Canadian Journal of Surgery

Journal canadien de chirurgie

19th Annual Scientific Conference of the Canadian Spine Society

Wednesday, February 27 to Saturday, March 2, 2019

Fairmont Royal York
100 Front St. West
Toronto, Ontario
Canada

Abstracts

The Canadian Spine Society is a collaborative organization of spine surgeons advancing excellence in research, education and patient care.

Accreditation: This event is an Accredited Group Learning Activity (Section 1) as defined by the Maintenance of Certification Program of the Royal College of Physicians and Surgeons of Canada, approved by The Canadian Orthopaedic Association.

Course objectives: The Annual Scientific Conference of the Canadian Spine Society is a yearly review of the state of spine care in Canada providing a uniquely Canadian perspective on the treatment of spinal problems. Held jointly with the Canadian Paediatric Spine Society the meeting encompasses both adult and pediatric issues. Attendees will discuss and debate current concepts in both the surgical and nonoperative management of a wide range of spinal pathologies. This year the conference highlights means to achieve optimal patient care both before and after surgery: "prehabilitation" as well as rehabilitation. It examines the highly relevant subject of civility and professionalism in an increasingly confrontational society. The program takes a broad look at the contemporary pressures driving spine care from the impact of wait times to the influence of the latest technological advances. Topics encompass everything from breakthroughs in basic science to surgical manpower requirements. This meeting offers participants in the Canadian Spine Outcomes and Research Network (CSORN) a chance to come together and review ongoing research while exchanging ideas for future projects. This Annual Scientific Conference with its CME approved mix of didactic lectures, interactive symposia, hands-on product demonstrations and professional interaction is the most important spine meeting in Canada.

Conflict of interest: This information is available for all speakers presenting abstracts at the 19th Annual Scientific Conference of the Canadian Spine Society. To view, please refer to: PART II – COI Download, available online at www.spinecanada.ca.

CANADIAN PAEDIATRIC SPINE SOCIETY PRESENTATIONS

Surgical complications of anterior vertebral body growth modulation for skeletally immature patients with idiopathic scoliosis. *Abdulmajeed Alzakri[1,2], Marjolaine Roy-Beaudry[3], Isabelle Turgeon[3], Marie Beausejour[1,3], Olivier Turcot[1], Stefan Parent[1,3].* From the [1]Université de Montréal, Montreal, Canada; [2]King Saud University, Saudi Arabia; and [3]CHU Sainte-Justine, Montreal, Canada.

Background: Anterior Vertebral Body Growth Modulation (AVBGM) has been shown to have the potential to correct scoliosis while maintaining spine flexibility. We aim to report the minimum 2-year outcomes and surgical complications of AVBGM in skeletally immature patients. **Methods:** Fifty-three patients (50 female, 3 male) who underwent AVBGM between December 2013 and January 2017 were included. Inclusion criteria were idiopathic scoliosis and Lenke type 1A-C and 2A-B. We recorded demographics, perioperative data, radiographic outcomes and postoperative complications. **Results:** Mean follow-up was 33.4 ± 7.9 months. Preoperatively, 42 patients were Risser stage 0, 5 stage 1, 2 stage 2, and 4 stage 3. Mean age at surgery was 12 ± 1.3 years, with an average of 7.2 ± 0.8 vertebrae tethered per patient. Average Cobb angle was $49.4° \pm 11°$ preoperatively, $25.4° \pm 11°$ at 2 months, $17° \pm 12.4°$ at 16 months and $16° \pm 12.6°$ at last follow-up. Revision surgery was performed in 6 patients: 1 tether removal due to overcorrection, 1 lumbar tether added due to distal curve progression, 1 tether replaced due to breakage, 1 screw repositioning and 2 revised to a posterior spinal fusion due to progression. Sixteen (30%) patients had a suspected broken tether. Two patients had overcorrection that didn't require revision. Two patients had pneumothorax that developed after drain removal and resolved spontaneously. Two patients had a blood patch for small dural tear recognized postoperatively. **Conclusion:** This prospective study found a reoperation rate of 11% with otherwise good clinical and radiological outcomes. Understanding the surgical indications of AVBGM for progressive idiopathic scoliosis is critical to have a higher success rate of nonfusion treatment in the future. Although not necessarily requiring surgery, 16 patients were suspected to have a broken cable.

Do patients with anterior vertebral body growth modulation have a better quality of life than patients with a posterior spinal fusion? *Marjolaine Roy-Beaudry[1], Julie Joncas[1], Isabelle Turgeon[1], Abdulmajeed Alzakri[2,3], Stefan Parent[1,3].* From the [1]CHU Sainte-Justine, Montreal, Canada; [2]King Saud University, Saudi-Arabia; and [3]Université de Montréal, Montreal, Canada.

Background: Anterior Vertebral Body Growth Modulation (AVBGM) aims to gradually correct scoliosis, using the patient's growth, while preserving spine motion. We aimed to compare patients with idiopathic scoliosis (IS) undergoing correction with AVGBM with a matched cohort of patients with posterior spinal fusion (PSF). **Methods:** Prospectively collected clinical, perioperative and radiological data of 53 patients who underwent AVBGM at our institution were reviewed. Each AVBGM patient was matched to a PSF patient based on preoperative Cobb angle, sex and Lenke classification. Quality of life questionnaires (SRS-22, SF-12) were collected. Preoperative and 2-year postoperative data were analyzed. Paired t test and questionnaire scores were calculated for 49 patients with AVBGM who reached 2-year follow-up. **Results:** Patients were compared for preoperative Cobb angle (PSF: $53.5° \pm 8.2°$, AVBGM: $49.6° \pm 8.7°$), Lenke type and sex. The AVBGM cohort was younger (12.4 ± 1.2 yr v. 13.9 ± 2.4 yr). Two-year postoperative %correction showed similar rates for AVBGM and PSF (69% v. 73.1%, $p = 0.342$). Preoperative SRS-22 questionnaire analysis demonstrated that AVBGM patients had less pain ($p = 0.03$), a better self-image ($p = 0.005$) and a better total score ($p = 0.019$) than PSF patients. Preoperative SF-12 questionnaire analysis demonstrated that AVBGM patients had better social functioning ($p = 0.023$) than PSF patients. Postoperative SRS-22 questionnaire analysis demonstrated that AVBGM patients scored better in all domains. Postoperative SF-12 quesionnaire analysis demonstrated that AVBGM patients had better general health ($p = 0.025$), social functioning ($p = 0.041$) and role-emotional scores ($p = 0.05$) than PSF patients. AVBGM and PSF patients reached the minimal clinically important difference for the self-image domain. **Conclusion:** Although patients in the PSF group had slightly

larger preoperative curves, AVBGM patients showed a better quality of life 2 years postoperative while obtaining similar surgical correction rates. Their health-related quality of life was better before the surgery, and this trend persisted after surgery.

Reference values for 3D spinal dimensions in healthy boys and girls. *Marie Beauséjour[1], Paul Dallaire[1], Félix Thibeault[1], Ron El-Hawary[2], James O. Sanders[3], Burt Yaszay[4], Behrooz A. Akbarnia[4], Marjolaine Roy-Beaudry[1], Patrick Tohmé[1], Léonie Tremblay[1], Julien Bellefleur[1], Stefan Parent[1].* **From the [1]CHU Sainte-Justine Hospital Centre, Montreal, Canada; the [2]Izaak Walton Killam Health Centre, Halifax, Canada; [3]University of Rochester, Rochester, USA; and [4]Rady Children's Hospital, San Diego, USA.**

Background: There is a crucial gap in the knowledge of normative spinal growth in children. Our objective was to provide detailed and accurate 3D reference values for global and segmental spinal dimensions in healthy girls and boys younger than 11 years. **Methods:** Biplanar radiographic spine examinations conducted to rule out scoliosis in healthy children (3–11 yr) were reviewed in 4 scoliosis referral centres in North America. 3D reconstruction and computation of vertebral body heights and spine length were executed for 638 consecutive patients (397 girls, 241 boys). The Lambda-Mu-Sigma method was used to fit smooth 3D indices calibrated centile curves using Box-Cox Power Exponential distribution as a function of age (GAMLSS package for R). Centiles were then predicted from the computed models for selected ages. **Results:** Mid-vertebral body 3D True Spinal Length (3DTSL) between T1 and S1 medians (and interquartile ranges) were 284 (27) mm, 314 (25) mm and 349 (28) mm, respectively for the 3–5 yr, 6–8 yr and 9–11 yr groups. Centile curves for the 3DTSL (T1–S1) and for the mid-vertebral heights of T5, T12 and L3, for the 5th, 10th, 25th, 50th, 75th, 90th and 95th centiles were derived as a function of age separately for boys and girls. In general, boys presented linear relationships between spinal dimensions and age, and girls presented more diverging trends with increased variance for older ages. **Conclusion:** Accurate reference values were derived for spinal dimensions in healthy children. Spinal dimension charts showed that the spinal lengths and vertebral heights changed relatively constantly across the age groups, closely resembling World Health Organization body height charts. The reference values will help physicians better assess their patients' growth potential. It could also be used to predict expected spinal dimensions at maturity or changes in pathologic conditions and to assess the impact of growth friendly interventions in the correction of spinal deformities.

