumours of the spine (PST), which have a low incidence, are pathologically heterogeneous and treatment approaches have been diverse. Despite these difficulties, appropriate evidence-based care of these complex patients is imperative. Failure to follow validated oncologic principles may lead to unnecessary mortality and profound morbidity. With the aim of offering patients the most appropriate treatment based on the best available evidence a novel scientific model was developed and employed. This paper outlines this model, which has not only provided significant evidence guiding treatment of this rare condition, but we believe is readily transferrable to other similarly rare conditions. **Methods:** A 4-stage approach was employed. 1) Planning: data from large volume centres were reviewed together with results from a feasibility questionnaire to provide insight into epidemiology, patient volumes, tumour pathology, treatment modalities and outcomes. 2) Recruitment: centres with sufficient volume and valid data were enrolled and provided with the necessary infrastructure. This included study coordinators and a secure, web-based database (REDCap, Vanderbilt University, Nashville, Tenn.) to capture international data from 6 modules comprising: demographic, clinical, diagnostic, therapeutic, cross sectional survival and local recurrence, and perioperative morbidity. The AOSpine Tumor Knowledge Forum designed these modules and provided funding. Each centre received institutional ethics approval. 3) Retrospective phase: prospectively collected data from all recruited centres was retrospectively reviewed and analyzed. 4) Prospective phase: following interim analysis and validation, prospective data collection has been implemented. In addition, a PST biobank has been created to link clinical data with tumour pathology and molecular analysis. **Results:** It took 18 months to implement stages 1–3 of this model and stage 4 is ongoing. A total of 1251 tumour cases were captured and diagnosed as 1 of the 18 primary spine tumour subtypes listed. The most prevalent diagnosis was chordoma (n = 274, 22%). There were 563 females and 688 males with a mean age of 43 ± 20 years at the time of surgery. Surgical treatment was performed between the years 1981–2012. The survival at 5 and 10 years postsurgery was 72.3% and 55.8% respectively, with a median survival of 13 years postsurgery. **Conclusion:** To date, this is the largest international collection of PST. This novel scientific model has not only aggregated a large amount of PST data, but has also established an international collaborative network of spine oncology centers. The access to large volumes of clinical and biobank data will generate further research to guide and enhance the clinical management of PST. This novel scientific model could be of similar tremendous value if applied to other rare neoplastic conditions.

1.4.13

Does radiofrequency ablation treatment comprehensively destroy bone and tumour cells? ***P. Pezeshki,[*†] M. Akens,[*†] C. Whyne,[*] A. Yee.[*†]***

From *Sunnybrook Research Institute, Toronto, Ont., and the †University of Toronto, Toronto, Ont.

Background: Application of radiofrequency ablation (RFA) in spinal metastases has been rising, yet its impact on bone is poorly understood. Previously we evaluated safety and feasibility of a novel bipolar RFA probe on healthy pig spines. Here, we evaluated RFA effects on bone and tumour cells in a preclinical rabbit bone tumour model. **Methods:** Twelve New Zealand White rabbits received a 200 µl injection of VX2 tumour cells into 1 femur. Four experimental groups were analyzed: tumour-bearing RF-treated, healthy RF-treated, tumour-bearing sham and healthy sham femora. The MRI was conducted immediately before RF treatment on day 14 and before sacrifice on day 28. Excised femora were histologically analyzed with hematoxylin-eosin staining (for general evaluation), AE1/AE3 (for VX2 tumour evaluation), tartrate-resistent acid phosphate activity (TRAP [for osteoclast evaluation]) and terminal deoxynucleotidyl transferase dUTP nick end labelling (TUNEL [for osteocyte ablation evaluation]) staining. **Results:** Histological results correlated well with ablation regions determined using gadolinium-enhanced MRI sequences (R = 0.9). Large zones of RFA (average volume = 12.9 ± 5.5 cm^3) extending beyond the cortex (corresponding to probe design) into the surrounding soft tissue was observed on MRI and confirmed histologically. The RFA-treated tumour-involved specimens demonstrated a significant reduction in tumour volume compared with sham femora; however, a small number of viable tumour cells remained within the ablation volume. The TRAP staining demonstrated a significant reduction of osteoclast number postRFA in both tumour-involved and healthy groups. Terminal deoxynucleotidyl transferase dUTP nick end

labelling stains revealed areas of patchy cortical osteocyte necrosis within the ablation zone. **Conclusion:** Histology verified large, oval, regions of ablation by RF treatment consistent with MRI, which are suitable for spinal tumour treatments. While osteoclasts were very susceptible to RFA, a few tumour cells and osteocytes in treated regions remained viable. Since treatment zone did not encompass the full extent of intramedullary lesions, sporadic VX2 cell viability may be explained by local tumour cell migration. Incomplete destruction of healthy osteocytes by RFA may be clinically desirable for restoring spinal bone health.

1.4.14

Spinal Instability Neoplastic Score: an analysis of reliability and validity in radiologists: an AOSpine knowledge forum tumour project. ***C. Fisher,[*] M. Nadeau,[*] P.P. Varga,[†] S. Boriani,[‡] L. Rhines,[§] N. Kawahara,[¶] D. Fourney,[††] J. Reynolds,[**] M. Fehlings,[‡‡] R. Schouten,[*] Z. Gokaslan.[§§]***
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Background: Standardized recognition of tumour-related spinal instability and referral patterns initiated by radiologists are hampered by the lack of a valid and reliable classification system. The uncertainty of this diagnosis could lead to inappropriate referrals and/or undertreatment of patients with instability. The Spinal Instability Neoplastic Score (SINS) was developed to facilitate the diagnosis of spinal neoplastic instability. The aim of this study was to determine the inter- and intraobserver reliability, as well as the validity of SINS among radiologists. **Methods:** Thirty-seven radiologists from 11 sites reviewed 30 spinal neoplastic cases. They independently performed the SINS evaluation twice for each case and categorized them into 3 domains: stable (0–6 points), impending instability (7–12 points), and unstable (13–18 points). In addition, a 2-category scale was used: stable (0–6 points) or requiring a surgical referral (7–18 points). The single independent evaluation of 11 spine surgeons determined the gold standard SINS value for each case. The κ coefficients were calculated to evaluate the intra- and inter-rater reliability of the 0–18 SINS, 3- and 2-category scales. Validity was defined as the agreement between raters and gold standard. **Results:** Interobserver agreement was fair regarding the 0–18 point SINS (κ = 0.25 and 0.24), moderate for the 3-category SINS (κ = 0.53 and 0.58), and substantial to excellent for the 2-category scale (κ = 0.76 and 0.81), respectively. Intraobserver reproducibility was moderate for the 0–18 SINS (κ = 0.40), substantial for the 3-category scale (κ = 0.69) and excellent for the 2-category scale (κ = 0.82). The agreement of the radiologists with the gold standard was fair for the 0–18 SINS (κ = 0.33 and 0.34), substantial for the 3-category (κ = 0.65 and 0.71) and excellent for 2-category scale (κ = 0.83 and 0.89). **Conclusion:** Among radiologists, SINS results represent highly reliable and valid assessments to categorize cases as stable versus impending unstable/unstable cases. This supports appropriate referral patterns.

Friday, March 1, 2013

2.1.15

Results of a North American, multicentre, blinded, pilot study of a novel peptide in promoting lumbar spine fusion. ***Z. Sardar,[*] D. Alexander,[†] W. Oxner,[†] S. Du Plessis,[‡] A. Yee,[§] E. Wai,[¶] P. Jarzem,[*] D.G. Anderson.[**]***
From the *McGill University Health Centre, Montréal, Que., †Queen Elizabeth II Health Sciences Centre, Halifax, NS, ‡Foothills Medical Centre, Calgary, Alta., §Sunnybrook Health Sciences Centre, Toronto, Ont., ¶Ottawa Hospital, University of Ottawa, Ottawa, Ont., and **Thomas Jefferson Hospital, Philadelphia, Pa.

Background: Fusion failure in transforaminal lumbar interbody fusion (TLIF) procedures is a challenging problem that can lead to poor functional outcomes, ongoing back pain, dependence on pain medication and inability to return to work. B2A is a synthetic peptide that has proven efficacy in achieving fusion in animal studies, with no reports of heterotopic ossification, and may be a cheaper but safer alternative to other bone morphogenetic proteins (BMPs) while avoiding iliac crest bone graft (ICBG) harvesting morbidity. The purpose of this study was to assess the safety and effectiveness of B2A peptide–enhanced ceramic granules in achieving fusion at 12 months after surgery. **Methods:** This is a multicentre, North American, prospective pilot study. Skeletally mature patients (18–70 yr) with degenerative lumbar disease at L2–S1 requiring single level TLIF were randomized to 3 groups: ICBG, B2A concentration 150 g and B2A concentration 750 g; B2A was combined 1:1 with locally derived autograft before implanting. Thirty-nine patients (13 control, 19 B2A 150 g, 7 B2A 750 g; 24 Canada, 15 USA; 19 males, 20 females) were enrolled between 2009 and 2010. The patients had preoperative screening low back pain or leg pain of at least 6 cm using a 10 cm visual analogue back pain scale (VAS) and had at least 20 points (40%) on the Oswestry Disability Index (ODI) questionnaire. Postoperative rehabilitation plans were similar among patients. Outcome measures included ODI, VAS, and fusion as assessed by CT scans and dynamic flexion–extension radiographs (all interpreted by an independent, blinded radiologist). Patients were evaluated at 6 weeks, and 3, 6 and 12 months after surgery. **Results:** Blood loss during surgery was higher in ICBG (431 cc) than both prefix 150 (251 cc) and prefix 750 (314 cc). Fusion at 6 months was 42%, 32%, and 71% for ICBG, low and high dose, respectively. At 12 months, fusion was 83%, 50% and 100% for ICBG, prefix 150 and 750, respectively. The mean ODI was 19.9 for ICBG, 31.1 for prefix 750 and 27.8 for prefix 150 at 12 months; differences were not statistically significant. There were no significant differences in serum chemistry between groups. No patients developed antibodies to B2A. Complications included 1 adjacent level infection needing reoperation (prefix 750), 1 seroma that was drained without consequence (prefix 150) and 2 reoperations due to nonunion (prefix 150). **Conclusion:** Prefix provides a safe alternative to ICBG and avoids donor site morbidity. B2A 750 showed superior fusion rate to autograft at 12 months. Both prefix groups and autografts were equivalent in improving ODI at all time points up to 12 months.

2.1.16

Determining stability in degenerative spondylolisthesis: a systematic review. ***A. Simmonds, C. Fisher.*** **From the University of British Columbia, Vancouver, BC**

Background: A range of surgical options from decompression alone to decompression and 360° fusion exist for the treatment of adult degenerative spondylolisthesis (DS). Choosing the right procedure is highly dependent on the type or "stability" of the spondylolisthesis. Despite a substantial quantity of literature dedicated to outcome analysis of numerous procedures, no consensus has been reached as to defining or classifying DS with respect to stability. Therefore the purpose of this study is to define DS with respect to grades of stability, in order to provide guidance for the optimal approach in the surgical management of this disease. **Methods:** A qualitative systematic review was conducted. Relevant studies were identified through a search of MEDLINE and EMBASE databases, recent conference proceedings, and a bibliography search of identified papers. The included studies were any clinical or biomechanical analyses evaluating the classification or assessment of degenerative spondylolisthesis, from 1990 to present. Exclusion criteria included research focused on nondegenerative forms of spondylolisthesis, or evaluating spinal stenosis without associated DS. Titles and abstracts of the identified studies were evaluated, and full text versions of potential studies were assessed for inclusion. The primary extracted results were clinical findings indicative of stability at the diseased segment, and radiographic parameters that prognosticate increased likelihood of listhesis progression. **Results:** Facet joint orientation of patients with DS is more sagittally oriented in the transverse plane than controls. The literature suggests that this finding may be related to secondary remodelling and unlikely to contribute to instability. Flexion-extension radiographs are helpful for assessing angular motion, which is correlated with translational motion, and therefore indicative of instability. A kyphotic disc angle in flexion is a prognosticator of stability. Facet joint effusion identified on MRI correlates in a linear fashion to instability noted on flexion–extension lateral radiographs. Smaller joint effusions may indicate restabilization of the affected segment. In vitro research shows that both disc resection and anterior and posterior ligament compromise must be present to produce a grade I listhesis. Decreased preoperative range of motion is correlated with increased stability. Joint laxity is likely a contributing factor in DS. Narrowed disc height, spur formation, subcartilaginous sclerosis, or ossification of ligaments indicates restabilization of the segment, and their presence on preoperative assessment indicates a lower probability of listhesis progression. Anterior osteophyte size was not found to be predictive of stability. **Conclusion:** Based on the best available research, and given that different clinical scenarios will influence management, the factors indicating a spondylolisthesis is stable, and therefore not requiring fusion are narrowed disc height, spur formation, subcartilaginous sclerosis, ossification of ligaments, decreased range of motion on flexion-extension radiographs, and small facet joint effusions on MRI. Patients without these findings, particularly in the setting of ligamentous laxity, likely have an unstable DS that will benefit from fusion. DS with large joint effusions on MRI, or a kyphotic disc angle on flexion-extension views indicates a greater probability of highly unstable slip, and probably require 360° fusion. Prospective research will be required to further refine these recommendations.

2.1.17

Comparative clinical and economic outcomes of minimally invasive surgery for posterior lumbar fusion: a systematic review and meta-analysis.

C. Goldstein,*† K. Macwan,† K. Sundararajan,† R. Rampersaud.*† **From the *University of Toronto, Toronto, Ont., and the †University Health Network, Toronto, Ont.**

Background: The comparative effectiveness and economic benefit of minimally invasive surgery (MIS) for lumbar fusion remains unclear. The purpose of this systematic review and meta-analysis is to summarize the results of comparative effectiveness and economic research comparing MIS transforaminal lumbar interbody fusion (TLIF) to traditional open midline techniques. **Methods:** A systematic review was performed. MEDLINE, EMBASE, PubMed, Web of Science and Cochrane databases were queried. A hand search of reference lists was performed. Studies were reviewed by 2 independent assessors to identify randomized controlled trials or comparative cohort studies including more than or equal to 10 patients undergoing open or MIS TLIF for degenerative pathology and reporting at least 1 of clinical outcome measure, perioperative outcome measure, radiographic outcome, complications, or economic analysis. Study quality was assessed using the GRADE protocol. A meta-analysis was conducted on outcomes data when appropriate. **Results:** The literature search identified 3306 articles of which 26 met our inclusion criteria. All studies were of low or very low quality. The cohorts (n = 856 MIS; n = 806 open) were comparable in age, sex, surgical levels and diagnosis. Meta-analysis revealed changes in perioperative outcomes (estimated blood loss, time to ambulation, length of stay) favouring an MIS approach. At a median follow-up time of 24 months mean, Oswestry Disability Index scores were slightly better in the MIS patients (mean difference MIS v. open = 3.32, p = 0.001). A statistically significant decrease in complication rates was also identified in the MIS cohort. Limited economic evaluations consistently showed decreased direct hospital costs associated with MIS lumbar fusion (range 10.6%–23.9%). **Conclusion:** Pooled analysis of the current literature comparing MIS to open TLIF for degenerative lumbar pathology suggests improved clinical and perioperative outcomes associated with decreased direct health care costs. Thus, there appears to be value associated with the performance of MIS lumbar fusion in this patient population.

2.1.18

Change in pain rating between postoperative and nonoperative patients seeking rehabilitation.