Preoperative hyperkyphosis predicts the development of proximal junctional kyphosis for patients with adolescent idiopathic scoliosis: results from the PORSCHE study. *Ron El-Hawary, Jason J. Howard, Jean A. Ouellet, Neil Saran, Edward P. Abraham, Neil Manson, Devin C. Peterson, Paul Missuna, Douglas M. Hedden, Yasser AlKhalife, Kedar P. Padhye, Vibhu Viswanathan, David L. Parsons, Fabio Ferri-de-Barros, James G. Jarvis, Paul J. Moroz, Stefan Parent, Jean-Marc Mac-Thiong, Jennifer K. Hurry, Ben Orlik, Kristen M. Bailey, Jill Chorney.* **From the IWK Health Centre, PORSCHE Study Group, Canadian Paediatric Spine Society, Halifax, Canada.**

Background: Proximal junctional kyphosis (PJK) is defined as adjacent segment kyphosis > 10° between the upper instrumented vertebrae and the vertebrae 2 levels above following scoliosis surgery. There are few studies investigating the predictors and clinical sequalae involved with this relatively common complication. Our purpose was to determine the radiographic predictors of postoperative PJK and to examine the association between PJK and pain/heatlh-related quality of life (HRQoL) following surgery for adolescent idiopathic scoliosis (AIS). **Methods:** The Postoperative Recovery after Scoliosis Correction: Home Experience (PORSCHE) study was a prospective multicentre cohort of AIS patients undergoing spinal fusion surgery. Preoperative and minimum 2-year fllow-up scoliosis and sagittal spinopelvic parameters (thoracic kyphosis [TK], lordosis [LL], pelvic tilt [PT], sacral slope [SS], pelvic incidence [PI]) were measured and compared with numeric rating scale for pain (NRS) score, SRS-30 HRQoL and to the presence or absence of PJK (proximal junctional angle > 10°). Continuous and categorical variables were assessed using logistic regression and binomial variables were compared with binomial outcomes using χ^2. **Results:** A total of 163 (137 female) patients from 8 Canadian centres met the inclusion criteria. At final follow-up, PJK was present in 27 patients (17%). Preoperative means for PJK v. no PJK were as follows: age 14.1 v. 14.7 yr; female 85% v. 86%; scoliosis 57° ± 22° v. 62° ± 15°; TK 28° ± 18° v. 19° ± 16° ($p < 0.05$); LL 62° ± 11° v. 60° ± 12°; PT 8° ± 12° v. 10° ± 10°; SS 39° ± 8° v. 41° ± 9°; PI 47° ± 14° v. 52° ± 13°; sagittal vertical axis (SVA) –9 ± 30 mm v. –7 ± 31 mm. Final follow-up for PJK v. no PJK measurements were as follows: scoliosis 20° ± 11° v. 18° ± 8°; final TK 26° ± 12° v. 19° ± 10° ($p < 0.05$); LL 60° ± 11° v. 57° ± 12°; PT 9° ± 12° v. 12° ± 13°; SS 39° ± 9° v. 41° ± 9°; PI 48° ± 17° v. 52° ± 14°; SVA –23 ± 26 mm v. –9 ± 32 mm ($p < 0.05$). Preoperative kyphosis > 40° was associated with development of PJK (odds ratio 4.41, 95% confidence interval 1.50–12.92; $p < 0.05$). The presence of PJK was not associated with any significant differences in NRS or SRS-30. **Conclusion:** This prospective, multicentre cohort of AIS patients demonstrated a 17% risk of developing PJK. Preoperative thoracic kyphosis > 40° was associated with the development of PJK; however, the presence of PJK was not associated with increased pain or decreased HRQoL.

Large deformity and postoperative pelvic incidence–lordosis matching predict improvements in pain for patients with adolescent idiopathic scoliosis: results from the PORSCHE study. *Ron El-Hawary, Jason J. Howard, Jean A. Ouellet, Neil Saran, Edward P. Abraham, Neil Manson, Devin C. Peterson, Paul Missuna, Douglas M. Hedden, Yasser AlKhalife, Kedar P. Padhye, Vibhu Viswanathan, David L. Parsons, Fabio Ferri-de-Barros, James G. Jarvis, Paul J. Moroz, Stefan Parent, Jean-Marc Mac-Thiong, Jennifer K. Hurry, Ben Orlik, Kristen M. Bailey, Jill Chorney.* **From the IWK Health Centre, PORSCHE Study Group, Canadian Paediatric Spine Society, Halifax, Canada.**

Background: It is well documented that there is wide variability in the treatment of postoperative pain in children at home following minor surgery. To date, there has been very little systematic, prospective research examining the severity, trajectory and treatment of children's pain at home following major surgery. The purpose of this research was to examine the radiographic predictors of

postoperative pain following surgery for adolescent idiopathic scoliosis (AIS). **Methods:** The Postoperative Recovery after Scoliosis Correction: Home Experience (PORSCHE) study evaluated preoperative and minimum 2-year follow-up scoliosis and sagittal spinopelvic parameters (thoracic kyphosis [TK], lordosis [LL], pelvic tilt [PT], sacral slope [SS], pelvic incidence [PI]). These variables were compared with "average" and "worst" numeric rating scale for pain (NRS) scores; NRS 0–3 = mild, 4–6 = moderate, 7–10 = severe. Continuous and categorical variables were assessed using logistic regression, and binomial variables were compared with binomial outcomes using χ^2. **Results:** A total of 190 (163 female) patients with a mean age of 14.6 (range 11–19) years from 8 Canadian centres met the inclusion criteria. Mean preoperative v. final measurements were as follows: scoliosis 61° ± 16° v. 18° ± 8° ($p < 0.05$); TK 21° ± 17° v. 20° ± 10°; LL 60° ± 12° v. 57° ± 12° ($p < 0.05$); PT 10° ± 11° v. 11° ± 13°; SS 41° ± 9° v. 41° ± 9°; PI 51 ± 13° v. 51° ± 15°; sagittal vertical axis (SVA) –7 ± 30 mm v. –11 ± 31 mm. Mean "worst" NRS was 4.8 preoperatively v. a final score of 1.6 ($p < 0.05$). Number of patients with "worst" preoperative v. final NRS scroes were as follows: mild 72 v. 102; moderate 48 v. 15; severe 65 v. 4. Significant findings were as follows: preoperative scoliosis > 80° was associated with having preoperative "average" NRS scores (moderate or severe) improve to mild at final follow-up (odds ratio [OR] 6.4, 95% confidence interval [CI] 1.1–35.6, $p < 0.05$); preoperative TK > 40° was associated with having preoperative "worst" NRS scores (severe) improve to mild or moderate at final follow-up (OR 4.7, 95% CI 1.1–19.3, $p < 0.05$); postoperative PI–LL > 10° was associated with having final follow-up "worst" NRS scores (moderate or severe) (OR 4.7, 95% CI 1.3–17.7, $p < 0.05$). **Conclusion:** AIS patients with large preoperative scoliosis or large preoperative TK should be counselled that their pain may improve postoperatively. Surgeons should ensure PI–LL matching postoperatively to minimize postoperative pain.

PODIUM PRESENTATIONS

33

Vertical Expandable Prosthetic Titanium Rib treatment of early-onset scoliosis in children without rib abnormalities: long-term results of a prospective, multicentre study. *Ron El-Hawary[1], Kevin Morash[1], Muayad Kadhim[1], Michael Vitale[2], John Smith[3], Amer Samdani[4], Jack Flynn[5]. From the [1]IWK Health Centre, Halifax, Canada; the [2]Columbia Presbyterian Hospital, New York, USA; the [3]University of Utah, Salt Lake City, USA; the [4]Philadelphia Shriner's Hospital, Philadelphia, USA; and the [5]Children's Hospital of Philadelphia, Philadelphia, USA.*

Background: In 2007, a prospective study on Vertical Expandable Prosthetic Titanium Rib (VEPTR) treatment of early-onset scoliosis (EOS) in children without rib abnormalities was initiated. Two-year follow-up results from this cohort have demonstrated that scoliosis is controlled and spinal growth continues. This study examines whether, at minimum 5-year follow-up, VEPTR continues to control scoliosis and allow spinal growth. **Methods:** A prospective, multicentre design was used. Participants underwent traditional VEPTR implantation ≥ 5 years before analysis. Preimplantation and last available images were compared, regardless of whether VEPTR remained in vivo. Additional analysis was performed if VEPTR was in vivo ≥ 5 years. **Results:** Fifty-nine patients (age at insertion 6.1 ± 2.4 yr) had a mean follow-up of 6.9 ± 1.4 years. Currently 24 patients still have VEPTR, 24 have converted (13 fusions, 6 magnetically controlled growing rods, 3 growing rods, 1 hybrid and 1 Shilla), 3 have had VEPTR explanted, 6 are status unknown and 2 are deceased. On last available imaging ($n = 59$; mean follow-up 4.8 ± 1.9 yr), scoliosis improved from 71.8° ± 18.0° preoperatively to 60.9° ± 20.3° ($p < 0.001$) and T1–T12 height increased (15.8 ± 3.2 cm to 19.3 ± 3.8 cm, $p < 0.001$). T1–S1 height increased (24.8 ± 4.4 cm to 31.2 ± 5.3 cm, $p < 0.001$), representing 119% age-matched growth. Composite improvement of scoliosis, T1–T12 and T1–S1 height was achieved in 79% of patients. A subset of 29 VEPTR patients was analyzed at most recent follow-up ≥ 5 years while VEPTR remained in vivo (24 VEPTR patients above, and 5 who later had VEPTR removed). Age at insertion was 5.0 ± 2.2 years, with mean VEPTR treatment duration of 6.2 ± 1.1 years. Scoliosis improved preoperatively (69.3° ± 14.5° to 61.6° ± 16.1°, $p = 0.006$), with mild recurrence from postoperative to 5 years. T1–T12 height increased (15.0 ± 3.3 cm to 18.7 ± 3.3 cm, $p < 0.001$) and T1–S1 height increased (23.7 ± 4.5 cm to 30.1 ± 4.6 cm, $p < 0.001$), representing 83% age-matched growth. Composite improvement was achieved in 83% of patients. Instrumented sagittal length also increased during this period (21.8 ± 4.2 cm to 30.3 ± 5.1 cm, $p < 0.001$). **Conclusion:** At minimum 5-year follow-up, VEPTR treatment continues to control scoliosis and allow spinal growth.