G. McIntosh, H. Hall, T. Carter. **From CBIHealth Group, Toronto, Ont.**

Background: This study compares change in pain rating in 2 distinct groups of low back pain patients: those with a history of spine surgery (n = 169) and those treated solely nonoperatively with active exercise (n = 1943). **Methods:** This was a retrospective study of low back pain (LBP) cases (n = 2112) assessed at 40 spine care clinics across 4 provinces between January 2008 and June 2010. The lag time from surgery to the start of rehabilitation was less than 2 years. All patients had mechanical LBP as determined by the Saskatchewan Spine Pathway triage methodology. **Results:** The mean age of the cohort was 39.9 years (SD 11.9, range 18–65) with 62.3% males. There were no baseline statistically significant differences between groups for numerical pain rating, dominant pain location, medication use or constancy. The postsurgical group had significantly longer symptom duration, poorer function, fewer at work, more smokers and fewer females. After adjusting for

differences between groups, those with a history of spine surgery averaged less pain reduction than the nonoperative group (p = 0.002). The surgery group also had significantly more time in treatment, and lower return to work rates ($p < 0.05$). **Conclusion:** Despite baseline similarities in pain rating, the rehabilitation of those that require treatment after surgery takes longer; these patients do not generally achieve the same reductions in pain as nonoperative patients. Those with a history of spine surgery represent a challenging group to treat because they struggle to achieve similar outcomes as nonoperative patients.

2.2.19

Can a clinical classification of symptoms and signs predict candidacy for lumbar spine surgery? ***D. Fourney, C. Wilgenbusch.*** **From the University of Saskatchewan, Saskatoon, Sask.**

Background: The Saskatchewan Spine Pathway classification (SSPc), derived from the work of Hall and colleagues, utilizes symptoms and signs to determine a mechanical pattern of lower back and leg pain. Although it has been shown to be reliable and to improve outcomes for nonoperative care, its efficacy in determining the indication for surgery has not been established. The objective of this study was to determine how well SSPc predicts an indication for surgery and to compare it to back dominance and leg dominance by visual analogue scale (VAS) score. **Methods:** A retrospective chart review of 124 consecutive elective referrals for low back and leg pain from a single surgeon's practice was conducted over 1 year (June 1, 2011–May 30, 2012). **Results:** There was no difference between mean VAS back for back dominant and leg dominant SSPc patterns (6.1 of 10 v. 5.6 of 10, respectively, p = 0.27, t test), and VAS leg did not achieve minimum clinically important differences (5.1 of 10 v. 6.4 of 10, respectively, p = 0.0147). The VAS back and leg scores were highly correlated ($p <$ 0.0001, Pearson correlation coefficient). Back dominant pain patterns (SSPc 1 and 2) were found in 50 patients (40.3%), and only 2 (4.2%) were offered surgery. Leg dominant pain patterns (SSPc 3 and 4) were found in 74 patients (60.7%), including 46 with SSPc 3 (sciatica) and 28 with SSPc 4 (neurogenic claudication). Twenty-three SSPc 3 patients (23 of 46 = 50%) and 17 SSPc 4 patients (17 of 28 = 60.7%) were offered surgery. There was a strong correlation between SSPc and whether or not surgery was indicated ($p <$ 0.0001, χ^2 test). **Conclusion:** Leg dominant SSPc pain patterns strongly predicted an indication for surgery. The VAS back and VAS leg scores were highly correlated with each other, but did not correlate well with SSPc pain pattern. This preliminary study suggests that the SSPc is superior to VAS back or leg for triaging referrals to surgery. However, these finding need to be confirmed in other practice settings to determine generalizability.

2.2.20

Impact of age on clinical and patient-reported outcomes in minimally invasive surgery for spinal stenosis. ***I. Aleem,*† O. Persaud,† R. Rampersaud.*†*** **From the *University of Toronto, Toronto, Ont., and †Toronto Western Hospital, Toronto, Ont.**

Background: Clinically significant lumbar spinal stenosis (LSS) is a major cause of morbidity among the elderly. When indicated, surgical treatment significantly improves health-related quality of life. Our objective was to compare clinical and patient-reported outcomes after minimally invasive (MIS) decompression (D) and decompression and fusion for the treatment of spinal stenosis in patients above and below 70 years of age. **Methods:** A retrospective cohort study was performed. Patients were divided based on age (group 1 < 70 yr; group 2 > 70 yr) and procedure (D, MIS decompression; distractive flexion [DF], MIS decompression and fusion). We compared pre- and postoperative Oswestry Disability Index (ODI), adverse events (AE), and patient satisfaction scores with minimum follow-up time of 1 year. **Results:** Baseline characteristics between group 1 (n = 68) and group 2 (n = 41), respectively, were as follows (significance where indicated): mean age of 57.0 versus 75.0 years ($p < 0.05$), female sex represented 44% versus 43%, body mass index of 28.8 versus 27.8, mean comorbidity index of 1.9 versus 2.5 (p = 0.05), ASA of 2.1 versus 2.5 ($p < 0.05$), presence of spondylolisthesis for 51% versus 56% and day surgery for 59% versus 54%. At 1 year, all groups demonstrated significant ($p < 0.05$) improvement in ODI pre- and postsurgery (group 1D [n = 40] 42.6–21.2, group 2D [n = 28] 41.1–26.5, group 1DF [n = 28] 41.7–18.7, group 2DF [n = 13] 45.2–18.5). Comparison between groups at 1 year showed no difference in ODI (group 1D 21.2, 2D 26.5 [p = 0.3]; group 1DF 18.7, 2DF 18.5 [p = 0.9]). Group 1 was found to have 9 postoperative AEs (1 grade 1, 5 grade 2, 3 grade 3); group 2 was found to have 8 AEs (all grade 2). Overall, both groups were equally satisfied with treatment at 1 year (73.5% v. 75.6%, p = 0.9). **Conclusion:** In carefully selected patients with LSS, the outcome of MIS decompression or decompression and fusion in the elderly is comparable to that of younger patients.

2.2.21

Subjective patient outcomes and surgical morbidity in decompression with an Interspinous Process Device (IPD) versus decompression and fusion for treatment of stable degenerative spondylolisthesis. ***E.P. Abraham,*† A.J. Green,* M.D. McKeon,* J. Murray,‡ N.A. Manson.*†*** **From the *Canada East Spine Centre, Saint John, NB, †Dalhousie University, Halifax, NS, and the ‡Horizon Health Network, Moncton, NB**

Background: Indirect decompression with an Interspinous Process Device (IPD) has recently emerged as an alternative to decompression and fusion for patients with stable degenerative spondylolisthesis (DS). However, there is little research comparing the applied outcomes of these methods. This study assessed surgical morbidity and subjective patient outcomes between decompression with an IPD (DIPD) and decompression and fusion (DF). **Methods:** The DS patients (n = 57; male:female 29:28) were recruited using data from a prospective surgical outcomes database. Baseline variables were examined using independent samples t tests and χ^2 tests. Operating room (OR) time and blood loss were log-transformed and compared using t tests. Patient satisfaction was tested with a χ^2 test. Time-varying outcomes (i.e., changes in pain, physical and mental functioning) were examined with a multilevel model of change. **Results:** No differences in baseline characteristics were found between the 2 surgical groups. Average age was 65.42 years and average body mass index was 29.91. Compared with the DF group, patients in the DIPD group had shorter OR times (DIPD 79.48 min; DF 153.50 min; t = –8.89, $p < 0.00$), lost less blood (DIPD 49.66 mL;

DF 382.14 mL; $t = -11.28$, $p < 0.00$) and had shorter hospitalization (DIPD 0.45 d; DF 5.57 d, $t = 10.09$, $p = 0.02$). There was no statistical difference in overall treatment satisfaction, with more than 90% of patients reporting high satisfaction in both groups. Overall, patients experienced significantly lower Oswestry Disability Index scores, and higher physical and mental functioning over the course of the 2-year follow-up. Although there was significant variation in the rate of improvement, there were no significant differences between groups. **Conclusion:** Lower surgical morbidity, equivalent reoperation rate, and similar patient outcomes indicate that DIPD may be a valuable alternative to DF for the treatment of stable DS. There may also be reduced costs associated with DIPD. Further studies should aim to quantify the cost benefits and evaluate long-term patient outcomes of DIPD versus DF.

2.2.22

Fusion rates and cost analysis of stand-alone anterior lumbar interbody fusion versus anterior lumbar interbody fusion with supplemental anterior or posterior instrumentation. ***A. Zahrai,*[*] *J. Chiles,*[†] *N. Thakur,*[‡] *D. Refai,*[†] *J. Heller,*[†] *S. Boden.*[†] **From the *University of New Mexico, Albuquerque, NM, †Emory University, Atlanta, Ga., and ‡Upstate Medical University, Syracuse, NY**

Background: Radiographic fusion guidelines and cost analyses are currently lacking for anterior lumbar interbody fusion (ALIF) procedures. This study was designed to assess fusion rates and costs in patients receiving ALIF procedures with 3 different configurations. **Methods:** A retrospective review of 62 patients was conducted, including collection of demographic information, treatment information, and follow-up CT images at different intervals. Patients either received a stand-alone ALIF ($n = 37$), an ALIF with anterior plating ($n = 12$), or an ALIF with posterior pedicle screw instrumentation ($n = 13$). Seventy-seven levels were treated: L4–L5 ($n = 25$) and L5–S1 ($n = 52$). Assessment of the CT images ($n = 118$) for fusion status was conducted by 3 independent readers using previously agreed-upon grading criteria. Cost data were available for 59 patients. These included total cost, operative cost (surgery, anesthesia and recovery room), supply (implants and surgical supply) and all other costs. Statistical comparisons were made using the Kruskal–Wallis test and logistic regression. Inter-rater reliability was judged using Fleiss κ. **Results:** There was no significant difference between groups with respect to age or sex. Fusion rates after 6 months were not significantly different between stand-alone (90.6%), added anterior (100%) and posterior (87.0%) instrumentation groups. Logistic regression showed increase in fusion status with postoperative time ($p = 0.0013$), while level fused and treatment type had no significant effect. Inter-rater reliability was low with a κ of 0.2631. Cost data on single level fusions revealed significant differences in total, supply, and operation cost between treatment groups ($p < 0.001$). Median supply costs increased for anterior and posterior fixation when compared with stand-alone ALIF (+29% and 62%, respectively), as did operation costs (10% and 88%), resulting in total cost increases (+19% and 56%). **Conclusion:** Fusion status was not significantly different between treatment options, while cost increased substantially with supplemental anterior or posterior instrumentation. When clinically indicated, standalone ALIFs may be preferable to additional anterior or posterior instrumentation.

2.3.23

A comparison of subjective versus objective outcome measures in postoperative spine patients. ***M. McKeon,*[*] *N. Manson,*[*†] *E. Abraham,*[*†] *W. Albert.*[‡] **From the *Canada East Spine Centre, Saint John, NB, †Dalhousie University, Halifax, NS, and the ‡University of New Brunswick, Fredericton, NB**

Background: Degenerative pathologies of the lumbar spine may cause compression of adjacent neurologic structures, leading to lower extremity pain and dysfunction and restrictions to quality of life. Postoperatively, the literature suggests discordance between surgeon and patient perceptions of outcome and true objective physical performance. Therefore the purpose of this study is to compare the results of standard validated subjective patient questionnaires (Oswestry Disability Index [ODI], visual analogue scale [VAS] for back and leg) to validated objective functional measurements (Short Physical Performance Battery [SPPB]) in patients following lumbar spine surgery. **Methods:** All subjective and objective measures were collected on 114 patients during routine postoperative assessments. Subjective questionnaires recorded patient perception of pain, function, and recovery. Objective physical testing quantified performance during activities of daily living: balance, walking, sitting and standing. Pearson correlation assessed the subjective versus objective outcomes at various postoperative intervals (days 0–90, 91–200, 201–365, 366–730, and 730+). **Results:** Significant correlation ($p < 0.05$) between patient perception (ODI and/or VAS) and physical function (SPPB) was observed for the intervals during 0 to 90 days (SPPB 11.8 ± 1.9; ODI 34.2 ± 19.9; VAS-back 3.9 ± 2.5, VAS-leg 3.5 ± 2.7), 365 to 730 days (SPPB 11.5 ± 1.6, ODI 24.4 ± 16.6, VAS-leg 2.1 ± 2.3) and more than 730 days (SPPB 11.7 ± 1.4; VAS-back 4.3 ± 3.1, VAS-leg 4.6 ± 3.3). The 91 to 365 days postop intervals did not provide any significant correlation between scores. Walk time was found to be significantly different between males (2.0 ± 0.3) and females (2.8 ± 1.3) at the zero to 90-day interval. No other sex differences were found. **Conclusion:** Patient perception of pain and function appears to reflect objective physical function during periods of postoperative recovery. These questionnaires appear to provide reliable insight into postoperative mobility and function, yet at specific points in the assessment process. Further investigations are required to understand the time specific nature of the findings in an effort to optimize patient postoperative satisfaction.

2.3.24

Mesenchymal precursor cell mediated disc regeneration at the time of microdiscectomy. ***T. Goldschlager,*[*†] *D. Oehme,*[*] *P. Ghosh,*[*‡] *S. Shimon,*[‡] *I. Ghosh,*[‡] *J. Wu,*[‡] *J.V. Rosenfeld,*[¶] *A. Danks,*[§] *J. Troupis,*[§] *C. McDonald,*[*] *G. Jenkin.*[*] **From *The Ritchie Centre, Monash Institute of Medical Research, Monash University, Melbourne, Australia, †Spine Program, University of British Columbia, Vancouver, BC, ‡Proteobioactives, Sydney, NSW, Australia, §Monash Medical Centre, Melbourne, Australia, and ¶The Alfred Hospital, Melbourne, Australia**

Background: Lumbar microdiscectomy typically alleviates symptoms relating to neural compression, however it fails to address the underlying problem of disc degeneration. Following

microdiscectomy, discs fail to undergo spontaneous regeneration and patients may experience chronic lower back pain, persistent sciatica and radiculopathy, and recurrent disc prolapse (1–3). We hypothesized that the transplantation of mesenchymal progenitor cells (MPCs) formulated with pentosan polysulfate (PPS), embedded within a collagen scaffold, at the time of microdiscectomy, would induce disc regeneration. Here, we report the results of studies undertaken to test this hypothesis using an ovine microdiscectomy model. **Methods:** Six adult sheep underwent a standardized lumbar microdiscectomy procedure at 3 lumbar levels (L2/L3, L3/L4, L4/L5) via a lateral retroperitoneal approach. LI/L2 and L5/L6 discs served as untreated controls. Disc defects caused by microdiscectomy received either no treatment (NIL), a gelatin/fibrin glue scaffold (SCAF) only, or MPCs and PPS in SCAF (MPC+PPS+SCAF). Necropsies were undertaken 6 months postoperation and imaging (radiography and MRI), histological and biochemical assessment was performed. **Results:** The reduction in disc height of the NIL and SCAF groups was significantly greater than the MPCs+PPS+SCAF group ($p < 0.05$), The difference in MRI (modified Pfirrmann degeneration scores) observed between SCAF and MPC, PPS and SCAF groups was significant ($p = 0.0213$). Biochemical analysis demonstrated a significant increase in the content and, extractability of PGs from the nucleus pulposus (NP) of discs treated with MPC, PPS and SCAF versus discs receiving SCAF alone ($p < 0.03$). The percentage of newly synthesized proteoglycan aggregates in the NP of MPC, PPS and SCAF discs was also significantly higher than in the NP of nonoperated control discs as well as in the NP of the discs of 2 out of 3 animals that received NIL or SCAF alone. **Conclusion:** These preliminary results demonstrate the potential capacity of MPCs and PPS, when administered in adhesive biological scaffold, to restore NP proteoglycan content, and preserve disc height and morphology following microdiscectomy. Although promising, further more rigorous preclinical studies are required before the translation of this technique into clinical practice.