103

A prospective, multicentre analysis of the efficacy of anterior vertebral body tethering in the treatment of idiopathic scoliosis. *Firoz Miyanji[1], Jeff Pawelek[2], Luigi Nasto[1], Stefan Parent[3], Andrea Simmonds[1]. From the [1]BC Children's Hospital, Vancouver, Canada; the [2]Growing Spine Foundation, San Diego, USA; and the [3]Université de Montréal, Montreal, Canada.*

Background: Anterior vertebral body tethering (AVBT) has sparked interest as a possible alternative in the management of progressive idiopathic scoliosis (IS). To date, limited data are available regarding its efficacy and complication rate. Our aim was to evaluate clinical, radiographic and perioperative outcomes and complication rates to determine the efficacy of AVBT in skeletally immature IS patients. **Methods:** A retrospective review of all consecutive patients treated with AVBT at 2 centres with minimum 2-year follow-up was conducted using a prospective multicentre database. Clinical success was set a priori as major coronal curve size ≤ 30° at most recent follow-up. **Results:** Fifty-seven patients were analyzed. Mean surgical age was 12.7 (8.2–16.8) years, with majority female patients (95%), and mean follow-up was 29.2 (22.1–51.4) months. Mean preoperative major curve of 51° (32° to 81°) improved to 29° (5° to 63°) at first erect x-ray (mean 43% correction), with further correction to a mean 23° (-5° to 47°) at

most recent follow-up (55% 2-year curve correction, $p < 0.01$). Significant spontaneous curve correction was also observed in the uninstrumented curves on average by 31% ($p < 0.01$) at 2-year follow-up. Average estimated blood loss was 219 (50–650) mL, with no patient requiring allogeneic blood. Length of hospital stay was mean 4.7 (3.0–8.0) days. Clinical success was noted in 70% of patients at most recent follow-up. Fourteen complications were reported, with 6 unplanned revision surgeries in 5 patients: 3 reoperations for tether breakage, adding on, and overcorrection; and 3 conversions to fusion. Among those not requiring reoperation, 1 tether breakage, 2 persistent pain in the hip and shoulder, 1 superficial infection, and 4 respiratory issues were reported. **Conclusion:** AVBT was effective in obtaining clinical success in immature IS patients at minimum 2-year follow-up with an acceptable safety profile. Although initial results are promising, a 9.5% reoperation rate demonstrates the need for further scrutiny of AVBT regarding its true effectiveness and long-term risk in the surgical management of IS.

60

Variability in forces applied during traction films for scoliosis preoperative planning and correlation with two-year postoperative correction. *Jennifer Hurry, Alan Spurway, Benjamin Orlik, Ron El-Hawary.* **From the IWK Health Centre, Halifax, Canada.**

Background: Our objective was to quantify forces applied during traction radiographs and examine relationships between forces and curve reduction as well as correction during preoperative exams compared with actual postoperative correction. **Methods:** All preoperative scoliosis patients during a 1-year period were prospectively invited. The force applied during traction exams, preoperative standing and traction Cobb angles, postoperative Cobb angles, and patient demographics were assessed. **Results:** Thirty-one patients enrolled (23 female, 8 male, mean age 13.9 ± 3.9 [range 3.0–18.9] yr, and mean weight 48.5 ± 22.4 [range 13.1–107.7] kg). Twenty were idiopathic, 7 neuromuscular, 3 congenital, and 1 syndromic. Two orthopedic technologists pulled "firm but not painful" during traction exams, with an average force of 25.6 ± 8.1 kg. One technologist applied an average 16.5 kg ± 4.7 (range 10.9–24.1) kg and a second applied 30.1 kg ± 5.3 (range 21.3–43.1) kg ($p < 0.05$). There was a moderate correlation between applied traction forces and age ($r = 0.47$, $p < 0.05$), but none between force and weight ($r = 0.28$, $p = 0.17$) or Cobb angle change ($r = 0.10$, $p = 0.60$). There was a high correlation between the correction with traction and the pre- to postoperative correction for upper, thoracic and lumbar curves (r from 0.75 to 0.89, $p < 0.05$), whereas supine bending was significant for thoracic only ($r = 0.86$, $p < 0.05$). Both traction and bending results maintained correlation at 2-year follow-up for thoracic curves only. **Conclusion:** This study shows a variability in applied forces in preoperative traction exams, but the high correlation with postoperative curve reduction suggests the clinical goal has been reached. Knowing these forces could allow this exam to be moved to the EOS imager as well as further research may allow for patient-specific, measured traction forces, which could provide a quantitative measure of spine rigidity.

65

The evolution of scoliosis surgery: Which advancements have improved patient outcomes? *Michael Ching, Timothy Carey, Parham Rasoulinejad.* **From Western University, London, Canada.**

Background: Scoliosis corrective surgery has many risks and complications. The infection rate is 5%–10% and the reoperation rate is 20%–40%. Literature shows improved outcomes with 2 surgeons operating simultaneously v. 1 surgeon, with decreased complications and shorter hospital stay. No study has examined the reoperation rate with 2 surgeons. At London Spine Centre, halo-femoral traction, intraoperative 3D imaging, SmartLinks sequential rod reducers, bone scalpel, and simultaneous operation by 2 surgeons have been instituted over the last 10 years. The objective of this study was to determine the effect of these measures on the infection, complication, and reoperation rates. **Methods:** Retrospective review identified 262 scoliosis cases from 2007 to 2018. The inclusion criterion was scoliosis surgery. Exclusion criteria were staged surgeries, revision surgeries, incomplete data, growing rods, and placement of cages. Intraoperative records and clinic follow-ups were used to determine operative duration, number of screws, and complications. Outcomes were infection and complication rate, blood loss, and reoperation. Statistical analysis was performed with SPSS. **Results:** A total of 218 cases with a mean 2 years of follow-up were identified. Mean age was 15.5 ± 5.8 years; 181 (83%) were pediatric patients. Two surgeons were present for 101 (46%) cases. In all, 156 (71%) cases used traction, 45 (21%) cases used 3D imaging, 84 (39%) cases used SmartLinks, and 75 (34%) cases used the bone scalpel. The infection rate was 10% ($n = 23$), complication rate was 20% ($n = 44$), and reoperation rate was 18% ($n = 40$). Simultaneous operation by 2 surgeons was associated with a lower infection rate ($p = 0.006$), lower reoperation rate ($p = 0.006$), and shorter operations ($p = 0.04$). Traction was associated with a lower reoperation rate ($p < 0.001$). There were no statistically significant differences with 3D imaging, SmartLinks, or the bone scalpel. **Conclusion:** At London Spine Centre, 2 surgeons operating simultaneously decreased infection rate, reoperation rate, and operative duration. Halo-femoral traction was associated with lower reoperation rate. This study did not find any significant differences attributable to 3D imaging, SmartLinks, or the bone scalpel, and did not examine the degree of correction obtained. This presentation does not differentiate among causes of scoliosis.

34

Spinopelvic alignment affects health-related quality of life for patients with early-onset scoliosis. *Jaime Gomez[1], Jacob Shulz[1], Ozren Kubat[2], Jennifer Hurry[3], Alexandra Soroceanu[4], Tara Flynn[5], Myra Tovar[1], Regina Hanstein[1], Virginie Lafage[6], Frank Schwab[6], John Smith[7], David Skaggs[8], Ron El-Hawary[3].* **From the [1]Children's Hospital at Montefiore, New York, USA; the [2]University of Zagreb, Zagreb, Croatia; the [3]IWK Health Centre, Halifax, Canada; the [4]University of Calgary, Calgary, Canada; the [5]Children's Spine Study Group, Philadelphia, USA; the [6]Hospital for Special Surgery, New York, USA; the [7]University of Utah, Salt Lake City, USA; and the [8]Children's Hospital of Los Angeles, Los Angeles, USA.**

Background: The purpose of this study is to determine if spinopelvic parameters affect health-related quality of life (HRQoL) in patients with early-onset scoliosis (EOS). **Methods:** Severnty-five children from 2 EOS registries treated with rib- (n = 52) and spine-based (n = 23) distraction implants at a mean age of 5.4 years were evaluated using the EOS 24-Item Questionnaire (EOSQ-24) and radiographs at a mean follow-up of 4.5 years. Spinopelvic parameters were measured on anteroposterior and lateral radiographs. For HRQoL domains — general health, pain/discomfort, pulmonary function, transfer, physical function, daily living, fatigue, emotion, parental impact, satisfaction — scores ≥ 80 were considered good outcomes and scores < 80 poor outcomes. Scores were compared using unpaired t test; risk ratios were calculated and analyzed using χ^2 test. **Results:** Etiologies were as follows: 32 congenital, 20 idiopathic, 18 syndromic, 4 neuromuscular, 1 unknown. Preoperatively, major curve was 69°, thoracic kyphosis (TK) 40°, lumbar lordosis (LL) 51°, pelvic incidence (PI) 48°, and pelvic tilt (PT) 11°. At final follow-up, the major curve corrected to 55°, TK was 42°, LL 53°, PI 53° and PT 15°. Etiology affected general health (p = 0.007), as outcomes were poor in 56% of syndromic and 50% of neuromuscular patients compared with 25% of idiopathic and 9% of congenital patients. A postoperative PI–LL mismatch of > ± 20° increased the risk for poor outcomes (score < 80) in the following HRQoL domains: fatigue (RR 2.29, 95% CI 1.23–4.24, p = 0.01), pain (RR 1.70, 95% CI 1.07–2.71, p = 0.04), daily living (RR 2.37, 95% CI 1.17–4.82, p = 0.02), parental impact (RR 1.94, 95% CI 1.14–3.31, p = 0.002) and emotion (RR 1.82, 95% CI 1.03–3.22, p = 0.05). Postoperative LL > 70° increased the risk for high family burden (RR 1.88, 95% CI 1.17–2.87, p = 0.05) and postoperative PI > 60° negatively affected transfer (RR 1.76, 95% CI 1.24–13.25, p = 0.008). In contrast, pre- and postoperative TK > 40° decreased the risk for low pulmonary function (preoperative RR 0.202, 95% CI 0.05–0.84, p = 0.009; postoperative RR 0.313, 95% CI 0.10–1.03, p = 0.018). HRQoL was not affected by PT > 30°, implant type or fusion to pelvis. **Conclusion:** For children with EOS, postoperative PI–LL mismatch of more than ± 20° poses the greatest risk for low HRQoL.

99

Bone marrow concentration v. iliac crest bone graft: 2-year results in a single-blinded randomized controlled trial on thoracolumbar spinal fusion bone grafts in multi-level adult spinal deformity. *Peter Passias[1], Gregory Poorman[1], Samantha R. Horn[1], Cyrus Jalai[1], Frank A. Segreto[1], Cole Bortz[1], Avery Brown[1], Katherine Pierce[1], Haddy Alas[1], Nancy Worley[1], Sun Yang[1], Caroline Poorman[1], John Buza[1], Anthony Boniello[1], Alexandra Lee[1], Shaleen Vira[1], Bassel Diebo[1], Virginie Lafage[2], Frank Schwab[2], Themistocles Protopsaltis[1], Thomas Errico[1], Aaron Hockley[3].* **From the [1]Department of Orthopaedics, NYU Medical Center–Orthopaedic Hospital, New York, USA; the [2]Department of Orthopaedic Surgery, Hospital for Special Surgery, New York, USA; and the [3]University of Alberta, Edmonton, Canada.**

Background: The goal of this study was to compare the efficacy of bone marrow concentration (BMC)+allograft to iliac crest bone graft (ICBG) used in multilevel posterior fusion for lumbar or thoracolumbar deformity in high-risk patients for nonunion. **Methods:** Patients older than 18 years being surgically treated for adult spinal deformity were randomized in a 2:1 ratio into 2 study arms with respect to graft adjunct: BMC+allograft or ICBG. All patients received posterior lumbar fusion performed by an open posterior approach. Clinical data, health-related quality of life scores, and full-length radiographs were compared using t tests at baseline, 6 weeks, 3 months, 6 months, 1 year, and 2 years postoperative. Fusion assessment was performed using 1-year computed tomography scans by 2 independent radiologists. **Results:** Twenty-seven patients were randomized in a 2:1 fashion consisting of 17 patients receiving BMC+allograft and 10 receiving ICBG. Average fusion construct spanned 6.1 intervertebral levels. Within the 2-year follow-up period, there were 7 complications in the BMC+allograft group (41.1%) and 4 in the ICBG group (40%). ICBG patients had greater incidence of rod breakage (BMC+allograft 0% v. ICBG 25%, p = 0.024). In total, 88.2% of BMC+allograft and 60% of ICBG patients were graded "fused" at 1-year follow-up (p = 0.088). **Conclusion:** In long fusions for adult spinal deformity, where autologous graft is limited, bone marrow concentrated via centrifuge is a viable alternative to iliac crest bone graft. The current study found a decrease in implant failures in patients with BMC+allograft compared with ICBG, and a trend toward better fusion scores (p < 0.1).

139

The impact of surgical reduction of high-grade lumbosacral spondylolisthesis on quality of life. *Jean-Marc Mac-Thiong[1,2,3], M. Timothy Hresko[4], Abdulmajeed Alzakri[3], Stefan Parent[1,2], Dan J. Sucato[5], Lawrence G. Lenke[6], Michelle Marks[7], Hubert Labelle[1,2].* **From the [1]CHU Sainte-Justine, Montreal, Canada; the [2]Université de Montréal, Montreal, Canada; the [3]Hôpital du Sacré-Coeur de Montréal, Montreal, Canada; the [4]Boston Children's Hospital, Boston, USA; the [5]Texas Scottish Rite Hospital, Dallas, USA; the [6]The Spine Hospital New York-Presbyterian, New York, USA; and the [7]Setting Straight Scoliosis Foundation, San Diego, USA.**

Background: Surgical reduction of high-grade lumbosacral spondylolisthesis is often performed in young patients. However, reduction criteria leading to optimal outcomes have yet to be defined. The purpose of this study is to determine if surgical reduction of pelvic balance, slip grade, lumbosacral angle and L5 incidence are associated with quality of life after surgery. **Methods:** A prospective cohort of 61 patients (age 14.4 ± 2.7 yr) with high-grade lumbosacral spondylolisthesis was followed for a minimum of 2 years after surgery. SRS-22 quality of life questionnaire scores, slip grade, lumbosacral angle, pelvic balance and L5 incidence were assessed before surgery and at latest follow-up. Multivariable regression analyses were performed with postoperative SRS-22 scores as dependent variables. Independent variables consisted of preoperative SRS-22 scores, pelvic balance, slip grade, lumbosacral angle and L5 incidence. The influence of slip grade, lumbosacral angle and L5 incidence on pelvic balance was also assessed. **Results:** Achieving a balanced pelvis postoperatively was mainly predictive of improved satisfaction and self-image, and tended to be associated with higher scores for other domains. Improved mental health was associated with reduction

to a low-grade slip, but reduction of lumbosacral angle was not predictive of quality of life. Postoperative pelvic balance was mainly associated with preoperative pelvic balance, although there was a tendency for achieving normal pelvic balance when the postoperative L5 incidence was 60° or smaller. **Conclusion:** Achieving normal pelvic balance is important when performing surgery in young patients with high-grade lumbosacral spondylolisthesis because it is associated with improved quality of life. Reduction to a low-grade slip is predictive of improved mental health, but reduction of lumbosacral angle is not associated with postoperative quality of life. There was a tendency for obtaining normal postoperative balance in patients with postoperative L5 incidence 60° or smaller. Future studies should attempt to identify reduction techniques that can reliably restore or maintain pelvic balance after surgery.

20

Demographics, presentation and symptoms of patients with Klippel–Feil syndrome: analysis of a global patient reported registry. *Aria Nouri[1,2], Kishan Patel[2], Hardy Evans[1], Mohamed Saleh[1], Mark Kotter[3], Robert Heary[4], Enrico Tessitore[5], Michael Fehlings[6], Joseph Cheng[1].* From the [1]University of Cincinnati, Cincinnati, USA; [2]Yale University, New Haven, USA; the [3]University of Cambridge, Cambridge, UK; [4]Rutgers University, Newark, USA; the [5]University of Geneva, Geneva, Switzerland; and the [6]University of Toronto, Toronto, Canada.

Background: Klippel–Feil syndrome (KFS) occurs due to failure of vertebral segmentation during development. Minimal research has been done to understand the prevalence of associated symptoms and pain. It is therefore the objective of the present study to address this knowledge gap by investigating one of the largest collections of KFS patient data. **Methods:** Data were obtained from the CoRDS registry. Participants with cervical fusions were categorized into type I, II, or III based on the Samartzis criteria. Symptoms and comorbidities were assessed against type and location of fusion. **Results:** Seventy-five patients (60 female, 14 male, 1 unknown) were identified and classified as type I ($n = 21$, 28%), type II ($n = 15$, 20%), or type III ($n = 39$, 52%). Cervical fusions by level were OC–C1 ($n = 17$, 22.7%), C1–C2 ($n = 24$, 32%), C2–C3 ($n = 42$, 56%), C3–C4 ($n = 30$, 40%), C4–C5 ($n = 42$, 56%), C5–C6 ($n = 32$, 42.7%), C6–C7 ($n = 25$, 33.3%), and C7–T1 ($n = 13$, 17.3%). In total, 94.6% of patients reported current symptoms, and the average age when symptoms began and worsened was 17.5 ± 13.4 and 27.6 ± 15.3, respectively. Patients reported an average of 12.5 ± 7.1 comorbidities, and 12.2 ± 6.3 general and chronic symptoms. Sprengel deformity was reported in 26.7%. Multilevel fusions (Samartzis II or III) were associated with dizziness ($p = 0.040$), limited range in spine motion ($p = 0.022$), and Sprengel deformity ($p = 0.036$). Patients with cervical fusions in the upper region were more likely to report missing ribs ($p = 0.018$), craniocervical junction (CCJ) abnormalities ($p = 0.022$), cervical instability ($p = 0.001$), and mirror movements in hand ($p = 0.041$). Those with cervical fusions in the middle region were more likely to report osteoarthritis ($p = 0.019$) and headaches, migraines, and/or head pain ($p = 0.007$). Those with cervical fusions in the lower region were more likely to report mirror movements in hand ($p = 0.026$), spina bifida occulta ($p = 0.029$) and cord tethering ($p = 0.049$). **Conclusion:** KFS is associated with multiple musculoskeletal and neurologic problems.