2.3.25

A national survey of spine surgeons in Canada. ***S. Christie,*†** ***G. Thibault-Halman,*** ***H. Hall,†*** ***B. Oxner.*†*** **From *Dalhousie University, Halifax, NS, and the †Canadian Spine Society, Markdale, Ont.**

Background: There has been a trend over the past few years for government to have a greater influence on physician manpower resources. Governments in several provinces, including British Columbia, Alberta, Ontario and Nova Scotia, continue to develop physician resource plans which may have a large impact on how surgery is practised. There are no current accurate data on the number of surgeons in Canada performing spinal operations, and the percentage of their practices dedicated to spine. We have conducted a national survey of spine surgery in Canada, to provide validated information to advocate for resources. **Methods:** A questionnaire was distributed to the membership of the Canadian Orthopedic Association, Canadian Neurosurgical Society and the Canadian Spine Society. The percentage of surgeons' practice dedicated to clinical spine care was determined. The fraction of respondents who have completed a spine fellowship was established, and rates of fellowship subspecialty among neurosurgeons and orthopedic surgeons were compared. The number of years in practice was used to generate estimates of years to retirement, and was combined with Statistics Canada demographic predictions to forecast future need for spine surgeons. **Results:** Among respondents, 60% had completed a spine fellowship. Ninety-five percent of orthopedic surgeons who responded had completed a spine fellowship, while 41% of neurosurgeons had done so. Ninety-one percent of respondents who had completed a spine fellowship dedicated more than half of their clinical practices to spine, compared with 32% of those who did not complete a fellowship. Forty percent of respondents have been in practice for at least 20 years. **Conclusion:** A significant proportion of spine surgeons will reach a typical time of retirement in the next decade, while shifting demographics may be expected to increase the demand for surgery. This may result in further waitlist pressure for spine surgery in Canada and could require an increase in human resource support.

2.4.26

Spine surgery referrals redirected through a clinical pathway: effects of nonsurgeon triage including imaging utilization. ***D. Fourney, D. Kindrachuk.*** **From the University of Saskatchewan, Saskatoon, Sask.**

Background: The Saskatchewan Spine Pathway (SSP) includes triage clinics staffed by specialized physiotherapists. During the early implementation of the SSP, these clinics screened a backlog of elective referrals to a spine surgeon. There are very limited data regarding the efficacy of nonsurgeon triage of lumbar spine surgery referrals. The objectives of this study were: 1) determine the percentage of elective referrals to a spine surgeon for low back pain (LBP) which, when redirected through the SSP, ultimately required surgical evaluation, 2) estimate effects of nonsurgeon triage on MRI utilization, 3) determine if nonsurgeon triage missed clinical "red flags" later detected by the surgeon and 4) compare the SSP clinical diagnoses and level of disability in patients determined to require surgical assessment from those not requiring surgical assessment. **Methods:** A retrospective analysis of 87 consecutive patients with lower back and leg pain initially referred to a spine surgeon but triaged by the SSP clinic between May 1, 2011, and Nov. 30, 2011. Diagnosis was by the classification of Hall and colleagues. Pain and disability were scored by visual analogue pain scale (VAS), modified Oswestry Disability Index (ODI) and EuroQol EQ5D. **Results:** Sixty-two (71.26%) patients (group A) were discharged after patient education, self-care advice and/or referral for additional mechanical therapies. Twenty-five (28.74%) patients (group B) were referred for surgical assessment. The surgical yield in group B was 44%, compared with 15% for all new spine referrals before implementation of the SSP — an almost 3-fold increase. For the combined cohorts, we estimate that the triage clinic prevented 50 of 87 (57.5%) MRI studies. Nonsurgeon triage captured all red flags detected by the surgeon. Patients in group B were much more likely to have a leg dominant pain pattern ($p = 0.0088$) and had significantly greater ODI ($p = 0.0121$) and EQ5D mobility ($p = 0.0484$) scores. **Conclusion:** This preliminary study suggests that the SSP may reduce unnecessary imaging and surgical referrals.

2.4.27

Evaluation of an advanced practice physiotherapist (APP) in triaging patients with lumbar spine pain: surgeon–APP

level of agreement and patient satisfaction. ***S. Robarts, D. Kennedy,*† B. Malcolm,* J. Finkelstein.*** **From the *University of Toronto, Toronto, Ont., and †McMaster University, Hamilton, Ont.**

Background: Wait times to specialist consultation for lumbar spine pain are excessive. Use of advanced practice physiotherapists (APP) as alternate providers is at the forefront of health human resource strategies that make efficient use of specialists' time while maintaining quality care. The purpose of this study was to assess surgeon–APP level of agreement in the Spine Specialty Clinic as to patient's need for consultation with a surgeon and patient satisfaction with the APP role. **Methods:** This study used a cross-sectional prospective design of consecutive patients referred for lumbar spine pain to surgeons at a tertiary care outpatient spine clinic. An experienced APP trained with the surgeons before study commencement. Consenting patients completed the Oswestry Disability Index (ODI) and were assessed by the APP and a surgeon, blinded to the outcome of the APP assessment. κ Statistics were used to assess surgeon–APP level of agreement as to need for consultation for the presenting complaint. To assess patient satisfaction, patients completed a modified version of the visit-specific questionnaire. **Results:** The sample included 70 participants (36 females), mean age of 54.2 (SD 13.7). Mean ODI score was 36.9 (17). The κ was 0.76 (95% CI 0.60–0.93) on agreement as to need for consultation with a surgeon. Sixty-three percent of patients were identified as not requiring a consultation. Satisfaction scores on service provider items were high for the APP; mean score was 91.8 of 100. **Conclusion:** In patients with lumbar spine pain, the APP and surgeon have a high level of agreement as to patients' need for consultation with a surgeon. Patients are highly satisfied with the care provided by the APP. The APP role is a viable strategy to support the nonsurgical care traditionally performed by surgeons and has the potential to expedite conservative care and reduce wait times to consultation, reserving timely consultations for those that need them.

2.4.28

The 2-year experience of a nonphysician back triage program. ***L. McLaughlin, B. Dunlop.*** **From McMaster University, Hamilton, Ont.**

Background: With the scarcity of surgeon resources leading to extraordinary wait times, it was felt that a surgical screening program similar to that for hips and knees might be useful. Previous studies have shown that an advanced practice orthopaedic physiotherapist acting as a nonphysician expert can identify those patients for whom MRI would be helpful and further can identify those patients that would benefit from surgery. Additionally it was apparent that the orthopaedic physiotherapist would have the knowledge and experience in the conservative treatments for back-related conditions to guide those patient not requiring surgery to appropriate care. Using the advanced practice physiotherapist, the assessment would not be simply surgical screening, but triage guiding patients to either surgery, conservative care or further investigation as required. An advanced practice physiotherapist back assessment program was started in January 2010. How is this program doing and what have we learned? **Methods:** The 2-year experience of the triage of over 1500 patients are reviewed. **Results:** First, 20% of patients assessed were surgical candidates, 2) another 10% had medical or surgical issues requiring physician input, 3) demand for this service was such that patients travelled from 7 of the 14 local health integration networks in Ontario to be assessed, 4) referring physician "buy-in" to the program was better than expected. **Conclusion:** 1) Patients (and referring physicians) are seeking triage rather than simply surgical screening. The assessor must have a broad knowledge of conservative care options for the 80% of patients that are nonsurgical, 2) as with the hip and knee programs, ensuring physician confidence is critical. A certification process may be required, 3) responsive medical backup is important, 4) the knowledge, experience and humility of the assessor is critical for problems beyond the straightforward.

SATURDAY, MARCH 2, 2013

3.1.29

Nanoparticle labelling of anatomic structures in the spinal cord with magnetic resonance and histology. ***H. Westwick, M. Coyle, U. Shanmugalingam, E.C. Tsai.*** **From the University of Ottawa, Ottawa, Ont., and the Ottawa Hospital Research Institute, Ottawa, Ont.**

Background: Serial imaging of specific locations in the spinal cord is important in basic science research studies in regeneration, electrophysiology, spinal cord injury and neuroanatomy. Functionalization of superparamagnetic iron oxide (SPIO) nanoparticle contrast agents for MRI with a fluorescent dye can permit concurrent MRI and histology in the same research animal. **Methods:** The SPIO nanoparticles were encapsulated with a silica shell, incorporating a fluorescent dye, and different bioactive surfaces. In vitro studies were done to assess neuroprogenitor cell uptake of the nanoparticles and cellular toxicity, and in vivo studies were done in Sprague-Dawley rat spinal cords over a period of weeks. Rats with the nanoparticle tracer implanted into the spinal cord were serially imaged weekly with a Siemens 1.5 or 3 T clinical MRI scanner. **Results:** Nanoparticle concentrations of 10 mM were not toxic to adult rat neural progenitor cells and labelled 90% of cells. The nanoparticle labels were assessed for a period of 3 weeks in vivo in the rat spinal cords, and the contrast was stable over that time period compared with control. Histology of the spinal cords demonstrated that the nanoparticles could be visualized at 3 weeks. **Conclusion:** Preliminary results indicate that functionalized nanoparticle tracers can be used for serial imaging of a selected region of the spinal cord, and are nontoxic in a cell model. These tracers can be used to noninvasive label the spinal cord and can be used to assess spinal cord development, pathology and regeneration.

3.1.30

Riluzole mediated plasticity results in locomotor recovery after high cervical hemilesion. ***F. Nassiri,*† K. Satkunendrarajah,* S. Karadimas,* M. Fehlings.*** **From the *Toronto Western Research Institute, Toronto, Ont., and the †University of Toronto, Toronto, Ont.**

Background: Although riluzole is a neuroprotective therapeutic agent currently in clinical trials for use after spinal cord injury (SCI), the exact mechanism by which riluzole works has not yet

been elucidated. Riluzole may work through a neuroplastic mechanism in addition to glutamatergic blockade. We hypothesize that riluzole will enhance the intrinsic plasticity within the central nervous system (CNS) to promote robust locomotor recovery after cervical SCI. **Methods:** Female wistar rats underwent C2 hemisection injury or sham injury. Hemisectioned rats were blindly and randomly allocated into 2 groups: 1) vehicle treatment or 2) riluzole treatment for 7 days postsurgery. Animals underwent forelimb function testing for 6 weeks postsurgery (grip strength test, catwalk gait analysis, paw placement, ladderwalk rung test). At week 5 postinjury, animals received intracortical injections of anterograde tracers to delineate the corticospinal tracts. At 7 weeks postinjury, animals underwent electrophysiological recording of H-Reflex and then the tissue was processed for histological and immunohistological analysis. Data were analyzed based on analysis of variance along with Bonferonni post hoc analysis. **Results:** Riluzole treatment induced early ipsilateral forelimb grip strength recovery at 5 days and late contralateral forelimb recovery postsurgery at 23 days that was maintained for 6 weeks when compared with controls ($p < 0.05$). Riluzole improved ipsilateral forelimb swing speed, stride length, print width, and print length at 2 and 4 weeks after hemilesion when compared with controls ($p < 0.05$). Cortical spinal tract tracing and electrophysiological analysis showed that riluzole administration resulted in increased anterior horn cell excitability via interneuronal rewiring. **Conclusion:** Riluzole treatment results in CNS rewiring leading to robust locomotor recovery following cervical hemilesion.

3.1.31

Intervertebral disc-derived stem cells: implications for regenerative medicine and neural repair. ***W.M. Erwin,[*†] D. Islam,[*] E. Eftekarpour,[‡] Robert Inman,[*†] M. Fehlings.[*†]***
From the *University of Toronto, Toronto, Ont., †Toronto Western Hospital, Toronto, Ont., and the ‡University of Manitoba, Winnipeg, Man.

Background: Degenerative disc disease (DDD) is the most common form of spinal stenosis, a leading cause of spinal neurologic disability in those over 60 years of age. Cervical spondylotic myelopathy is most commonly caused by advanced DDD and may lead to tetraparesis or even death. It is known that the nucleus pulposus (NP) of human intervertebral discs (IVDs) contain multipotent progenitor cells that have been shown to have mesenchymal-like differentiation capacity in vitro. We elected to test the hypothesis that nucleus pulposus progenitor cells (NPPCs) would within the neural niche, differentiate into neural precursor cells for use in neural repair. **Methods:** We obtained NP cells from non-chondrodystrophic (mongrel) canine IVDs, following enzymatic digestion and generated populations of self-renewing cell colonies and evaluated them for the expression of stemness genes, their ability to differentiate along chondrogenic, adipogenic and neurogenic lineages in vitro. We then transfected them with green fluorescent protein (GFP) and determined their ability to differentiate into NP cells within the compact myelin deficient shiverer mouse brain. **Results:** The NPPCs express genes associated with "stemness," including *Sox2*, *Oct4*, *Nanog*, *CD133*, *Nestin* and *NCAM*. The NPPCs are capable of differentiation into chondrogenic, adipogenic and neural lineages in vitro. Following injection into the shiverer mouse brain NPPCs differentiate into the major classes of neural precursor cells, such as neuron and astro-glial cells. Most significantly we detected GFP-expressing cells that demonstrated immunoreactivity to *CNPase* a marker of oligodendrocyte precursor cells, as well as GFP-positive cells immunopositive for myelin basic protein. **Conclusion:** Progenitor cells obtained from the intervertebral disc have the capacity to be used not only for cartilage and IVD repair, but also for neural repair strategies and most importantly and of profound potential significance, offer the possibility of use in the case of the injured spinal cord.

3.1.32

What will traumatic spinal cord injury care look like in 20 years in Canada? Resource planning by forecasting. ***R. Lewis,[*] V. Noonan,[†] G. Zhong,[†] A. Santos,[†] A. Townson,[‡] B. Drew,[§] D. Tsui,[¶] J. Paquet,[**] C. Truchon,[††] J. Hurlbert,[‡‡] M. Fehlings,[§§] J. Finkelstein,[§§] A. Yee,[§§] C. Bailey,[¶¶] D. Wolfe,[***] S. Christie,[†††] C. Short,[‡‡‡] H. Ahn,[§§] A. Burns,[§§§] M. Dvorak.[†¶¶¶]***
From the *Centre for Operations Excellence, Sauder School of Business, University of British Columbia, Vancouver, BC, †Rick Hansen Institute, Vancouver, BC, ‡Division of Physical Medicine and Rehabilitation, University of British Columbia, Vancouver, BC, §Division of Orthopaedics, McMaster University, Hamilton, Ont. ¶Hamilton Health Sciences, Hamilton, Ont. **Hôpital de l'Enfant-Jésus du CHU de Québec, Québec, Que. ††Institut national d'excellence en santé et en services sociaux (INESSS), Québec and Institut de réadaptation en déficience physique de Québec (IRDPQ), Québec, Que., ‡‡Spine Program and Division of Neurosurgery, University of Calgary, Calgary, Alta., §§Department of Surgery and Spinal Program, University of Toronto, Toronto, Ont., ¶¶Division of Orthopaedics, University of Western Ontario, London, Ont., ***Parkwood Hospital, Lawson Health Research Institute, Western University, London, Ont., †††Division of Neurosurgery, Dalhousie University, Halifax, NS, ‡‡‡Division of Physical Medicine and Rehabilitation, Dalhousie University, Halifax, NS, §§§Division of Psychiatry, University of Toronto, Toronto, Ont., and the ¶¶¶Division of Spine, Department of Orthopaedics, University of British Columbia, Vancouver, BC

Background: Survivors of traumatic spinal cord injury (tSCI) have intense health care needs during their initial acute and rehabilitation admissions and often through the rest of life. To prepare for a growing and aging population, simulation modelling was used to estimate the change in health care resources and long-term outcomes between 2012 and 2032. **Methods:** Acute and rehabilitation care for tSCI was mapped in 13 acute and rehabilitation centres in 5 provinces. A simulation model was developed using data from a Canadian registry, literature and expert opinion. Data from the National Trauma Registry and Statistics Canada were used to predict future incidence by province. Assuming that the acute and rehabilitation centres maintain their current proportions of provincial admissions, future admissions were forecasted as well as corresponding resource use (average acute and rehabilitation beds used, inpatient care costs) and long-term outcomes (average life expectancy, quality-adjusted life years [QALYs], rest of life costs). **Results:** In the year 2032, the number of acute admissions will increase by an average of 37% and rehabilitation admissions will increase by 31% in Canadian SCI

centres compared with 2012. The increase in admissions will require a corresponding average increase in acute care beds by 3.2 and rehabilitation beds by 2.3. Due to an aging population, the average life expectancy will decrease by 0.5 years, QALYs will decrease by 1.2 and rest of life costs will decrease by 5.8%. Inpatient care costs, however, will rise by 36% due to increases in the incidence of tSCI. **Conclusion:** The management of tSCI is changing with an aging population. Increasingly, there will be more demand on acute and rehabilitation resources in the next 20 years, demonstrated by the 36% increase in costs for inpatient care. This information will be critical for decision-makers to consider when planning future health care for tSCI.