Fusions are more prevalent toward the centre of the cervical region, and less common at the occipital and thoracic junctions. Associated comorbidities including Sprengel deformity may be more common with multilevel cervical fusions.

32

Can distraction-based surgeries achieve minimum 18 cm thoracic height for patients with early onset scoliosis? *Yehia El-Bromboly[1], Jennifer Hurry[2], Charles Johnston[3], Anna McClung[4], Amer Samdani[5], Michael Glotzbecker[6], Tricia St. Hilaire[7], Tara Flynn[7], Ron El-Hawary[2].* From the [1]Zagazig University, Zagazig, Egypt; the [2]IWK Health Centre, Halifax, Canada; the [3]Texas Scottish Rite Hospital for Children, Dallas, USA; the [4]Growing Spine Study Group, San Diego, USA; the [5]Philadelphia Shriner's Hospital, Philadelphia, USA; the [6]Boston Children's Hospital, Boston, USA; and the [7]Children's Spine Study Group, Philadelphia, USA.

Background: It has been proven in previous studies that thoracic height has a strong correlation with pulmonary function. Karol and colleagues introduced the concept that 18 cm thoracic height is the critical point where a patient could maintain adequate pulmonary function. Our purpose was to determine if distraction-based surgeries will increase thoracic spine height to at least 18 cm in patients with early-onset scoliosis (EOS). **Methods:** Patients with EOS treated with distraction-based systems (minimum 5-year follow-up, minimum 5 lengthenings) were included. We performed a radiographic analysis of the thoracic spine height (T1–T12) at the last lengthening procedure. **Results:** We included 135 patients (25 idiopathic, 59 congenital, 32 syndromic, 19 neuromuscular) with preoperative mean age of 4.7 years, scoliosis 74°, kyphosis 44°. Mean age at final lengthening procedure was 11 (range 6–16.2) years, average number of lengthening procedures was 11 (range 5–21), mean final scoliosis was 55°, and kyphosis was 55°. Final thoracic height was > 18 cm in 65% ($n = 87$) and > 22 cm in 30% ($n = 41$) of patients. Based on etiology, only 48% of the congenital patients reached 18 cm compared with 80% neuromuscular, 86% syndromic and 68% idiopathic. This spine height gain was closely related to the percentage of scoliosis correction achieved for each etiology. Comparing congenital etiology to other etiologies, there was a lower percentage of patients in the congenital group who passed the 18 cm threshold (48% v. 77%, $p < 0.05$). **Conclusion:** At minimum 5-year follow-up, distraction-based surgeries increased thoracic spine height for patients with EOS to > 18 cm in 65% of patients; however, only 48% of congenital patients reached this thoracic spine height threshold.

79

Health state utility values in cerebral palsy patients following deformity surgery: Are we now ready for cost–utility analysis in this patient population? *Firoz Miyanji[1], Luigi Nasto[1], Michelle Marks[2], Paul Sponseller[3], Amer Samdani[4], David Clements[5], Unni Narayanan[6], Peter Newton[7], Andrea Simmonds[1].* From the [1]BC Children's Hospital, Vancouver, Canada; the [2]Harms Study Group, San Diego, USA; [3]Johns Hopkins Medicine, Baltimore, USA; the [4]Shriners Hospital for Children, Philadelphia, USA; [5]Cooper University Health Care, Camden, USA; [6]The Hospital for Sick Children, Toronto, Canada; and the [7]Rady Children's Specialists of San Diego, San Diego, USA.

Background: Cost–utility analysis (CUA) can quantify the economic value of surgery. Health state utilities (HSU) provide a value to health outcomes and are used in calculating quality-adjusted life-years. Disease-specific health-related quality of life (HRQoL) measures commonly lack preference weights necessary to produce HSU values for use in CUA. A solution is to map a disease-specific HRQoL measure to a generic preference-based measure. Our aim was therefore to develop HSU values for patients following scoliosis surgery for cerebral palsy (CP) by mapping disease-specific CPCHILD outcome scores to the preference-based Health Utility Index (HUI) questionnaire. **Methods:** A prospective, multicentre CP scoliosis surgical database identified consecutive patients with ≥ 2-year follow-up who completed both CPCHILD and HUI preoperatively and at 2-year follow-up. Spearman correlations between paired CPCHILD and HUI utility scores were calculated. Ordinary least squared regression models were constructed to estimate HUI utility values from CPCHILD scores. Influence of age, sex, weight, Gross Motor Function Classification System (GMFCS) level, and major coronal Cobb angle was explored for predictive accuracy. The regression model was developed using preoperative data, while 2-year follow-up data were used for confirmatory analysis and goodness of fit. **Results:** A total of 232 patients were included. Several significant correlations between CPCHILD scores and HUI utility were noted. Strongest correlation was observed between HUI total score and CPCHILD communication (ρ = 0.646, p < 0.001), HUI pain and CPCHILD comfort (ρ = 0.644, p < 0.001), and HUI cognition and CPCHILD communication (ρ = 0.585, p < 0.001). (R^2 0.442, root-mean-square error 0.185). The mean difference of means between observed HUI values and calculated HUI values at 2 years was 0.005 points (ρ = 0.708). **Conclusion:** We demonstrate that HUI scores can be accurately predicted using the CPCHILD questionnaire. This mapping algorithm will be useful in estimating HSU in clinical trials of CP patients undergoing scoliosis surgery to help better inform all stakeholders of the economic impact of surgery.

141

Understanding and managing neuromonitoring changes during spinal deformity surgery. *Stephen Lewis[1], Ian Wong[1], Christopher Nielsen[2], Hailey Bensky[1], Samuel Strantzas[1], Laura Holmes[1].* **From the [1]Hospital for Sick Children, Toronto, Canada; and the [2]Toronto Western Hospital, Toronto, Canada.**

Background: Intraoperative multimodality neuromonitoring (IONM) has been established as the standard adjunct to spinal deformity surgery. Despite its universal acceptance and use, there remains significant controversy into what constitutes a neuromonitoring change, what significance that change represents, what actions should be taken in response to the change, and which factors led to the changes. **Methods:** A retrospective review of prospectively collected neuromonitoring data in pre-established forms on consecutive patients undergoing spinal deformity surgery was performed. The inclusion criteria were pediatric patients with a minimum of 50° primary coronal deformity for idiopathic or syndromic causes. All patients underwent posterior column osteotomy (PCO) or intraoperative traction with motor-evoked and somatosensory-evoked

monitoring. **Results:** A total of 97 patients (71 females and 26 males) with a mean age of 14.9 (range 11–18) years were included in this study. There were 39 alerts in 27 patients (27.8% overall incidence). Significant differences were noted among the groups with no motor-evoked potential (MEP) changes (n = 70) v. those with MEP changes (n = 27) based on mean Cobb angle (76.6° v. 84.4°), and in patients who underwent PCOs (25.7% v. 51.9%). IONM alerts were divided into 2 subgroups: cases involving spinal cord perfusion deficits and those occurring as a result of direct trauma to the cord. All perfusion-based changes (n = 23) involved bilateral MEP loss without somatosensory-evoked potential (SSEP) loss. Direct trauma (n = 16) resulted in unilateral MEP alerts, with 2 cases having SSEP changes as well. All bilateral changes responded to a combination of transfusion, increasing blood pressure, and rod removal. Unilateral changes as a result of direct trauma, mainly during decompressions, resolved with removal of the causative agent and time. **Conclusion:** A high incidence of alerts occurred in our series. Dividing IONM changes into perfusion-based v. direct trauma helped direct treatment to the offending cause, allowing for safe corrections of the deformities. Patients did not need to recover signal to baseline to have a normal neurologic examination. Careful monitoring and management helped to maintain spinal cord perfusion in the perioperative period.

31

Pain and functional outcomes following scoliosis surgery in adolescents: a latent growth mixture modelling analysis. *Kristin Bailey[1], Jill Chorney[1], Jason Howard[2], Ron El-Hawary[1].* **From the [1]IWK Health Centre, Halifax, Canada; and the [2]Sidra Medicine, Doha, Qatar.**

Background: Our study objectives were to describe postsurgical pain trajectories using repeated assessments during the first postsurgical year and to compare functional outcomes across trajectories. **Methods:** We included 220 children aged 10–18 years who underwent posterior spinal fusion and instrumentation for adolescent idiopathic scoliosis. Participants completed assessments before surgery and at 6 postsurgical time points. Measures of average pain intensity, general and health-related quality of life and functional disability were administered. Latent class growth mixture modelling was used to produce a 3-trajectory model of the data that included baseline pain as a covariate. **Results:** The majority of the sample (48.6%, n = 98) was grouped into a trajectory labelled "moderate pain with good resolution." A large portion of the sample (38.6%, n = 78) was grouped into a trajectory labelled "mild pain with good resolution," and the smallest portion of the sample (12.9%, n = 26) was grouped into a trajectory labelled "moderate pain with incomplete resolution." A series of 1-way analyses of variance showed significant differences among the trajectories on functional outcomes, with individuals in the "moderate pain with incomplete resolution" trajectory having the poorest outcomes. **Conclusion:** Our findings suggest that most individuals with early postoperative pain can experience good recovery. A small subset of children demonstrated less complete recovery and lower functioning; the clinical implications of these findings should be evaluated.

132

Association between the molecular profiles and health outcomes in patients followed in a pediatric scoliosis clinic. *François Vaillancourt[1,2], Marie Beauséjour[2,3], Stefan Parent[2,3,4], Hubert Labelle[2,3,4], Julie Joncas[2,4], Anita Franco[2], Marjolaine Roy-Beaudry[2], Alain Moreau[2,5,6]*. **From the [1]Orthopaedic Surgery Residency Program, Université de Sherbrooke, Sherbrooke, Canada; the [2]Sainte-Justine University Hospital Research Centre, Montreal, Canada; the [3]Department of Surgery, Université de Montréal, Montreal, Canada; the [4]Orthopedic Division, Sainte-Justine University Hospital, Montreal, Canada; the [5]Department of Stomatology, Faculty of Dentistry, Université de Montréal, Montreal, Canada; and the [6]Department of Biochemistry and Molecular Medicine, Faculty of Medicine, Université de Montréal, Montreal, Canada.**

Background: It is currently difficult to identify children at higher risk of scoliosis progression. Treatments are less than optimal and based on the evaluation of an already developed deformity; better diagnostic and prognostic methods are needed. The objective of this study was to determine if molecular profiles are associated with differential spinal health outcomes in pediatric patients with idiopathic scoliosis. **Methods:** This was a retrospective cohort study evaluating spinal health outcomes in patients aged 5–21 years followed at Sainte-Justine University Hospital Centre. Data from clinical and radiological examinations were collected. Blood tests were done to stratify 563 patients into 3 biological endophenotypes or functional groups (FG1, FG2, FG3) corresponding to the maximal G-inhibitory response to melatonin stimulation in a cell-based assay. The main outcome was the maximum angle of the scoliosis curve (Cobb angle) attained at maturity. The second outcome described whether the patient reached severe curve size (45°) and/or had corrective surgery for scoliosis. Multivariate analyses were performed to evaluate the association between the molecular profiles and each outcome. **Results:** The bivariate analysis provided evidence that both outcomes were less favourable for the FG1 group (27.0° of maximum Cobb angle at maturity and 21.2% reaching 45° during follow-up or going through corrective surgery) compared with the FG3 group (23.9°, 11.2%). In a multivariate model, when controlling for all the confounding factors, there was a tendency toward higher Cobb angles at maturity for FG1 and FG2 patients ($p = 0.056$ and $p = 0.05$, respectively) compared with FG3 patients. There was clear evidence of increased likelihood of reaching 45° and/or going through spinal fusion for FG1 and FG2 patients compared with FG3 patients (odds ratio [OR] 2.181, 95% confidence interval [CI] 1.002–4.749 and OR 2.141, 95% CI 1.038–4.413, respectively). **Conclusion:** After controlling for independent predictors of severity outcomes and potential confounders, associations were identified between endophenotype classification groups and clinical outcomes. Patients classified as FG3 seem to have a more favourable outcome.

73

Impact of age on outcomes following degenerative scoliosis surgery. *Mina Aziz[1], Peter Jarzem[1], Greg McIntosh[2], Michael Weber[1]*. **From [1]McGill University, Montreal, Canada; and the [2]Canadian Spine Outcomes and Research Network, Markdale, Canada.**

Background: Seniors make up 16.9% of the Canadian population. The number of Canadians who are 65 years or older is increasing at an average rate of 20% every 5 years. In 2017, Sing and colleagues reported that there is an increasing number of patients undergoing degenerative scoliosis surgery, with the largest increase attributed to patients aged 65–69 years, followed by those aged 70–74 years. The purpose of this study was to assess the effectiveness of undergoing spinal surgery to correct degenerative spinal scoliosis in elderly v. nonelderly patients. We hypothesized no significant difference in outcomes between age groups following degenerative scoliosis surgery. **Methods:** A retrospective review of prospectively collected data within the Canadian Spine Outcomes and Research Network (CSORN) database was conducted. Analysis of variance was used to analyze continuous variables, while the χ^2 test was used to analyze categorical variables. Significance level was $p < 0.05$. **Results:** There were 165 patients identified from the registry who had undergone surgery to treat degenerative scoliosis; 94 patients (57%) were female, and 102 (61.8%) patients were 65 years or older. The average age was 66.6 ± 8.6 (range 35–84) years. There were 27 intraoperative complications, 44 perioperative complications and 18 postoperative complications. There was no statistically significant difference between the 2 age groups with regards to risk of developing intraoperative, perioperative and postoperative complications. Elderly patients who underwent degenerative scoliosis surgery reported an average improvement of 2.90 ± 3.23, 4.01 ± 3.58, and 15.19 ± 20.85 points compared with an average improvement for patients younger than 65 years of 3.04 ± 3.50, 3.00 ± 3.30, and 19.55 ± 19.66 points on the back pain scale, leg pain scale and the Oswestry Disability Index, respectively. There were no statistically significant differences in these measures between the 2 age groups. **Conclusion:** As the number of patients undergoing degenerative scoliosis surgery increases, clinicians will need to determine which factors will significantly affect patients' outcomes. This study shows that outcomes following degenerative scoliosis surgery are not associated with age.

149

Preoperative CT surface-merge navigation improves safety of pedicle screw placement in the treatment of adolescent idiopathic scoliosis. *Diego Tourn[1], Andrew Tice[1], James Jarvis[1], Tony Card[1], Kevin Smith[1,2]*. **From the [1]Children's Hospital of Eastern Ontario, Ottawa, Canada; and the [2]University of Ottawa, Ottawa, Canada.**

Background: The use of pedicle screws for the treatment of adolescent idiopathic scoliosis (AIS) is the fixation of choice for many surgeons. Various methods of pedicle screw insertion have been described, including freehand and navigation-guided techniques. The safety and complications of these techniques have been investigated, with medial breeches posing the highest risk of neurologic deficits. Furthermore, breeches may be described by intraoperative palpation, screw electrical stimulation, or postoperative imaging. This study evaluates screw placement by intraoperative surface-merge navigation compared with freehand technique using intraoperative screw stimulation to detect medial breeches. **Methods:** A single-centre retrospective chart review between April 2014 and September 2018 of posterior spinal instrumentation and fusion (PSF) for AIS was conducted. Two patient groups were based on a transition in practice:

freehand and navigation using preoperative computed tomography (CT) with intraoperative surface-merge navigation. All screws were tested with intraoperative electrical stimulation for the detection of breeches. Charts were reviewed for reported breeches, changes in motor-evoked potentials (MEP) or somatosensory-evoked potentials (SSEP) and postoperative clinical neurologic deficits. **Results:** There were 154 patients who had PSF for AIS: 83 in the freehand group and 71 in the navigation group. They were equivalent for age, preoperative Cobb angle, correction percentage, levels fused and estimated blood loss. A total of 2606 screws were placed: 1418 freehand and 1188 with navigation. The micro-breech rate was 4.4% in the freehand group and 3.5% in the navigation group ($p < 0.0001$). The frank-breech rate was 0.71% in the freehand group and 0.59% in the navigation group ($p = 0.035$). The total breech rate was 5.1% in the freehand group and 4.0% in the navigation group ($p < 0.0001$). In the freehand group there was 1 SSEP change, 9 MEP changes and no clinical neurologic deficits. In the navigation group there were no SSEP, MEP or clinical neurologic changes. **Conclusion:** Preoperative CT surface-merge navigation decreases the incidence of medial breeches measured by intraoperative screw stimulation compared with the freehand technique in AIS patients treated with PSF.

10

Effect of tobacco smoking on implant failure rate and risk of intraoperative bleeding: analysis of 270 patients from the prospective, multi-centre SCOLI-RISK-1 study of complex adult spinal deformity surgery. *Jamie Wilson[1], Frank Jiang[1], Christopher Shaffrey[2], Justin Smith[3], Leah Carreon[4], Kenneth Cheung[5], Benny Dahl[6,7], Stephen Lewis[1], Lawrence Lenke[8], Michael Fehlings[1]. From the [1]University of Toronto Spine Program, Toronto, Canada; the [2]Department of Neurosurgery, Duke University, Durham, USA; the [3]Department of Neurosurgery, University of Virginia, Charlottesville, USA; the [4]University of Louisville, Louisville, USA; the [5]Department of Orthopaedics and Traumatology, University of Hong Kong, Hong Kong; the [6]Division of Orthopedic Surgery, Texas Children's Hospital, Baylor College of Medicine, Houston, USA; [7]Rigshospitalet, National University of Denmark, Copenhagen, Denmark; and the [8]Department of Orthopedic Surgery, The Spine Hospital, Columbia University Medical Center, New York, USA.*

Background: Our objective was to determine the effect of tobacco smoking on the perioperative and long-term complications of patients undergoing complex adult spinal deformity surgery in the SCOLI-RISK 1 study. **Methods:** The SCOLI-RISK-1 study enrolled 272 patients who had undergone complex adult spinal deformity surgery at 15 centres, with a minimum 2-year follow-up. The outcomes and incidence of adverse events in patients with a history of smoking ($n = 26$) were compared with those of the nonsmoking patients ($n = 244$) using univariable analysis. Multivariable regression analysis was used to adjust for the effect of patient demographics, complexity of surgery and other confounders. **Results:** No difference was observed in the number of levels or complexity of surgery in both cohorts. In the univariable analysis, the rates of implant failure were almost double ($n = 7$, 26.9%, odds ratio [OR] 2.28,

95% confidence interval [CI] 0.75–6.18) that observed in the nonsmoking group ($n = 34$, 13.9%, $p = 0.088$), but this was not statistically significant. Surgery-related excessive bleeding was, however, significantly higher in the smoking group ($n = 5$ v. 9, 19.2% v. 3.7%, OR 6.22 95% CI 1.48–22.75, $p = 0.006$). Wound infection rates were similar ($n = 3$ v. 17, 11.5% v. 7.0%, OR 1.74, 95% CI 0.30–6.70, $p = 0.422$), as were rates of respiratory complications ($n = 1$ v. 13, 3.8% v. 5.3%, OR 0.71, 95% CI 0.02–5.13, $p > 0.99$). In the multivariable analysis, the smoking group demonstrated a higher incidence of surgery-related adverse events over 2 years ($n = 13$ v. 95, 50.0% v. 38.9%, OR 2.12, 95% CI 0.88–5.09, $p = 0.094$), but this was not statistically significant. **Conclusion:** Smoking significantly increased the risk of excessive intraoperative bleeding. The rate of implant failure was higher (but not significantly) in smokers, as was the rate of all postoperative surgery-related adverse events. Even though this subanalysis was likely underpowered, we recommend smokers undergo an active smoking cessation program before undergoing complex adult spinal deformity surgery.