3.2.33

Estimating the long-term impact of receiving early surgery: Does it make a difference? M. *Fehlings,[*] B. Drew,[†] J. Paquet,[‡] J. Hurlbert,[§] J. Finkelstein,[*] M. Ford,[*] A. Yee,[*] C. Bailey,[¶] S. Christie,[**] H. Ahn,[*] V. Noonan,[††] A. Santos,[††] G. Zhong,[††] L. Soril,[††] N. Fallah,[††] M. Dvorak.[†††‡‡] From the *Department of Surgery and Spinal Program, University of Toronto, Toronto, Ont., †Division of Orthopaedics, McMaster University, Hamilton, Ont., ‡Hôpital de l'Enfant-Jésus du CHU de Québec, Que., §The University of Calgary Spine Program and Division of Neurosurgery, University of Calgary, Calgary, Alta., ¶Division of Orthopaedics, Western University, London, Ont., **Division of Neurosurgery, Dalhousie University, Halifax, NS, ††Rick Hansen Institute, Vancouver, BC, and the ‡‡Division of Spine, Department of Orthopaedics, University of British Columbia, Vancouver, BC

Background: Early decompression performed within 24 hours following traumatic spinal cord injury (tSCI) was recently demonstrated to not only be safe in a large cohort of cervical tSCI patients, but was also associated with improved neurologic recovery 6 months postinjury (Fehlings et al, 2012). While the neurologic improvements are assumed to result in long-term benefits (e.g., improvements in quality adjusted life years (QALYs) and reduced health care costs), this has not been empirically evaluated. The objective of this study was to use simulation modelling to examine the long-term outcomes of providing early surgery for patients with cervical tSCI. **Methods:** A discrete event simulation model for inpatient care and rest of life was developed using data from a Canadian registry consisting of 13 acute and rehabilitation centres across Canada, literature and expert opinion. A hypothetical scenario whereby patients with cervical tSCI underwent either early surgery (< 24 h) or late surgery (> 24 h; control group) was simulated and various long-term impacts (e.g., incidence of hospital readmissions from the community, QALYs, life expectancy) were evaluated. **Results:** As anticipated, 34% of cervical tSCI patients (n = 27 per yr) that received early surgery demonstrated at least a 1-point American Spinal Injury Association Impairment Scale grade improvement compared with the late surgery group. The downstream effect of this neurologic improvement was an average increase of 7.6 QALYs and 62.7% longer life expectancy for this patient group. These patients had a $188 159 reduction in health care costs over the rest of their lives compared with the control group, despite their increased life expectancy. **Conclusion:** Early surgery for cervical tSCI patients produced improvements in neurologic recovery at 6 months but continue to have profound impacts on the rest of a person's life. Capturing the long-term effects can provide compelling evidence to support the implementation of early surgery in selected patient populations.

3.2.34

Implementing the "ideal model of care" for patients who sustain an acute traumatic spinal cord injury: What could we expect? *V. Noonan,[*] A. Santos,[*] R. Lewis,[†] A. Townson,[‡] B. Drew,[§] D. Tsui,[¶] J. Paquet,[**] C. Truchon,[††] J. Hurlbert,[‡‡] M. Fehlings,[§§] J. Finkelstein,[§§] M. Ford,[§§] A. Yee,[§§] C. Bailey,[¶] D. Wolfe,[***] S. Christie,[†††] C. Short,[‡‡‡] H. Ahn,[§§] A. Burns,[§§§] M. Dvorak.[*¶¶¶] From the *Rick Hansen Institute, Vancouver, BC, †Centre for Operations Excellence, Sauder School of Business, University of British Columbia, Vancouver, BC, ‡Division of Physical Medicine and Rehabilitation, University of British Columbia, Vancouver, BC, §Division of Orthopaedics, McMaster University, Hamilton, Ont., ¶Hamilton Health Sciences, Hamilton, Ont., **Hôpital de l'Enfant-Jésus du CHU de Québec, Québec, Que., ††Institut national d'excellence en santé et en services sociaux (INESSS), Québec and Institut de réadaptation en déficience physique de Québec (IRDPQ), Québec, Que., ‡‡Spine Program and Division of Neurosurgery, University of Calgary, Calgary, Alta., §§Department of Surgery and Spinal Program, University of Toronto, Toronto, Ont., ¶¶Division of Orthopaedics, Western University, London, Ont., ***Parkwood Hospital, Lawson Health Research Institute, Western University, London, Ont., †††Division of Neurosurgery, Dalhousie University, Halifax, NS, ‡‡‡Division of Physical Medicine and Rehabilitation, Dalhousie University, Halifax, NS, §§§Division of Psychiatry, University of Toronto, Toronto, Ont., and the ¶¶¶Division of Spine, Department of Orthopaedics, University of British Columbia, Vancouver, BC

Background: Emerging evidence suggests that timely care in specialized centres produces superior patient outcomes and is more cost effective for traumatic spinal cord injury (tSCI). The effect of implementing multiple best practices, such as direct admission to specialized acute centres, however, has not been estimated. The objective of this study was to conduct a sensitivity analysis to assess the impact of implementing 4 best practices in Canadian centres (comparing implementing none versus all 4 best practices) using simulation modelling. **Methods:** Patient flow in 13 acute and rehabilitation SCI centres, representing 5 provinces, was combined with data from a Canadian registry, literature and expert opinion to develop a discrete event simulation model for inpatient care and rest of life. A hypothetical policy, whereby patients received none of the best practices (direct admission, surgery < 24 h for cervical injuries, reduction in complications, eliminating discharge delays from acute centres) or all the best practices, was assessed. **Results:** Implementing the 4 best practices would decrease the average acute length of stay by 10.2 days and rehabilitation by 11.5 days for all patients with tSCI. Life expectancy would increase by 2.9 years and the quality-adjusted life years would increase by 1.8 for patients admitted with an American Spinal Injury Association Impairment Scale (AIS) A injury who are discharged with an incomplete injury (AIS

B, C, D) by receiving early surgery for cervical injuries. Cost savings for the 8% of patients with cervical AIS A injuries (6 patients per centre per year) who obtain neurologic improvement are $30 267 during acute and rehabilitation admissions, and $614 646 over the rest of life. **Conclusion:** Results from this simulation demonstrate significant cost savings and improvements in patient outcomes that could be achieved by implementing best practices. Additional analyses are ongoing to further refine the "ideal model of care" for tSCI in Canada.

3.2.35

Economic impact of traumatic spinal cord injury in Canada: total economic burden and potential cost avoidance by preventing secondary complications. ***C.S. Rivers,* V. Noonan,*† L. Trenaman,‡ P. Joshi,* H. Krueger.*** **From the *Rick Hansen Institute, Vancouver, BC, †University of British Columbia, Vancouver, BC, and ‡H. Krueger & Associates Inc., Vancouver, BC**

Background: An estimated 1400 Canadians survive a traumatic spinal cord injury (tSCI) per year and suffer a high rate of preventable secondary complications. We aim to determine the economic burden of tSCI in Canada, and evaluate potential costs avoided by reducing the incidence of secondary complications, particularly pressure ulcers (PUs) and urinary tract infections (UTIs). **Methods:** This study uses information from academic and grey literature on the incidence, prevalence, resource use, survival and quality of life of individuals with tSCI to estimate the lifetime economic burden of a tSCI and potential costs avoided if the incidence of secondary complications (e.g., PUs/UTIs) can be reduced. Direct and indirect costs are calculated in estimating the lifetime economic burden of a tSCI while the focus is on direct costs avoided by reducing the incidence of secondary complications. **Results:** Total lifetime economic burden of a tSCI occurring at age 35 is $1.47 to $3.03 million; 50% are direct costs. The total annual economic burden of tSCI in Canada is estimated at $2.67 billion. If grade II–IV PUs and hospitalizations for UTI were completely eliminated in the Canadian tSCI population, $197 million and $61 million in direct care costs, respectively, could be avoided annually. Reductions of 80% in PU incidence and hospitalizations for UTI could result in cost avoidance of $147 million and $49 million annually. Other significant secondary complications that should be addressed include neuropathic pain, autonomic dysreflexia, depression and respiratory issues. Results from a current survey of Canadians with SCI assessing the personal impact of secondary complications will be included in the presentation. **Conclusion:** The economic burden associated with tSCI is substantial. Advances in the prevention of secondary complications can reduce the burden on tSCI patients while reducing health care costs. These advances will likely be relevant to other patient groups, leading to even further patient and economic benefit.

3.3.36

Review of spine injuries over time to guide primary injury prevention: falls and leisure related injuries are increasingly responsible. ***D.C. Ghinda, E. Tsai, J. Dunne, C. Jones.*** **From the University of Ottawa, Ottawa, Ont.**

Background: Spinal injuries occur far too frequently and are often associated with significant disability and mortality. To improve the injury prevention programs in our region, we reviewed the injury trends over the past 5 years. **Methods:** From the prospectively obtained data in our trauma database, we selected patients with spine fracture and/or spinal cord injuries that occurred between January 2007 and January 2012. The cases were reviewed for age, sex, cause of injury and extent of injury. **Results:** A total of 861 patients were admitted for traumatic spinal fractures. Over time, there was no major change in the sex ratio of the patients, yet the average age was steadily increasing (male:female 7:3; mean age 50). There was also no change in the proportion of associated brain injuries (more than half of patients had associated brain injuries) and level of injury (most fractures occurred at the cervical level and caused incomplete spinal cord injury). While the absolute number of injuries remained stable over time, road traffic accidents (RTA) decreased from 51% to 33% from 2007 to 2011. However, the proportion of falls increased from 31% to 39% over the same period. The proportion of sports and leisure related trauma also increased over time from 10% to 15%. **Conclusion:** The preliminary data show a decrease in spine injures due to RTA; however, there was an increase in the proportion of injuries due to falls. Prevention strategies should thus be implemented in order to target these risk groups to prevent significant spinal cord injuries due to falls and to leisure related activities.

3.3.37

The clinical translation of riluzole for the treatment of traumatic spinal cord injury: results of phase I trial. ***M. Fehlings,* R. Grossman,† J. Wilson,* R. Frankowski,‡‡ K. Burau,‡‡ D. Chow,‡ Y. Teng,‡ E. Toups,† J. Harrop,** B. Aarabi,§ C. Shaffrey,¶ S. Harkema,†† M. Johnson,‡‡ J. Guest§§*** **From the *University of Toronto, Toronto, Ont., †The Methodist Hospital, Houston, Tex., ‡University of Houston, Houston, Tex., §University of Maryland, Baltimore, Md., ¶University of Virginia, Charlottesville, Va., **Thomas Jefferson University, Philadelphia, Pa., ††University of Louisville, Louisville, Ky., ‡‡University of Texas, Houston, Tex., and the §§University of Miami, Miami, Fla.**

Background: Riluzole, a benzothiazole anticonvulsant used in the treatment of amyotrophic lateral sclerosis (ALS), has shown preclinical efficacy in the treatment of spinal cord injury (SCI). A multicentre phase I trial was undertaken to assess the safety and feasibility of riluzole administration in SCI. **Methods:** This study took place at 6 hospitals within the North American Clinical Trials Network (NACTN) for treatment of SCI. Thirty-six adult patients with traumatic SCI and an American Spinal Injury Association (ASIA) Impairment Scale (AIS) grade of A, B or C received riluzole 50 mg every 12 hours for 2 weeks, with treatment initiated within 12 hours of injury. Adverse events were recorded during and after the period of riluzole administration. Neurological status was assessed at 3 and 6 months. **Results:** A total of 35 patients completed treatment: 27 cervical, 8 thoracic; 19 AIS A, 9 B and 7 C. Major categories of medical complications were infection, including pneumonia, in 39% of patients; pulmonary in 33%; hematological in 22%; cardiac in 14%; and psychiatric in 14%. The profile of complications was similar to that in a matched cohort of SCI patients in the NACTN SCI registry. There were no serious adverse events related to riluzole

administration. At 3 month follow-up, in the 27 cervical patients, the mean ASIA motor score improvement was 31 points. A matched cohort from the NACTN SCI registry exhibited an improvement of 15 points. AIS grade improved in 19 (70%) of the riluzole cohort; 11 improved 1 grade and 8 improved 2 or more grades. In the matched registry cohort, 9 (33%) patients improved; 6 improved 1 grade and 3 improved 2 or more grades. **Conclusion:** The safety and feasibility of riluzole administration in the treatment of human SCI has been established. Plans for a phase II/III trial to investigate riluzole's efficacy in SCI will be outlined.

3.3.38

Influence of neurologic status on surgical site infection in posterior cervical spinal surgery. ***R. Ghag,[*] M. Maltenfort,[‡] M. Nadeau,[†] C. Fisher,[†] T. Albert,[‡] A. Vaccaro[‡]*** **From *UBC Department of Orthopaedics, Vancouver, BC, †Combined Neurosurgical Orthopaedic Spine Program, Vancouver General Hospital, Vancouver, BC, and the ‡Rothman Institute, Thomas Jefferson University Hospital, Philadelphia, Pa.**

Background: The incidence of surgical site infection (SSI) after posterior cervical spinal surgery has been reported to range from 1.3% for elective fusion to 17% for traumatic injury stabilization. While general risk factors for SSI have been elucidated, the relationship of neurologic status to SSI has not been explicitly explored. The premise this study was to report the incidence of SSI in patients who have undergone posterior cervical spinal surgery for 1) cervical radiculopathy, 2) cervical myeloradiculopathy, 3) traumatic cervical injury without neurologic deficit, 4) traumatic cervical injury with neurologic deficit. The hypothesis is that the rate of SSI and thus resource utilization will increase significantly from group 1 to group 4. **Methods:** The Nationwide Inpatient Sample (NIS) database was used to access patient data from the years 2000 to 2009. Patients were selected for inclusion based on appropriate ICD-9-CM codes to stratify by 1 of the 4 preoperative diagnoses listed above. Procedural codes were selected such that only posterior approach procedures were entailed. Outcome variables included SSI, length of stay (LOS) and cost (in 2010 U.S. dollars). Statistical analyses included bivariate comparisons and χ^2 analysis of demographic data, and multivariable regression modelling for the outcome variables. **Results:** The NIS database identified 1 762 277 patients that met inclusion criteria. Patients with myelopathy and those with neurologic deficit were significantly older and more frequently of male sex. Incidence of SSI increased from 0.58% in group 1 to 2.44% in group 4. The LOS and resource utilization increased in a similar fashion. These differences reached statistical significance. SSI was predicted significantly by myelopathy (OR 1.82, $p < 0.01$) and associated neurologic deficit trended toward significance (OR 1.32, $p = 0.07$). Older age was a significant predictor in the setting of radiculopathy (OR 1.03, $p < 0.01$) and trauma (OR 1.01, $p = 0.02$). Female sex was significantly less predictive of SSI in the setting of radiculopathy (OR 0.61, $p < 0.01$) and fusion of 2–3 spinal segments was significantly less predictive of SSI in the setting of trauma (OR 0.49, $p < 0.01$). **Conclusion:** Cervical myelopathy and neurologic deficit in traumatic cervical injury were demonstrated to be significant risk factors for SSI after posterior cervical surgery. LOS and resource utilization increase in the setting of SSI. Although this study methodology is likely limited by underreporting of complications, the difference between the reported incidences of SSI by preoperative diagnosis is emphasized here. These findings underscore the importance of SSI preventive measures and highlight the vulnerability of patients who present for spinal surgery with associated neurologic dysfunction.

3.3.39

Incidence and prevention of delayed infection after spine surgery. ***P. Lewkonia,[*] S. Paquette,[†] C. DiPaola,[‡] J. Street.[†*]*** **From the *Division of Orthopaedics, Department of Surgery, University of Calgary, Calgary, Alta., †Combined Neurosurgical and Orthopaedic Spine Program, Vancouver General Hospital, Vancouver, BC, and the ‡Spine Division, Department of Orthopedics, University of Massachusetts Medical Centre, Worcester, Mass.**

Background: Infection after spinal fusion is a relatively common complication, which occurs in approximately 2% of procedures with instrumentation. Most infections occur early in the postoperative period and infections which occur more than 6 months from the index procedure are rare. Although there is a paucity of literature characterizing delayed infections, the available evidence indicates that they are often caused by atypical pathogens and can have an insidious onset which makes diagnosis difficult. **Methods:** The study has 2 parts. The first is a retrospective case series of patients with delayed infection whose index procedure was carried out at a quaternary referral centre between 2000 and 2008. We review the incidence and bacteriology of infections presenting more than 6 months from the index procedure. The second part is a survey of experts in Canada and the United States regarding their use of prophylactic antibiotics for patients undergoing invasive procedures following spine surgery. **Results:** The proportion of infections requiring debridement that occurred after 6 months from the index procedure was 4.3% (7 of 162). Over 85% of these infections were polymicrobial, with one-third of those containing methicillin-resistant *Staphylococcus aureus*. The most common operative indications were either trauma or tumour, and most patients with a delayed infection had a distant chronic infection. The majority of spine experts do not routinely recommend prophylactic antibiotics for invasive procedures after spine fusion. In multivariate analysis, experts were more likely to recommend antibiotics for patients undergoing a nondental procedure, those who are diabetic, and those who are greater than 1 year from their procedure. **Conclusion:** Delayed presentation of infection after instrumented spinal fusion is a rare but serious complication. The bacteriology of these infections is typically more complex than early infections, and may require different medical treatment. Due to its infrequency, however, routine prophylaxis to prevent hematogenous seeding is likely unnecessary.

3.4.40

An economic evaluation of perioperative adverse events associated with spinal surgery. ***E. Hellsten,[*] H. Michelle,[*] A. Manos,[*] S. Lewis,[*†] E. Massicotte,[*†] M. Fehlings,[*†] P. Coyte,[*] Y.R. Rampersaud.[*†]*** **From the *University of Toronto, Toronto, Ont., and the †University Health Network, Toronto Western Hospital, Toronto, Ont.**

Background: This primary purpose of this study is to estimate the economic impact in terms of incremental costs and length of

stay (LOS) of different severity grades of adverse events (AE) that occurred during perioperative spinal surgery. **Methods:** A health economic evaluation from the perspective of an academic hospital was performed. The Spine Adverse Events Severity (SAVES version 1) instrument was completed following inpatient spinal surgery between 2007 and 2010. A total of 1815 records were linked with patient-level costing information. We matched each adverse event case with 4 control cases based on their propensity score for risk of experiencing an adverse event, regressed against confounding variables. We estimated incremental cost and length of stay (LOS) for each severity grade of adverse events by calculating differences in means across cases and controls. **Results:** AEs were reported in 316 (17.4%) cases with 126 of these patients experiencing multiple events. The incremental cost/LOS for each severity grade are as follows: I = $4224–($p$ = 0.0351)/3.63 d–(p = 0.0001); II = $23 500–($p$ < 0.0001)/1403 d–(p < 0.0001); III = $147 285–($p$ = 0.0036)/74.5 d–(p = 0.0018); and IV = $121 366–($p$ = 0.0323)/46.44 d–(p = 0.0036). The total cost in millions/LOS (d) associated with each grade over the 4-year study period are as follows: I = $0.66 M/569.9 d; II = $2.96 M/1767.8 d; III = $4.27 M/2160.5 d; and IV = $0.49 M/185.8 d. Overall, adverse events contributed an estimated $8.38 million (16.0% of total costs for all patients) in incremental costs and 4684 additional bed days over the 4-year study period. **Conclusion:** In this surgical spine cohort, AEs accounted for 16% of the total cost of in-hospital care. Higher severity AEs are progressively more costly on a per case basis; however, the more frequent lower severity events (i.e., grade I and II) also had a substantial aggregate cost (43%). These results suggest a strong business case exist for patient safety strategies to focus not only on severe AEs, but perhaps more so on the reduction of lower severity events that may be more amenable to prevention efforts.

3.4.41

Symptomatic spinal epidural hematoma after posterior cervical surgery: incidence and risk factors. **C. *Goldstein,*‡ *I. Bains,*§ *J. Hurlbert.*†§ From the *Toronto Western Hospital, Toronto, Ont., †Foothills Medical Centre, Calgary, Alta., ‡University of Toronto, Toronto, Ont., and the §University of Calgary, Calgary, Alta.**

Background: Symptomatic spinal epidural hematoma (SEH) is a rare but potentially devastating complication of spinal surgery. This is especially true in the cervical spine where postoperative epidural hematoma can cause rapidly progressive quadriplegia, respiratory compromise and death. The purpose of this retrospective cohort study is to determine the 10-year incidence of symptomatic postoperative cervical spinal epidural hematoma at a tertiary care spine centre and determine risk factors associated with its development. **Methods:** Surgical procedure codes were used to identify patients undergoing posterior cervical surgery at the Foothills Medical Centre. Paper and electronic medical records were manually searched to extract information pertaining to patient demographics, surgical procedure, postoperative management and postoperative complications. The overall incidence of symptomatic SEH was calculated and categorical and continuous variables were summarized with percentages and means respectively. Step-wise forward selection logistic regression analysis was performed to identify predictors of symptomatic SEH in our patient population. **Results:** From January 2002 to December 2011, 565 patients were identified for study inclusion. The overall incidence of symptomatic SEH was 1.4% (n = 8). Step-wise logistic regression analysis identified postoperative nonsteroidal anti-inflammatory drug (NSAID) use and an increased Charlson Comorbidity Index as significant predictors of the development of a symptomatic SEH following posterior cervical surgery (p = 0.024 and 0.003, respectively). When all other variables remained the same a 1-point increase in cervical consistency index was associated with a 1.58 times increase in the odds of hematoma development while postoperative NSAID use increased the odds 6.64 times. **Conclusion:** Symptomatic SEH may occur in up to 1.4% of patients undergoing posterior cervical spine surgery. While patients with a higher level of comorbid disease appear to be at increased risk of development of a symptomatic SEH, avoidance of postoperative NSAIDs may decrease the risk of development of this significant surgical complication in this patient population.

3.4.42

Spinal infections: Are there predictive markers for catastrophic neurologic deterioration? ***M. Cwinn,** *A. Bradi,** *S. Ferrara, R. Pokrupa,**† From *Queen's University School of Medicine, Kingston, Ont., and †Kingston General Hospital, Department of Neurosurgery, Kingston, Ont.**

Background: Spinal epidural abscesses are uncommon and often result in paralysis or death. The affected patient population is heterogeneous and patients present with disease severity ranging from back pain to paralysis. Few studies have attempted to identify patient factors associated with poor prognosis. To our knowledge, none have performed subgroup analysis based on disease severity at presentation. **Methods:** We collected a retrospective case series of all spinal infections presenting to Kingston General Hospital, a tertiary care teaching hospital in Kingston, Ont., from 2004 to 2011. Cases with incomplete admission or follow-up data were excluded. Poor neurologic function at presentation and at follow-up was defined as any of a) new inability to ambulate, b) motor deficit less than or equal to 3 of 5 on the Medical Research Council Scale, c) complete sensory loss, d) bowel and/or bladder dysfunction. We examined the association of comorbidities (underlying spinal pathology, diabetes mellitus, immune compromise, injection drug use), presenting laboratories (fever, erythrocyte sedimentation rate [ESR], C-reactive protein, leukocytosis, sepsis, pathogen) or intervention (medical, surgical, percutaneous drainage) with outcome using χ^2 analysis, considering the p value of less than 0.05 as significant. **Results:** Of 119 patients identified, 81 had complete data. The mean age was 59 ± 13.9, 54% were male and 42% presented with significant neurologic deficits. Overall mortality was 6.2% and 19.8% had significant neurologic deficits at follow-up. Poor outcome was associated with underlying spinal pathology (p = 0.021), fever (p = 0.026), positive culture (p = 0.01) and elevated ESR measured after admission (p = 0.007). In the subgroup of patients presenting with significant neurologic deficits, poor outcome was associated with previous spinal pathology (p = 0.04), ESR measured after admission (p = 0.012) and concomitant osteomyelitis, discitis or a psoas abscess (p = 0.019). None of the selected variables were associated with poor prognosis in patients presenting with mild deficits. **Conclusion:** Risk factors for adverse outcome vary depending on disease severity at the time of presentation. Aggressive treatment is warranted in patients with underlying spinal pathology, fever or the presence of positive cultures.

Canadian Spine Society abstracts

Poster presentations

Thursday, February 28, 2013

1.5.01

Silicated calcium phosphate bone graft substitute in anterior cervical discectomy and fusion (ACDF): comparison with iliac crest bone graft. ***F.E. Vigna, D. Ceratt, B. Whiteside.*** **From Spine Surgery of Buffalo Niagara, Niagara Falls, NY**

Background: Anterior cervical discectomy and fusion (ACDF) is a standard surgical treatment. Donor site pain and other issues have led surgeons to look for bone graft substitutes. SiCaP (Actifuse®, Baxter Healthcare, Deerfield, Ill.) is a new ceramic with osteogenic properties and excellent handling characteristics **Methods:** Seventy-nine consecutive patients who underwent ACDF with polyetheretherketone spacers and cervical plating were reviewed. Thirty-nine had SiCaP bone graft, and this cohort was compared with 40 previous surgeries using iliac crest bone graft (ICBG). Fusion was determined successful with graft incorporation and the absence of motion on flexion-extension films. Where fusion could not be determined with these methods, CT scans were used. Clinical outcomes were assessed by visual analogue scale (VAS) for pain for neck, arm and shoulder pain done by the patient pre- and postop. **Results:** There were 13 men and 26 women in the SiCaP group and 19 men and 23 women in the ICBG group. Follow-up was 12 months in both groups (range 3–15 mo). Both groups exhibited risk factors, such as previous surgery (10% SiCaP, 5% ICBG), obesity (15% SiCaP, 20% ICBG) and smoking (38% SiCaP, 43% ICBG). Smokers in this study were all 1 ppd or greater. Thirty-seven of 39 patients were fused (95%) in the SiCaP group and 34 of 40 (85%) in the ICBG group. In the ICBG group smoking caused a 15% decrease in the fusion rate, while in the SiCaP group, the fusion rate for smokers was only 3% lower. Clinical improvement via VAS scales improved 38% to 40% in both groups. **Conclusion:** The SiCaP bone graft substitute is a viable alternative to ICBG bone in ACDF procedures either alone or in combination with local bone. While some progress has been made in patient education in recent years, tobacco use among spine patients remains problematic. Iliac crest morbidity can be avoided and equivalent outcomes can be obtained in ACDF surgery with the use of SiCaP bone graft substitute.

1.5.02

Pilot study of an electric synoptic operative report: spinal cord injury (eSOR-SCI). ***S. Christie, W. Bonney, G. Paterson, G. Thibault-Halman, S. Abidi.*** **From Dalhousie University, Halifax, NS**

Background: Traditional operative reports use broad and diverse nomenclature surrounding many diagnoses and procedures. They can be difficult to use for data analysis/statistics and are often not as complete as could be. Synoptic operative reports, standard in general oncology surgery, address this through the use of keywords and phrases to capture information in a standardized way. We developed an electric synoptic operative report–spinal cord injury (eSOR-SCI) template, with the goal of capturing information for use in spinal surgery, which can also be reused in prospective national registries and the Canadian Institute for Health Information Discharge Abstract Database (CIHI-DAD). **Methods:** The eSOR-SCI template was designed using core data elements from registry forms, surgical expertise, interoperable standards (HL7, SNOMED CT) and Microsoft InfoPath. Study participants were surgeons (residents and attendings) in an academic centre. Following informed consent, a repeated-measures design, randomly assigned each subject to group 1 or 2. Group 1 completed the operative report using traditional dictation followed by eSOR-SCI template, while group 2 used the reverse. Each participant completed a recruitment questionnaire examining possible control variables and a feedback questionnaire. The reports were compared for accuracy, conciseness, completeness and for data reuse for both registry and CIHI. **Results:** There was significant heterogeneity in the access and use of electronic sources of patient data. Participants were in agreement about their inability to find the diagnosis terms they needed in eSOR-SCI, but otherwise were able to use either method to complete an operative report. The dictated notes were more comprehensive, but the synoptic reports were more precise. The diagnostic codes were more compatible with registry requirements than CIHI-DAD. Participants felt a web-based platform would enhance usability. **Conclusion:** Synoptic operative reports can be adapted for spinal surgery and improve the accuracy of clinical event documentation and facilitate data input across platforms. Future efforts will enhance usability and portability.

1.5.03

Cellular changes in the lumbar enlargment mediate the development and maintenance of lower limbs spasticity and neuropathic pain in cervical spondylotic myelopathy. ***S. Karadimas,[*†] A. Laliberte,[*†] Y. Zhou,[†] M. Fehlings.[*‡]*** **From the *University of Toronto, Insitute of Medical Sciences, Toronto, Ont., †Krembil Neuroscience Centre, Toronto, Ont., and the ‡Department of Surgery, Division of Neurosurgery, Toronto, Ont.**

Background: Cervical spondylotic myelopathy (CSM) is commonly associated with lower extremities spasticity and neuropathic pain, although the mechanisms underlying these phenomena remain unclear. Here, we sought to elucidate the molecular mechanisms which lead to the development of neuropathic pain in CSM. **Methods:** A novel rat CSM model was used in this study. The CSM rats were blindly and randomly divided to 3 groups: 1) 6 weeks group, which received progressive compression for 6 weeks (n = 6); 2) 12 weeks group, which received 12 weeks compression (n = 6); 3) decompression group, which received decompression at 6 weeks postsurgery and sacrificed 6 weeks postdecompression. Hindlimb mechanical allodynia and

tail thermal hyperlagesia were evaluated using the von Frey and the Tail Flick tests, respectively. Gait analysis was performed using the automated computerized gait analysis system, CatWalk. The expression levels of activated microglia, interleukin-1 receptor (IL-1R), astrocytes, neuronal and oligodendrocytes apoptosis, GAD65 and GAD67 in the lumbar enlargement were evaluated using Western blot, reverse transcription polymerase chain reaction and immunohistochemistry. H-reflex recordings were performed in the hindlimbs of both compression and sham operated group. **Results:** There was a significant increase in mechanical and thermal allodynia at 6 weeks and 12 weeks in CSM rats. The Iba-1 and IL1-R levels were significantly higher in both 6- and 12-week CSM animals compared with controls.The expression of glial fibrillary acidic protein (GFAP) level increased significantly at 12 weeks of compression in the CSM rats. Decompression led to attenuation of mechanical and thermal allodynia and normalization of the Iba-1, IL1-R and GFAP expression levels. **Conclusion:** These results demonstrate for the first time that under the chronic cervical spinal cord compression the lumbar enlargement is subjective to cellular changes which mediate the development and maintenance of lower extremities spasticity and neuropathic pain ion CSM.