81

Outpatient 1-, 2- or 3-level anterior cervical discectomy and fusion procedures have similar complication rates and outcomes compared with overnight stay: analysis of 284 patients in the public health care setting. *Jamie Wilson[1], Frank Jiang[1], Jessica Bauer[2], Hetshree Joshi[2], Pang Hung Wu[1], Eric Massicotte[1]. From the [1]University of Toronto Spine Program, Toronto, Canada; and the [2]Spinal Cord Injury Clinical Research Unit, Toronto Western Hospital, Toronto, Canada.*

Background: Our objective was to assess the safety and efficacy of day surgery for 1-, 2- or 3-level anterior cervical discectomy and fusion (ACDF) at a single Canadian institution. **Methods:** A retrospective review of the inpatient spine surgery database of a single Canadian institution over 13 years was performed to compare the complication and readmission rates of patients undergoing day surgery or short-stay ACDF. Regression analysis was used to assess outcomes at 2 months and 2 years postsurgery with the Neck Disability Index (NDI). **Results:** In total, 143 patients underwent ACDF with intention to treat (ITT) as a day surgery procedure, with 130 admitted for short stay (24 h). The day surgery cohort included 73 single-, 51 2-level, and 19 3-level patients. The short stay cohort included 55 single-, 45 2-level, 29 3-level, and 1 4-level procedures. Six patients (4%) with the ITT as day surgery were admitted for overnight stay or longer (range 2–21 d). Intraoperative dural tear was reported in 8 patients (5.8%) in the day surgery group (4 required admission), compared with 4 patients (3.1%) in the short stay group (odds ratio [OR] 1.81, 95% confidence interval [CI] 0.53–6.2, $p = 0.5$). One patient (0.7%) in the day surgery group suffered a permanent postoperative neurologic deficit compared with 0 patients in the short stay group ($p > 0.99$). Three patients (2.1%) in the day surgery group and 2 patients (1.5%) in the short stay group required readmission within 30 days (OR 1.36, 95% CI 0.22–8.3, $p > 0.99$). Regression analysis showed no significant differences in the 2-month and 2-year outcomes post-ACDF between groups ($p = 0.796$ and $p = 0.315$, respectively) after accounting for total number of levels. **Conclusion:** Day surgery ACDF for 1-, 2- or

3-level procedures does not have a significantly higher rate of complications, readmission within 30 days, or differences in short- and long-term outcomes when compared with overnight stay. This provides evidence that day surgery ACDF is a safe and effective treatment option in the public health care setting.

55

The safety and efficacy of riluzole in enhancing clinical outcomes in patients undergoing surgery for cervical spondylotic myelopathy: results of the CSM-Protect double-blinded, multi-centre randomized controlled trial in 300 patients. *Michael Fehlings[1], Branko Kopjar[2], Jetan Badhiwala[1], Henry Ahn[3], H. Francis Farhadi[4], Christopher Shaffrey[5], Ahmad Nassr[6], Praveen Mummaneni[7], Paul Arnold[8], Bradley Jacobs[9], K. Daniel Riew[10], Michael Kelly[11], Darrel Brodke[12], Alexander Vaccaro[13], Alan Hilibrand[13], Jason Wilson[14], James Harrop[13], S. Tim Yoon[15], Kee Kim[16], Daryl Fourney[17], Carlo Santaguida[18].* **From the [1]University of Toronto, Toronto, Canada; [2]University of Washington, Seattle, USA; [3]St. Michael's Hospital, Toronto, Canada; [4]Ohio State University, Columbus, USA; [5]University of Virginia, Charlottesville, USA; the [6]Mayo Clinic, Rochester, USA; the [7]University of California San Francisco, San Francisco, USA; the [8]University Medical Center Kansas City, Kansas City, USA; the [9]University of Calgary, Calgary, Canada; [10]Columbia University, New York, USA; [11]Washington University, St. Louis, USA; [12]University of Utah, Salt Lake City, USA; [13]Thomas Jefferson University, Philadelphia, USA; [14]Louisiana State University, New Orleans, USA; [15]Emory University, Atlanta, USA; the [16]University of California San Diego, San Diego, USA; the [17]University of Saskatchewan, Saskatoon, Canada; and [18]McGill University, Montreal, Canada.**

Background: Cervical spondylotic myelopathy (CSM) is the most common cause of spinal cord dysfunction in adults. Surgical decompression improves clinical outcomes; however, many patients have residual disability. We hypothesized that adjuvant treatment with the sodium-glutamate blocker riluzole may be effective in enhancing surgical outcomes. **Methods:** In this phase 3, multicentre, placebo-controlled, double-blinded, randomized controlled trial (ClinicalTrials.gov NCT01257828), surgically naïve patients undergoing operative decompression for moderately severe CSM (modified Japanese Orthopaedic Association [mJOA] scale score 8–14) received riluzole (50 mg bid) for 14 days before surgery and 28 days after surgery, or placebo. The primary outcome was change in mJOA score at 6 months postoperatively. Patients were followed for 6 months for the primary efficacy analysis and 12 months in total. **Results:** In total 300 patients were enrolled, and 290 (141 riluzole and 149 placebo) received surgery. Patients in both trial arms improved with regard to all end points. At 6-month and 12-month follow-up, there was no difference between riluzole and placebo regarding improvement in mJOA (2.45 and 2.82 in riluzole and placebo groups at 6 months, respectively, $p = 0.16$), Nurick grade, Neck Disability Index, SF-36, EQ-5D, American Spinal Injury Association motor and sensory scores, pain, and grip strength. In a repeated-measurement analysis, riluzole patients showed greater 35-day reduction in neck pain (visual analogue scale) that was maintained at 6 and 12 months. **Conclusion:** Adjuvant treatment with riluzole does not improve functional recovery because the effects of surgical decompression dominate the clinical picture. The potential effect of riluzole in reducing pain in surgically treated CSM patients merits further study.

111

Shoulder traction device for increasing visualization of cervical vertebra on fluoroscopy during cervical spine surgery. *Van Tri Truong, Ghassan Boubez, Fidaa Al-Shakfa, Daniel Shedid, Sung-Joo Yuh, Zhi Wang.* **From CHUM, Montreal, Canada.**

Background: Intraoperative fluoroscopic imaging of the cervical spine is usually used to locate the right level in cervical spine surgery. Radiographic visualization of all cervical vertebra on lateral projection is sometimes not achievable because of the shadow of shoulders. Here, we describe and evaluate the Cervision system, a new traction device designed to decrease the shoulder superimposition on the cervical fluoroscopy. **Methods:** A retrospective matching-cohort study was conducted to evaluate the system. Patients undergoing cervical spine surgery at our institution were included in this study and divided into 2 cohorts. The first cohort included 33 consecutive patients operated by the senior author, and the Cervision system was used to pull the patients' shoulders down. The second cohort included 33 patients operated by other spine surgeons, and adhesive tape was used for shoulder caudal displacement. These 2 cohorts were matched. We compared the number of cervical vertebra visible on lateral fluoroscopy, the installation time and the rate of postoperative brachial plexus palsy between the 2 groups. **Results:** There was a difference in cervical vertebra visualization on lateral radiography between 2 groups. The mean number of vertebra visible in the Cervision cohort was 6.3 ± 0.41, while it was 5.6 ± 0.32 in the control group ($p < 0.01$, unpaired t test). The number of patients with T1 vertebra visible was 5 of 33 (15.15%) in the Cervision cohort and 0 of 33 (0%) in the control cohort ($p = 0.02$, Pearson χ^2 test). The installation time, which was the period from the beginning of intubation procedure until the moment of making the incision, was 83.9 ± 5.15 minutes in the Cervision cohort and 73.7 ± 6.32 minutes in the control group ($p = 0.02$). Analysis of the data showed a learning curve with a decreasing tendency in installation time with the Cervision system. There was no postoperative brachial palsy in the 2 cohorts. **Conclusion:** Cervision is a safe and useful device for increasing the visualization of lower cervical vertebra levels on the intraoperative fluoroscopy.