1.5.04

Can wait times for surgical assessment and imaging be reduced through a spine care pathway? *D. Fourney, C. Wilgenbusch*. From the University of Saskatchewan, Saskatoon, Sask.

Background: In Canada, wait times for elective surgical procedures are used as a measure of quality in health care delivery. However, a national survey by the Canadian Spine Society suggests that the wait time for surgical assessment is often longer than the wait for surgery. One factor may be inappropriate elective spine referrals, particularly for mechanical lower back pain. The Saskatchewan Spine Pathway (SSP) includes triage clinics for imaging and surgical assessment. There is concern that the "extra step" of a triage clinic could lengthen the total wait to see the spine surgeon. The objective of this preliminary study was to compare wait times to surgical assessment in SSP patients versus routine care. Since access to imaging influences the wait to see the spine surgeon, this was also evaluated. **Methods:** A retrospective chart review of 124 consecutive elective referrals for low back and leg pain from a single surgeon's practice was conducted over 1 year (June 1, 2011–May 30, 2012). Group A patients were referred from the SSP and group B were conventional referrals. Patients with clinical red flags were excluded. Wait time start for imaging and surgical assessment in both groups were based on the original date of referral from the source physician. The Wilcoxon 2-sample test with Kruskal–Wallis test was used for the nonparametric distribution of data. **Results:** There were 35 (28.2%) patients in group A and 89 (71.8%) patients in group B. The mean wait time for surgical assessment was 69.9 days (SD 46.4, range 37–92) in group A and 144.0 days (SD 117.3, range 41–219) in group B ($p = 0.004$). Wait time start dates for MRI were available for 23 patients in group A and 45 in group B. The mean wait time for MRI was 29.4 days (SD 22.6, range 14–36) in group A and 73.8 days (SD 41.4, range 55–99) in group B ($p < 0.0001$). **Conclusion:** This preliminary study suggests that wait times for MRI and surgical assessment may be significantly reduced through implementation of a spine care pathway. However, population-based data derived from multiple practice settings is required to confirm these results.

1.5.05

Validity of somatosensory evoked potentials as early indicators of neural compromise in rat model of spinal cord compression. *S. Morris,[*†] R. El-Hawary,[*†] J. Howard,[*†] D. Rasmusson.[†]* From the *IWK Health Centre, Halifax, NS, and †Dalhousie University, Halifax, NS

Background: While evidence exists to suggest that somatosensory evoked potentials (SSEPs) are useful safeguards during spine surgery, research evidence to date has largely been restricted to chart-based retrospective studies. There are no randomized controlled studies that definitively prove whether SSEPs are useful in the actual prevention of intraoperative spinal cord injury. However, this kind of study, wherein some individuals are denied mitigating steps to reduce the risk of spinal cord injury after signal changes are detected, cannot be undertaken in human patients for obvious ethical reasons. The alternative is to employ animal models in which a known intraoperative compromise is introduced and determine whether monitoring signal changes represents a window of opportunity in which an injury in evolution can be reversed. **Methods:** Thirty-two adult male Wistar rats were divided into 4 groups according to the percentage of induced SSEP signal loss; all animals had preoperative functional testing. Following surgical placement of a balloon catheter in the thoracic sublaminar space, SSEPs were recorded while the spinal cord was compressed by inflation of the balloon. The recordings were terminated after a different percentage loss of SSEP amplitude in each group. Functional behavioural testing was repeated after 24 hours. **Results:** Only the group wherein the catheter was left inflated for 15 minutes after a complete (100%) loss of SSEP amplitude showed a significant deterioration in functional testing as compared with preoperative baseline values. Functional testing remained normal for the groups in which termination of spinal cord compression occurred immediately after a decrease of SSEP amplitude to 50% or 100%. **Conclusion:** An SSEP loss of up to 100% can be tolerated in a rat model of spinal cord compression as long as the compression is terminated immediately after the SSEP decrease is detected. Prolonged spinal cord compression, with concomitant SSEP decrease, can result in postoperative functional deficits despite mitigating procedures to remove the compression.

1.5.06

Non-neurologic outcomes in complete traumatic spinal cord injury: the role of surgical timing. *É. Bourassa-Moreau,[*†] J.-M. Mac-Thiong,[†‡] D. Ehrmann Feldman,[*§] C. Thompson,[†] S. Parent.[†‡]* From the *Faculté de Médecine de l'Université de Montréal, Montréal, Que., †Hôpital du Sacré-Coeur de Montréal, Montréal, Que., ‡CHU Sainte-Justine, Montréal, Que., and the §Public Health Department of Montréal, Montréal, Que.

Background: There is a tendency to delay surgical decompression of neurologically complete spinal cord injury (SCI) compared with incomplete SCI. We wanted to compare the effect of early and late surgical timing on non-neurologic outcome in complete SCI population. **Methods:** A retrospective cohort

study was performed in a single institution. One hundred and ninety-seven cases of traumatic complete SCI were reviewed. The occurrence of pneumonia, urinary tract infection (UTI), pressure ulcer (PU) and all other postoperative complications were recorded for each patient. Cost of hospitalization was calculated for each patients based on administrative data. Patients operated within 24 hours of the trauma were compared with patients operated later. The effect of surgical timing on complication rate and cost of hospitalization was adjusted for potential confounding variables using regression analysis. Potential confounding variables collected were tetraplegia, mild or moderate traumatic brain injury, injury severity score, age, Charlson Comorbidity Index and Surgical Invasiveness Index. **Results:** Our cohort comprised 197 SCI with complete lesions and 55 were operated less than or equal to 24 hours from injury and 142 patients were operated more than 24 hours from injury. Baseline demographic and clinical variable appeared comparable between the patients operated before and over 24 hours from injury. The rate of PU was not statistically different in patients with early or late surgery. Pneumonia, UTI and the rate of any complications was significantly higher in the group operated more than 24 hours from injury. Patients operated on more than 24 hours from injury had significantly more expensive hospitalization (≤ 24 h: $22.828 ± $16.098 v. > 24 h: S7329.714 ± $19.433). Surgical timing over 24 hours remained a predictor of pneumonia, UTI, any complications and higher cost of hospitalization after controlling for other confounding variables. **Conclusion:** Neurological stabilization may be beneficial for neurologic improvement in complete SCI patients although it was never clearly demonstrated. This study supports that surgical stabilization less than 24 hours from injury for complete SCI patients may reduce complications rate during the acute phase hospitalization and may contribute to decrease the cost of acute care hospitalization.

1.5.07

Why do I feel stuck in a 75-year-old man's body when I am only in my forties? ***M. Nadeau,* A. Vaccaro,† M. Fehlings,‡ J. Dimar,§ M. Dvorak,* C. Fisher.*** **From the *University of British Columbia, Vancouver, BC, †Thomas Jefferson University, Philadelphia, Pa., ‡University Health Network, Toronto, Ont., and the §Norton Leatherman Spine Center, Louisville, Ky.**

Background: Burst fractures may be treated conservatively or operatively, and controversy still exists as to which approach is best. This study compares outcomes between neurologically intact patients with thoracolumbar burst fractures treated operatively (Op) and nonoperatively (NOp), and looks at whether or not certain patient factors affect outcomes regardless of treatment. **Methods:** Patients sustaining a burst fracture and being treated in 2 level 1 trauma centres between 2003 and 2012 were entered in a database. Next, *t* tests were performed to compare the outcomes of neurologically intact patients with T11-L1 burst fractures treated conservatively and those treated operatively. Outcome measures consisted of the rate of return to work at 6 months ($n = 65$) and SF-36 Physical Component Scores (PCS) at 1 year postinjury ($n = 69$). Logistic regression analysis was done to look at whether age, sex, smoking, body mass index (BMI) and/or Charlson Comorbidity Index (CCI) affected these outcomes. **Results:** There was no significant difference in rate of return to work at 6 months (36% v. 43% for the NOp and Op groups, respectfully) and SF-36 PCS at 1 year (46.8 v. 42.9) between both groups. Age, sex, smoking, BMI and CCI did not affect the SF-36 PCS; however, patient BMI negatively correlated with return to work at 6 months. **Conclusion:** Our data demonstrate a trend for lower SF-36 PCS in the Op group, with an average score inferior to that of the average Canadian man aged 75 years or older (SF-36 PCS = 43.7), while the actual average age of these patients was 42.2 years. This suggests that surgery may not be helping patient physical well-being after sustaining a burst fracture as much as spine surgeons would believe. Future larger scale observational studies with increased power may be able to demonstrate a statistically significant difference in outcomes after conservative versus operative treatment.

1.5.08

Comparison of patients receiving rBMP-2 versus a SiCaP bone graft substitute undergoing posterolateral spinal fusion: a cost analysis using the premier database. ***S. Tackett,* J. Li-McLeod,* H. Kreuwel,* S. Czop,* D. Baumer,† G. Magee.†*** **From *Baxter Healthcare Corporation — BioScience, Westlake Village, Calif., and †Premier Research Services, Charlotte, NC**

Background: The use of various bone graft substitutes to autologous bone graft in spinal fusion procedures has increased in recent years. While showing improvements in some outcome variables, there are concerns regarding the additional associated costs (Lad SP et al, Feb. 2011). A previous study comparing the cost of care for patients undergoing posterolateral spinal fusion (PLF) based on the use of the specific bone graft substitutes SiCaP or rBMP-2 demonstrated lower total costs for SiCaP patients. This study focuses only on patients undergoing initial PLF surgery (no previous surgery 12 months prior). **Methods:** Patients over age 18 having an initial PLF procedure (ICD-9 codes 81.62, 81.63 or 81.64) and receiving SiCaP or rBMP-2 on the day of procedure between January 2006 and Dec. 31, 2011, were selected. Patients with a previous PLF surgery within 12 months were excluded. Comorbidities were identified using a modified Charlson method. Patients with 9 or more levels fused were excluded. Univariate group comparisons were made using χ^2 and Student *t* tests where appropriate. Multivariate linear models were developed using both normal and log transformation. Costs were compared in multivariate analyses using standard log-transformed models. **Results:** A total of 65 167 patients met the inclusion criteria. Univariate comparisons of total tost as well as operating room and supply costs were significantly lower for the SiCaP cohort ($p < 0.05$). After adjusting for patient and hospital covariates, differences in estimated means using log-transformed values for total costs ($6894), and supply costs ($5290) were significantly lower for SiCaP patients when compared with patients using rBMP-2 ($p < 0.001$). There was no statistically significant difference in operating room costs. **Conclusion:** After adjusting for patient and hospital covariates, SiCaP patients had significantly lower total patient costs. While supply costs showed similar reductions, they do not fully explain the reduction in total cost suggesting that there are other cost advantages besides product acquisition cost. These findings are consistent with the previous study. Further research should consider cost of complications and readmission.

Friday, March 1, 2013

2.5.09

Dexamethasone perioperative coanalgesia in lumbar spine fusion: a controlled cohort study of efficacy and safety. ***D. Bednar, A. Wong, F. Farroukhyar, J. Paul.*** **From McMaster University, Hamilton, Ont.**

Background: In May 2008 we gave a 48-hour trial of dexamethasone (4 mg IV q4h × 48 h) to a problem case. The method became standard practice. This is our Research Ethics Board–approved review of this experience as compared with the historical precedent control cohort. We do not report the results of spine fusion, only to present a possible adjunct in perioperative pain control. **Methods:** Case logs were reviewed so as to identify all cases of 1- and 2-level elective lumbar decompression and fusion surgery performed since May 2008 and with regard to which minimum 6-month follow-up (sufficient to identify wound healing problems and perioperative infections) information was available. These were all open posterior lumbar interbody fusion (PLIF) reconstructions treating stenosis, spondylolisthesis or recurrent disc herniation, using only local bone graft without bone morphogenetic proteins. Hospital, pain service and office records were then reviewed and analyzed for significance. **Results:** We report on 278 fusions. Cases consisted of 70 males (53%) and 62 females (47%) 54 years of age (range 18–84). Seventy-five (57%) cases were narcotics-dependant at baseline, consuming a mean of 79.5 mg morphine equivalent daily. Controls were 78 males (53%) and 68 females (47%) aged 55 years (range 27–85). Eighty-nine (61%) controls used narcotics at baseline, a mean of 101.2 mg morphine equivalents daily. Narcotic consumption for 48 hours after surgery averaged 262.9 mg in the cases and 280.7 mg in the controls. Visual analogue scale pain scores (10-point scale) at 48 hours averaged 4.4 and 6.9 during rest and activity in the cases, and 3.7 and 6.3 during rest and activity in the controls. Length of stay (LOS) averaged 3.9 days in cases and 5.2 days in controls. Delayed wound healing and surgical site infections were not observed. **Conclusion:** Dexamethasone for 48 hours after 1- and 2-level lumbar fusion surgery demonstrated no impact on 48 hours perioperative narcotics use. There was no detriment to pain control, wound healing or infections. The LOS was shortened by 25%.

2.5.10

A disc degeneration model induced by collagenase partial digestion: an in vivo organ culture system. ***K.-Y. Lee,* M.-H. Chen.†*** **From the *Institute of Biomedical Engineering, National Yang-Ming University, Taipei, Taiwan, and the †Department of Neurosurgery, National Taiwan University Hospital Hsin-Chu Branch, Hsin-Chu City, Taiwan**

Background: The most important limitation of disc degeneration studies is the source of experimental model. In this study, a rodent disc degeneration model was developed by enzyme partial digestion of intervertebral discs and then culturing the discs in vivo. The degenerative changes of discs were evaluated histologically, and biochemically. In addition, a comparison between different concentrations of enzyme solution and disc degeneration degree was also evaluated. **Methods:** Motion segments of the intervertebral disc from Sprague-Dawley rats of were soaked in specific collagenase (liberase, Roche) of 2 different concentrations (0.001 unit/mm^2, 0.002 unit/mm^2) for 20 minutes at 37°C for partial digestion of the discs. The samples without enzyme treatment were used as control. After enzyme treatment, the motion segments (n = 6 for each group) were implanted into subcutaneous pockets on the back of nude rats as an in vivo organ culture system for 28 days. All disc samples were analyzed with hematoxylin and eosin stain and safranin-o. All samples were evaluated using a modified histologic assessment scale built up by Bin Han and colleagues. Immunohistochemical stains were used to evaluate the content of type I and II collagen. **Results:** After enzyme treatment, the whole structure of disc was maintained. The degradation level digested by enzyme was dose dependent. After 28 days in vivo culture, the margin of nucleus pulposus (NP) became irregular in control group and progressively disorganized in enzyme treatment groups. Chondrocytes proliferated and migrated into NP region, replaced notochord cells were prominent in enzyme treatment groups. The borders between annulus and nucleus were more indistinctive in enzyme treatment groups. End plate microfractures and scar formation in end plate were more serious in 0.002 unit/mm^2 enzyme treatment group.after implantation. After 28 days in vivo culture, semiquantitative analysis showed that glycosaminoglycan content was significantly decreased in enzyme treatment group. **Conclusion:** In this study, we developed a new animal model to mimic disc degeneration in moderate to severe level using collagenase digestion method.

2.5.11

Canadian spine CRE tragedies that are being missed: a Southern Ontario perspective and a call to action for the Canadian Spine Society. ***D. Bednar.*** **From McMaster University, Hamilton, Ont.**

Background: Spine care professionalism brings some mandates to improve and optimize care. We all do this within the confines of our practices and our hospitals, and some propose "screening clinics" where physician assistants could help us more rapidly process those cases referred to us. But there may be a greater burden of need in those who are not referred to us when they should be. Canadian surgeons often see a nonstop litany of decompensated stenosis and missed cancers or infections presenting in extremis to us when we are on call. The Canadian Spine Society (CSS) may best act to improve Canadian spine care with initiatives going beyond the membership, educating the primary caregiver on red flags and bringing these tragedies to the attention of policymakers and health administrators. **Methods:** I have reviewed my on-call experience from the 2012 calendar year and present a barrage of spinological tragedies that all presented classical red flags that were missed and which if recognized and acted on might easily have improved patient outcomes and greatly decreased care cost. **Results:** Missed red flags are disturbingly common. These cases often evolve to permanent disability and compromised outcome with enormous acute and long-term care cost implications. **Conclusion:** A national primary caregivers education program from CSS has promise to greatly improve our country's spine care outcomes.

2.5.12

A prospective evaluation of hemodynamic management in acute spinal cord injury patients. ***C.Y. Kong,* A.M. Hosseini,†***

L.M. Belanger,* J.J. Ronco,* S.J. Paquette,* M.C. Boyd,* N. Dea,* J. Street,* C.G. Fisher,* M.F. Dvorak,* B.K. Kwon.*
From the *University of British Columbia, Vancouver, BC, and †Simon Fraser University, Vancouver, BC

Background: Following acute spinal cord trauma, hemodynamic support to avoid hypotension is important for minimizing secondary injury. Guidelines based on weak clinical evidence have suggested maintaining a target mean arterial pressure (MAP) of 85 to 90 mm Hg for 5 to 7 days. To our knowledge, the success of actually maintaining such a target MAP in acute spinal cord-injured (SCI) patients has not been previously studied. We conducted a prospective observational study of acute SCI patients at our level one trauma centre. Our objective was to determine how effectively MAP and spinal cord perfusion pressure (SCPP) were maintained at target levels in acute SCI patients. **Methods:** Twenty-one cervical and thoracic SCI were enrolled within 48 hours of injury. A lumbar intrathecal drain was used to monitor intrathecal cerebrospinal fluid pressure (ITP). The MAP was monitored concurrently with ITP, and the SCPP was calculated. A target MAP of at least 80 mm Hg was agreed upon for the study. Data was recorded hourly from the time of first assessment until at least the end of the fifth day postinjury. **Results:** All patients had at least 1 recorded episode with a MAP below 80 mm Hg, and 81% had at least one episode with a MAP below 70 mm Hg. On average, patients with cervical and thoracic SCI had 18.4% and 35.9% of their pressure recordings respectively below 80 mm Hg. **Conclusion:** It is common practice to establish MAP targets for optimizing cord perfusion in acute SCI. This study suggests that even in an acute SCI referral centre, when prospectively scrutinized, the actual MAP may frequently fall below the intended targets. Such results raise awareness of the vigilance that must be kept in the hemodynamic management of these patients, and the potential discrepancy between routinely setting target MAP according to practice guidelines and actually achieving them.

2.5.13

Single level anterior cervical discectomy and fusion with polyetheretherketone (PEEK) prevail cages versus graft and plating technique. ***M. Taylor, D. Yen.*** **From Queen's University, Kingston, Ont.**

Background: Anterior cervical discectomy and fusion (ACDF) is a surgical procedure used in the treatment of patients with cervical disc disease when conservative treatment has failed. An anterior approach to the cervical spine with discectomy and fusion using iliac crest bone graft was first described by Smith and Robinson in 1955. Although autologous iliac crest bone graft provides satisfactory fusion rates and clinical results, donor site complications can approach 20%. Various implants have been used for the purpose of fusion, and in 1988 Bagby and colleagues were the first group to describe the use of interbody fusion cages. Cages provide the necessary stability and by filling the disc space avoid the need for autologous bone graft. Polyetheretherketone (PEEK) cages are made of biomaterials that are biocompatible, corrosion-resistant and have a modulus of elasticity that approaches that of bone. The PEEK cages are radiolucent allowing for better evaluation of fusion. Several studies have found fusion rates and stability to be similar between PEEK cages and traditional graft and plating techniques, we were interested in looking at operative time, blood loss and hospital length of stay. **Methods:** This study was a 2-cohort series, with various surgeons in the plate cohort and 3 surgeons (F.S., P.E., D.Y.) in the PEEK cohort. Sixty-six patients underwent single level ACDF. The Medtronic PEEK Prevail cervical interbody device was used in 30 patients, and 36 patients underwent traditional fixation with graft and plating technique. Blood loss, operative time and hospital length of stay were compared between the 2 groups. **Results:** The ACDF performed using the PEEK Prevail cervical interbody device had an average operative time of 156.77 minutes (SD 32.3) compared with 195.31 minutes for graft and plating method (p = 0.017), an average blood loss of 108.15 cc (SD 70.1) versus 178.61 cc (p = 0.005) and an average length of stay in hospital of 1.77 days (SD 1.1) versus 2.53 days (p = 0.018). The results were significant for all 3 analyzed clinical variables. Results from the t test were confirmed with the nonparametric Mann–Whitney U test. **Conclusion:** In the current study, ACDF using PEEK Prevail showed a statistically significant reduction in operative time, blood loss and total hospital length of stay when compared with a traditional graft and plating ACDF technique. At our institution, the unit cost of a single level PEEK system was estimated at $1900 while the cost of single level graft and plating construct with 4 screws was $1500. The average daily cost of a standard orthopaedic ward room is $500 excluding diagnostic and therapeutic procedures. The PEEK Prevail system has been shown to offer similar postoperative fusion rates and clinical results when compared with autograft and allograft constructs and, in our institution, also decreased intraoperative blood loss, total operative time and total length of stay. Study limitations include a lack of patient randomization and we did not assess postoperative fusion rates. Methods for determining fusion after ACDF using PEEK cages have not been well defined and with recent studies suggesting slower fusion rates for cage constructs, it will be worth following these patients to assess fusion rates at follow-up.

2.5.14

Normative values of T1ρ MRI for intervertebral disc at different ages and different severity of degenerative disc disease: validation of T1ρ MRI as a tool to quantify early degenerative disc disease. ***L. Haglund,*† K. Mulligan,†‡ R. Gawri,*† Y.W. Shao,† W. Awwad,*† A. Kumar,* A. Borthakur,§ J. Ouellet.*†*** **From *McGill University, Montréal, Que., †McGill Scoliosis and Spinal Research Group, Montréal, Que., ‡Sherbrooke University, Sherbrooke, Que., and the §University of Pennsylvania, Philadelphia, Pa.**

Background: Current diagnostic modalities are not able to diagnose the advent of early disc degeneration, nor are they able to provide insight into the biochemical composition of human in vitro diagnostics (IVDs). The aim of this study was to provide normative values for T1ρ of human IVD and correlated these values to biochemical composition at different age groups as well at different severity of disc disease. **Methods:** Twelve human lumbar spines totaling 47 IVDs were harvested from levels T11–12 to L5/S1. Standard T2 and T1ρ MRIs were acquired for all discs both in sagittal and axial planes. Average T1ρ values were recorded for specific zones of interest in nucleus pulposus (NP)

and annulus fibrosus (AF) for each disc. A core biopsy was taken representing this zone of interest and proteoglycan content was quantified using 1,9-dimethylmethylene blue (DMMB) analysis. Correlation between T1ρ values, Pfirrmann grade and proteoglycan concentration was performed. **Results:** Lower T1ρ values are observed in the AF than in the NP region of healthy discs. With increasing Pfirrmann grade, T1ρ values in both the AF and NP decreased. The T1ρ in the NP decreased more prominently than those of the AF and begin to converge with AF with increasing Pfirrmann grades. The T1ρ values at the punch location that was used for performing DMMB of the NP were within 5%, which was validated for 12 IVDs. The DMMB analysis for proteoglycans showed lower concentrations at lower T1ρ intensity associated with increasing Pfirrmann grades. **Conclusion:** Having a diagnostic tool allowing us to detect early biochemical changes in otherwise healthy looking disc (Pfirmann 1–2) is crucial in the hope that we can alter the natural history of degenerative disc disease. We have demonstrated that we can three dimensionally map the health of IVD using axial and sagittal T1ρ MRI images that these T1ρ values grossly correlate with established degenerative disc disease grading schemes as well as loss of proteoglycan concentration.

2.5.15

Risk factors for the development of complications in spinal trauma: a prospective study of 874 surgical patients from the spine trauma study group (STSG).

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Background: The primary purpose of this study was to assess which patient and/or surgical factors are independent predictors of adverse events following spinal trauma. **Methods:** Retrospective study of consecutive spine trauma patients registered in the spine trauma study group (STSG) database from February 2001 to July 2010. Univariate and multivariate (stepwise regression) analysis was performed to identify significant factors associated with a greater odds ratio of developing complications in patients undergoing surgical management. Clinically relevant patient factors (age, gender, body mass index [BMI], Charlson Comorbidity Index [CCI] and neurologic status [Glasgow Coma Scale and American Spinal Injury Association status]) and management factors (timing of surgery, steroid use, and surgical intensity) were included in the analysis. To assess the impact of timing of surgery, 3 separate multivariate models were performed (surgical treatment before or after 24 h, 48 h, or 72 h from injury). **Results:** A total of 874 surgical patients were included in analysis. At baseline, the mean age was 45.1 (+ 17.9), mean BMI was 26.4 (+ 5.4), mean CCI was 0.29 (+ 0.76) and 74.2% patients were males. The median time from injury to surgery was 28.70 (range 3.00–99.9) hours. Complications occurred in 374 patients (42.8%). Multivariate analysis demonstrated that neurologically impaired patients (OR 3.85, 95% CI 2.75–5.39), baseline CCI (OR 1.3, 95% CI 1.17–1.59) and surgery after 72 hours of injury (OR 2.12, 95% CI 1.19–3.78) were independently predictive of a greater odds of developing a complication. Timing was not significant in the models assessing before or after 24 or 48 hours. **Conclusion:** The complication rate (43%) associated with surgical management of spinal trauma is high. Although many factors are implicated, impaired neurologic status, base line comorbidity and surgery greater than 72 hours after injury were the only independent predictors of developing a complication in this population. However, timing of surgery is the only factor that is potentially modifiable in the short term.

2.5.16

A summary of assessment tools for patients suffering from cervical spondylotic myelopathy: What outcome measure and why?

A. Singh, L. Tetreault, A. Casey, P. Statham, R. Laing, M. Fehlings. **From Toronto Western Hospital, Toronto, Ont.**

Background: Cervical spondylotic myelopathy (CSM) is a degenerative disease of the cervical spine and the most common cause of spinal cord dysfunction worldwide. The proper diagnosis of CSM and assessment of patient impairment and disability is essential for the implementation of appropriate treatment programs and surgical strategies. It is often the case that a patient undergoes surgery either unnecessarily or too late for optimal recovery due to nonstandardized and subjective assessment. The objective of this narrative review is to provide the history of and to summarize the outcome measures used for the assessment of patients with cervical spondylotic myelopathy. This review notes the qualities of an ideal scale and identifies those that are quantitative, valid, reliable and responsive measures of impairment and disability. **Methods:** A literature review of studies discussing the important outcome measures used for the assessment of CSM was conducted. **Results:** An ideal scale should be one that is quantifiable, valid, sensitive, responsive and easy to perform, has high inter/intrarater reliability, internal consistency and a suitable distribution, and is 1-dimensional and relevant. In the context of CSM, it is essential that the scale also addresses the pathophysiology and its key signs and symptoms as well as its natural history. Many impairment scales, including American Spinal Injury Association (ASIA) and Ranawat have been applied to CSM populations. Many functional disability scales, such as the Nurick, Modified Japanese Orthopaedic Association, Emergency Medical Services, Odom's Criteria, myelopathy disability index, and handicap scales, specifically SF-36 and quality-adjusted life years, have also been applied to CSM populations. The 30 metre timed walking test and variations of this scale, including the triangle step test and 10-second step test, were designed to bridge the gap between impairment and disability measures and to evaluate voluntary movement, balance and coordinated activity. Not only are these scales directed toward lower limb function, one of the primary concerns of CSM, but they are all sensitive enough to detect mild leg symptoms, addressing the natural history of the disease. **Conclusion:** This review summarizes some of the significant outcome measures designed for or modified for the assessment of cervical spondylotic myelopathy.

SATURDAY, MARCH 2, 2013

3.5.17

Factors associated with poor outcome following the nonoperative treatment of thoracolumbar burst fractures. ***C.S. Bailey,* J. Fleming,* M. Nadeau,* M.F. Dvorak,† K.R. Gurr,* S.I. Bailey,* C.G. Fisher.†*** **From *Western University, London Health Science Centre, London, Ont., and †Vancouver Hospital and Health Sciences, University of British Columbia, Vancouver, BC**

Background: The nonoperative treatment of thoracolumbar burst fractures demonstrates satisfactory results with or without an orthosis and early ambulation. However, a minority of patients (≈15%–20%) have persistent pain and dysfunction. Our objective was to identify factors associated with a suboptimal result. **Methods:** A post hoc analysis was performed on a cohort of 71 patients enrolled in a randomized clinical trial treated randomly with or without a thoracolumbosacral orthosis (TLSO). Inclusion criteria were AO A3 burst fracture between T10-L3, kyphotic deformity less than or equal to 35°, neurologically intact, and age of 16 to 60 years. Pearson r correlation and linear regression analysis was performed. Dependent factors representative of outcome were Roland Morris Disability Questionnaire (RMDQ), visual analogue scale back pain, and SF-36 Physical Component Score (PCS), which were all assessed at 3 and 12 months postinjury. We assessed the following independent factors: age, sex, compensation status, smoking status, initial kyphosis greater than or equal to 25°, difference in Cobb angle between supine and upright kyphosis, load sharing classification score, anterior and posterior column height loss, AO fracture type, and injury level. To adjust for possible effect of missing data, comparative analysis replaced missing data, with mean values. **Results:** Only compensation status and kyphosis greater than or equal to 25° correlated with outcome (Pearson r range 0.27–0.46, $p < 0.05$). Simple linear regression showed that Workers' Compensation Board patients scored 5.2 and 3.5 points higher on the RMDQ at 3 and 12 months, respectively, and 6.3 points lower on the PCS at 3 months ($p < 0.004$). Patients with a kyphosis greater than or equal to 25° scored 5.6 and 5 points higher on the RMDQ at 3 and 12 months, respectively, and 8.8 points lower on the PCS at 12 months ($p < 0.02$). **Conclusion:** Future study should be considered into alternative treatment options, such as surgery, for the cohort of patients that have a positive compensation status and/or have a kyphosis greater than or equal to 25° initially following injury.

3.5.18

Canine notochordal cell-secreted factors protect murine and human nucleus pulposus cells from apoptosis by inhibition of activated caspases-9, and -3/7. ***A. Mehrkens,*† R. Hilario,* S. Kim,* Z. Karim,* M. Fehlings,* M. Erwin.**** **From the *Toronto Western Research Institute, University of Toronto, Toronto, Ont., and the †Department of Orthopaedic Surgery — Spine Unit, Basel University Hospital, Basel, Switzerland**

Background: Effective therapies that may stop or even reverse disc degeneration remain elusive. A minimally invasive method through which nucleus pulposus (NP) cell viability could be achieved would revolutionize the treatment of degenerative disc disease. With the presented work, we have investigated if non-chondrodystrophic (NCD) canine intervertebral disc (IVD)-derived notochordal cell conditioned medium (NCCM) and chondrodystrophic (CD) canine IVD-derived conditioned medium (CDCM) are able to protect murine and human NP cells from apoptosis. **Methods:** We developed NCCM and CDCM from hypoxic culture of freshly isolated NP from NCD and CD canines, respectively. We obtained murine NP cells from 9 different C57BL/6 mice and human NP cells from 4 patients who underwent surgery for discectomy. The cells were cultured with aDMEM/F-12 (control media), NCCM or CDCM under hypoxic conditions (3.5% O2) and treated with IL-1β+FasL or etoposide. All media were supplemented with 2% fetal bovine serum. We then determined the expression of specific apoptotic pathways in the murine and human NP cells by recording activated caspase-8, -9 and -3/7 activity. **Results:** In the murine NP cells, NCCM inhibits IL-1β+FasL- and etoposide-mediated apoptosis via suppression of activated caspase-9 and caspase-3/7, CDCM demonstrated an inhibitory effect on IL-1β+FasL mediated apoptosis via caspase-3/7. In the human NP cells, NCCM inhibits etoposide-mediated apoptosis via suppression of activated caspase-8, caspase-9 and mainly caspase-3/7. The CDCM demonstrated an inhibitory effect on etoposide-mediated apoptosis via suppression of activated caspase-8, caspase-9 and mainly caspase-3/7, though not as effective as NCCM. **Conclusion:** Soluble factors secreted by the NCD IVD NP strongly protect murine and human NP cells from induced apoptosis via suppression of activated caspase-9 and -3/-7. A better understanding and harnessing of the restorative powers of the notochordal cell could lead to novel cellular and molecular strategies for the treatment of degenerative disc disease.

3.5.19

Test-retest and inter-rater reliability of full torso surface topography measurements in adolescents with idiopathic scoliosis. ***L. Westover,* E. Parent,*† P. Zhang,* D. Hill,*‡ M. Moreau,*‡ D. Hedden.*‡*** **From *Alberta Health Services, Edmonton, Alta., †Department of Physical Therapy, University of Alberta, Edmonton, Alta., and the ‡Department of Surgery, University of Alberta, Edmonton, Alta.**

Background: Surface topography (ST) is a noninvasive assessment of the external torso shape proposed as an alternative or supplementary method for monitoring deformity in adolescents with idiopathic scoliosis (AIS). Many full torso ST parameters have been developed. This study quantifies the test-retest and interrater reliability of 30 parameters used for AIS participants, selected primarily from literature. **Methods:** We recruited 173 volunteers with AIS from our scoliosis clinic (age: 14.1 ± 1.9 yr, Cobb angle: 32 ± 15°). One evaluator positioned standing subjects in a standard frame, marked 15 landmarks and acquired ST scans using 4 laser scanners. Landmarks were replaced, participants repositioned and scanning was repeated. The ST parameters were extracted independently by 2 evaluators for each scan. Reliability for parameters based on dividing the torso into 90 horizontal cross-sections was compared for the full range of values and the 10^{th} to 90^{th} percentile range. Intraclass correlation coefficients (ICC) quantified reliability: test-retest for each evaluator, interrater for the same scan, and interrater for different scans. **Results:** Intrarater test-retest reliability varied between 0.03 and 0.97. Interrater reliability varied between 0.12 and 0.99 for the same scan and between 0.06

and 0.96 for different scans with 98% of the same scan estimates exceeding the corresponding different scan estimates. The 10th to 90th percentile ranges demonstrated better reliability than full ranges for 11 of 13 comparisons. Cross-sectional parameters with the best reliability were the principal axis, back surface rotation, rib hump, and half area difference. Several new parameters based on digitized landmarks showed good reliability (8 of 16 ICC > 0.85 for same scan and 4 of 16 ICC > 0.7 for different scans). **Conclusion:** Test-retest error was higher than interrater processing. Several parameters did not show adequate reliability, including measurements based on the half cross-sectional area and some based on digitized landmarks. Overall, many ST parameters showed good reliability and will be assessed for validity and responsiveness, with the goal of being implemented for clinical use.

3.5.20

Comparing traumatic spinal cord injury across Canada: describing the similarities and differences among the provinces. ***V. Noonan,*† N. Thorogood,* G. Zhong,* A. Farry,* D. Baxter,‡ M. Dvorak.*†*** **From *Rick Hansen Institute, Vancouver, BC, †Division of Spine, Department of Orthopaedics, University of British Columbia, Vancouver, BC, and the ‡Urban Futures Institute, Vancouver, BC**

Background: To date, there are no Canada-wide studies describing the epidemiology of traumatic spinal cord injury (tSCI) or health care delivery. The objective of this study was to use data from the National Trauma Registry (NTR) to describe tSCI in Canada, both nationally and regionally. **Methods:** Data from the Canadian Institute of Health Information's National Trauma Registry was obtained for 2004 to 2009. Cases of tSCI were identified using International Classification of Disease (ICD)-10 codes based on a literature search. Characteristics of the patient (e.g., age, sex), injury (e.g., type of tSCI) and treatment variables (e.g., length of stay) were described and compared among Western, Prairie, Central and Atlantic regions. **Results:** There were 4340 patient records from all provinces (excluding Quebec and the territories). Nationally, no significant change in patient, injury and treatment variables was identified from year to year. Over the 6-year period, cervical injuries represented the most common type of injury across all regions. There were significant regional differences in the patient and treatment variables. For example, the mean age was highest in Ontario (49.76 ± 21.38), followed by the Atlantic (48.76 ± 21.89), Western (45.03 ± 20.71) and Prairie regions (42.09 ± 21.29), compared with the national mean of 46.78 plus or minus 21.30. The mean acute length of stay was highest in the Prairies (42.42 ± 72.40), followed by the Western (35.30 ± 50.89), Atlantic (23.32 ± 56.95) and Ontario regions (20.10 ± 32.38), compared with the national mean of 29.33 plus or minus 49.26. **Conclusion:** The NTR data provides an opportunity to examine the epidemiology of tSCI within Canada. Over a 6-year period, the tSCI population is stable but regional differences were identified. Comparisons with data from the Rick Hansen SCI Registry are needed to further explore these differences and examine the impact on outcomes to plan and provide care for this patient population.

3.5.21

The role for percutaneous thoracolumbar stabilization for trauma. ***F. Pencle,*‡ N. Manson,*† R. Elliott,† C. Wheeler-O'Neil,‡ S. Christie.*‡*** **From *Dalhousie University, Halifax, NS, †Saint John Regional Hospital, Saint John, NB, and the ‡QEII Health Sciences Centre, Halifax, NS**

Background: Percutaneous pedicle screw-rod instrumentation (PercStab) without direct decompression or fusion is a surgical option to manage thoracolumbar trauma. The current standard of care includes instrumentation removal following osseoligamentous healing. It is hypothesized that instrumentation removal is not required following PercStab. To evaluate the utility of PercStab in the following areas: 1) patient satisfaction, 2) return of function and 3) need for repeat surgery including instrumentation removal or revision decompression and/or fusion procedures. **Methods:** Retrospective review of prospective databases identified patients receiving PercStab for trauma from January 2007 to August 2011. Validated clinical outcome measures, patient demographics, perioperative data and the need for further surgery were assessed via clinic follow-up, chart review, and telephone interview at 2 centres. Medians and ranges were reported **Results:** Twenty-six trauma patients with a median Injury Severity Score (ISS) of 10 (9–41) received PercStab to treat spinal instability over 2 levels (range 1–5) and were followed for 22 months (2 mo–4.5 yr). Minimal surgical morbidity was incurred: operating room time: 90.5 minutes (40–183 min), blood loss: 100 cc (50 cc–500 cc), days postop to hospital discharge: 6 days (1–37 d). Patients reported satisfaction: visual analogue scale (VAS) back: 2 (0–8), VAS leg: 1 (0–7), Oswestry Disability Index: 16 (0–54), average of 3 months to return to work. Patients scored a median outcome satisfaction of 5 (3.75–5) out of 5 on a Likert-type questionnaire. Only 4 patients required instrumentation removal: 2 for screw loosening causing back pain and 2 thin patients for screw prominence causing discomfort with direct pressure. **Conclusion:** This surgical option provides rapid mobilization and discharge from hospital, medium-term satisfaction, with minimal surgical morbidity. Instrumentation removal can be considered on an individual basis. Further research is required to quantify the utility of this technique in comparison to traditional surgical options.

3.5.22

Management of flexion distraction cervical spine injuries with anterior cervical surgery: a retrospective review from 2 centres. ***G. Choy,* R. Amritanand,† I. Bains,† J. Hurlbert,† F. Kortbeek,* A. Nataraj.*** **From the *University of Alberta, Edmonton, Alta., and the †University of Calgary, Calgary, Alta.**

Background: Unifacet and bifacet injuries in the cervical spine have been treated with anterior, posterior, or combined anterior/posterior fusion. Studies have demonstrated that posterior and combined anterior/posterior fixation are biomechanically superior. Anterior alone surgery has been associated with increased risk of radiographic failure when a facet or end plate fracture is present and combined anterior/posterior fixation has been advocated. This, however, leads to significantly increased operating time and posterior surgery can lead to increased wound complications. We aimed to demonstrate that anterior alone surgery provides satisfactory clinical and radiological outcomes in the majority of patients in our institutions. **Methods:** A retrospective review was performed from 2006 to 2012 at 2 Canadian centres. Patients with a cervical unifacet, bifacet or flexion distraction injury were

included. Ankylosing spondylitis, pathological or burst fractures were excluded. Patients were identified by reviewing operative billing codes. Preoperative, postoperative and final follow-up radiographs were analyzed for segmental kyphosis and translation. Presence of facet fractures and end plate fractures were identified. SF-12 and neck disability index (NDI) scores were obtained by telephone questionnaire. **Results:** Current results include 71 patients, with 19 bifacet, 43 unifacet, and 9 ligamentous distraction injuries. Anterior fixation was performed in 52 patients, posterior in 13 and anterior/posterior in 6 patients. Thirty-nine percent had an associated end plate fracture. Five percent of all anterior patients and 7% with an associated end plate fracture required posterior revision due to progressive kyphosis. Preoperative segmental kyphosis and translation were –7.3° and 5.4 mm compared with 1.9° and 0.5 mm postoperatively and 2.5° and 1.2 mm with final radiographs. Average NDI was 16% and mean SF-12 physical and mental health scores were 45 and 51, respectively. **Conclusion:** Despite biomechanical evidence of improved rigidity of combined anterior and posterior constructs, in the majority of cases anterior cervical plating and fusion alone provides satisfactory radiographic and clinical outcomes.

3.5.23

The sodium channel blocker riluzole is complementary to decompression in a preclinical experimental model of cervical spondylotic myelopathy: implications for translational clinical application. ***S. Karadimas,*[*] *M. Fehlings.*[*†]**
From the *University of Toronto, Institute of Medical Sciences, Toronto, Ont., and the †Department of Surgery, Division of Neurosurgery, University of Toronto, Toronto, Ont.

Background: While successful surgical intervention can arrest the progression of cervical spondylotic myelopathy (CSM), most patients are left with significant residual neurologic impairment. Hence, there is considerable interest in the potential application of neuroprotective agents as a complementary strategy to surgical decompression in CSM. With this background, we hypothesized that the sodium/glutamate antagonist riluzole would provide complementary benefits to surgical decompression in an animal model of CSM. **Methods:** In this study we used a novel CSM rat model which has been developed in our laboratory. The animals were blindly and randomly divided into the following groups: 1) control group (n = 5), which received artificial cerebrospinal fluid (aCSF); 2) riluzole group (n = 7), which received riluzole; 3) decompression group (n = 7), which received decompression and aCSF (n = 7); 4) decompression-riluzole group (n = 7), which receive riluzole and decompression; and 5) sham group (n = 5). Decompression was achieved at 6 weeks postsurgery by removal of the C6 and the compression formation underneath it. Injections were performed in person daily for 7 weeks started at third week postoperatively. The MRI was performed twice: at 5 and 10 weeks postsurgery. Gait analysis was performed weekly using a computerized kinematic assessment (CatWalk). Immunohistochemistry techniques were used for detection of apoptosis between the experimental groups. Data were analyzed using analysis of variance (ANOVA) with Bonferonni post hoc analysis. **Results:** At 12 weeks postsurgery, the forelimb stride length of the control, riluzole, decompression, decompression-riluzole, and sham groups was 62.31 ± 6.99, 78.8 ± 5.88, 96.89 ± 7.89, 124.33 ± 7.14 and 145.76 ± 4.87, respectively. There was a statistically significant difference between decompression versus decompression-riluzole groups (p = 0.002), riluzole versus control groups (p < 0.05) and control versus decompression groups (p = 0.036). Moreover, the initial contact of the control, riluzole, decompression, decompression-riluzole, and sham groups was 3.78 ± 0.068, 2.895 ± 0.15, 1.98 ± 0.14, 1.02 ± 0.13 and 0.73 ± 0.091, respectively. There was a significant difference between decompression versus decompression-riluzole groups (p = 0.036), riluzole versus control groups (p < 0.05) and control versus decompression groups (p = 0.002). These results indicate that the decompression in combination with riluzole leads to significant increased attenuation of forelimbs and hindlimb spasticity and greater improvement in forelimbs dexterity compared with the decompression treatment alone. **Conclusion:** These results demonstrate for the first time that riluzole in synergy with the spinal cord decompression leads to better functional outcomes than the decompression alone in CSM. This work provides a scientific rationale to examine the synergistic effects of riluzole and decompressive surgery in patients with CSM (CSM Protect).

3.5.24

Visualizing plasticity and altered neuronal signalling in the injured human spinal cord with fMRI. ***D. Cadotte,*[*] *R. Bosma,*[†] *P. Stroman,*[†] *M. Fehlings.*[*]**
From the *University of Toronto, Toronto, Ont., and †Queen's University, Kingston, Ont.

Background: Evidence of central nervous system plasticity after traumatic spinal cord injury has been observed in animal models and human brain functional MRI (fMRI) studies. In this work, we conduct a spinal fMRI study and apply a functional connectivity analysis to determine whether or not the injured spinal cord processes sensory information differently than healthy controls. **Methods:** Using an automated thermal delivery system, heat (44°C) was applied to 2 dermatomes above and 2 below the level of spinal cord injury (SCI). Spinal fMRI data was collected on a 3T system using a security enhanced electronic payment-based protocol developed by our group (single-shot fast spin-echo, echo time 30 ms, repetition time 1 s). Data were spatially normalized and analyzed using the general linear model (p = 0.001). We divided the cervical spinal cord into zones based on known anatomic relationships of nerve rootlets entering the cord from the segmental nerve root. We conducted a functional connectivity analysis between the dorsal quadrant of the spinal cord corresponding to the stimulated dermatome and other regions of the spinal cord and brainstem. Clinical measures were conducted at the time of scan (American Spinal Injury Association [ASIA] examination). **Results:** A total of 35 people were examined: 20 controls, 9 incomplete SCI and 6 ASIA E patients. We demonstrate that dermatomes of abnormal sensation negatively correlate with the number of active voxels (R^2 = 0.93, p < 0.001). We show that the number of interspinal connections is significantly higher in incomplete SCI patients stimulated above the level of their injury in a dermatome of normal sensation (p = 0.045) in comparison to healthy controls. This was also observed in ASIA E patients (p = 0.03). **Conclusion:** For the first time, we report a graph theory analysis of spinal fMRI data to understand how neural networks change after spinal cord injury. We show for evidence for spinal plasticity in incomplete SCI patients; these plastic changes are evident in those who fully recover from their injury.