95

Rates and predictors of return to work after surgery for cervical spondylotic myelopathy: analysis from the Canadian Spine Outcomes and Research Network. *Jefferson Wilson[1], Jetan Badhiwala[1], Bradley Jacobs[2], Michael Johnson[3], Christopher Bailey[4], Sean Christie[5], Raphaele Charest-Morin[6], Jérome Paquet[7], Andrew Nataraj[8], David Cadotte[2], Neil Manson[9], Hamilton Hall[1], Ken Thomas[2], Raja Rampersaud[1], Greg McIntosh[10], Charles Fisher[6], Nicolas Dea[6].* **From the [1]University of Toronto, Toronto, Canada; the [2]University of Calgary, Calgary, Canada; the [3]University of Manitoba, Winnipeg, Canada; [4]Western University, London, Canada; [5]Dalhousie University, Halifax, Canada; the [6]University of British Columbia, Vancouver, Canada; [7]Université Laval, Québec, Canada; the [8]University of Alberta, Edmonton, Canada; the [9]Canada East Spine Centre, Saint John, Canada; and the [10]Canadian Spine Society, Toronto, Canada.**

Background: Cervical spondylotic myelopathy (CSM) is the most common cause of spinal cord dysfunction internationally; however, few studies have evaluated return to work (RTW) after CSM surgery. Our goals were to determine rates and predictors of postoperative RTW and to compare postoperative rates to a lumbar spondylolisthesis cohort. **Methods:** Data were derived from the Canadian Spine Outcomes and Research Network (CSORN) prospective, multicentre surgical CSM registry. From this cohort, we included all nonretired patients with at least 1-year follow-up. RTW rate was defined as the proportion of patients with active employment 1 year from the time of surgery. Bivariable and multivariable logistic regression were used to identify patient, disease and treatment variables predicting RTW. **Results:** Of 211 surgically treated CSM patients with 1-year follow-up, 102 (48.3%) were considered nonretired preoperatively, with 54.5% working and 45.5% not working in the immediate period before surgery. At 1 year, 60 patients (58.8%) had returned to work, while 42 (41.2%) were not working. In bivariable analyses, while working preoperatively predicted postoperative RTW ($p < 0.05$), there were no significant differences between the postoperative employment groups with respect to age, gender, preoperative modified Japanese Orthopaedic Association score, duration of symptoms and anterior v. posterior surgical approach ($p > 0.05$). In multivariable analyses, only preoperative employment status predicted RTW, with those working preoperatively having 12 times greater odds of working at 12 months postoperatively (odds ratio 12.1, 95% confidence interval 2.2–66.5). For comparison, the 1-year postsurgical RTW rate in the CSORN lumbar spondylolisthesis study cohort was 70.0%. **Conclusion:** Most (58.8%) nonretired patients undergoing surgery for CSM had returned to work 12 months postoperatively; preoperative work status was the only significant predictor of RTW in this analysis. RTW rates appear to be lower in CSM compared with lumbar spondylolisthesis. These results will help to inform preoperative patient counselling, enable economic analyses and serve as a focus for future quality improvement efforts.

150

Multiparametric quantitative MRI as an accurate diagnostic tool for myelopathy. *Muhammad Ali Akbar[1], Allan Martin[1], Julien Cohen-Adad[2], Jetan Badhiwala[1], David Mikulis[1], Adrian Crawley[1], Sukhvinder Kalsi-Ryan[1], Jefferson Wilson[1], Michael Fehlings[1].* **From the [1]University of Toronto, Toronto, Canada; and [2]École Polytechnique Montréal, Montreal, Canada.**

Background: Clinical diagnosis of myelopathy is challenging as symptoms and signs can be subjective and diagnostic uncertainty is common. Anatomic magnetic resonance imaging (MRI) in this setting has poor specificity. MRI techniques that measure demyelination, axonal injury and atrophy may provide enhanced accuracy in such cases. The diagnosis of degenerative cervical myelopathy (DCM) is important because it is a progressive disease and early treatment can avoid permanent disability. We describe a multiparametric quantitative MRI protocol for microstructure analysis of the spinal cord to determine the precise degree of injury to the spine in the setting of DCM. We used the metrics to develop a diagnostic tool, comparing 5 statistical approaches for classification between healthy individuals and those with DCM. **Methods:** Thirty-five

controls and 56 DCM patients were studied. All participants were examined clinically followed by MRI scans acquiring T_2-weighted imaging, diffusion tensor imaging (DTI), magnetization transfer (MT), and T_2*-weighted imaging covering C1–C7. Image analysis was performed on Spinal Cord Toolbox to calculate cross-sectional area (CSA), fractional anisotropy (FA), MT ratio (MTR), and T_2*-weighted white:grey matter ratio. Statistical analysis was performed using R version 3.3. Models were developed using participant characteristics and MRI data using logistic regression (LR), linear discriminant analysis (LDA), principle component analysis with logistic regression (PCA-LR), k-nearest neighbours (kNN) with various k values (3,5,7), and a support vector machine (SVM) model. Estimates of diagnostic accuracy were reported as corrected area under receiver operating characteristic curves (AUC). **Results:** All 5 models showed good diagnostic accuracy, with the SVM model showing the highest performance (AUC 95.6%), outperforming LR (AUC 93.6%), PCA-LR (AUC 89.0%), LDA (AUC 87.9%), and kNN (k = 5, AUC 84.6%). The SVM model with cost = 100 outperformed other SVM models, which showed AUC ranging from 91.2% to 94.3%. **Conclusion:** Multiparametric quantitative MRI techniques can provide immense amounts of data for a single patient. Supervised machine learning algorithms such as SVM allow clinicians to harness this information and achieve greater diagnostic accuracy than conventional statistical approaches.

96

A comparison of surgical outcomes in mild, moderate, and severe degenerative cervical myelopathy: analysis of a prospective multicentre cohort of 735 patients. *Hetshree Joshi, Jetan Badhiwala, Michael Fehlings.* **From the University Health Network/University of Toronto, Toronto, Canada.**

Background: Degenerative cervical myelopathy (DCM) is the most common cause of spinal cord dysfunction in adults worldwide, leading to significant impairment in quality of life (QoL). Current treatment paradigms indicate surgery for moderate or severe DCM, whereas there is controversy over the optimal treatment strategy in mild DCM. With the aging population, this remains a critical knowledge gap to address. The objective of this study was to compare the functional, disability, and QoL outcomes in patients with mild versus moderate versus severe DCM. **Methods:** Data were derived from 2 prospective, multicentre cohort studies (AOSpine CSM-North America and AOSpine CSM-International). Outcomes were evaluated preoperatively and at 6 months, 1 year, and 2 years after surgery using the modified Japanese Orthopaedic Association (mJOA), Neck Disability Index (NDI), and SF-36 and SF-6D questionnaires. A normalized recovery index using a novel area under the curve technique measuring total recovery as a proportion of maximal possible recovery was calculated and compared between mild (mJOA 15–17), moderate (mJOA 12–14) and severe (mJOA < 12) DCM groups by 1-way analysis of variance. **Results:** A total of 735 patients were enrolled, 192 with mild, 294 with moderate, and 249 with severe DCM. Baseline characteristics for each group were assessed. The mJOA scores showed greater relative upper limb sensory improvement in mild DCM compared with moderate and severe DCM ($p < 0.05$). However, the overall improvement in mJOA score was lower in the mild group ($p < 0.05$). NDI scores showed significantly higher relative improvements in personal care, driving, and concentration in mild DCM compared with moderate DCM ($p < 0.05$). The

bodily pain component of SF-36 scores showed a significantly greater improvement in mild DCM, but physical component scores demonstrated lesser improvement in mild DCM compared with moderate and severe DCM ($p < 0.05$). SF-6D scores showed the greatest relative improvement in mild DCM compared with moderate and severe DCM ($p < 0.05$). **Conclusion:** More sensory improvements were seen in mild DCM patients, whereas more gait improvements were seen in moderate and severe DCM patients. Overall, this study suggests that patients with mild DCM do receive significant benefit from surgical decompression.

21

The influence of cervical spondylolisthesis on clinical presentation and surgical outcome in patients with degenerative cervical myelopathy: analysis of a multicentre global cohort of 458 patients. *Aria Nouri[1,2], So Kato[3], Jetan Badhiwala[4], Michael Robinson[1], Juan Mejia Munne[1], George Yang[1], William Jeong[1], Rani Nasser[1], David Gimbel[1], Joseph Cheng[1], Michael Fehlings[4].* **From the [1]University of Cincinnati, Cincinnati, USA; [2]Yale University, New Haven, USA; the [3]University of Tokyo, Tokyo, Japan; and the [4]University of Toronto, Toronto, Canada.**

Background: Cervical spondylolisthesis (CS) is common among patients with degenerative cervical myelopathy (DCM). However, its impact on clinical presentation and surgical outcome has not been well described. It is thus the objective of the present study to address this knowledge gap by comparing the difference between patients with and without CS undergoing surgical treatment for DCM. **Methods:** We reviewed 458 magnetic resonance images (MRIs) from the AOSpine North America and International Studies. CS was identified using MRIs. Patients with DCM were divided into 2 cohorts, those with CS and those without, and propensity matching was performed. Patient demographics, neurologic and functional status at baseline and 2-year follow-up were compared. **Results:** Compared with nonspondylolisthesis patients ($n = 404$), CS patients ($n = 54$) were 8.8 years older ($p < 0.0001$), presented with worse baseline neurologic and function status (modified Japanese Orthopaedic Association [mJOA] score, $p = 0.008$; Nurick, $p = 0.008$; SF-36 physical, $p = 0.01$), more commonly presented with ligamentum flavum enlargement (81.5% v. 53.5%, $p < 0.0001$), were less commonly from Asia ($p = 0.0002$), and tended to have more compressed levels ($p = 0.052$) and lower prevalence of ossification of the posterior longitudinal ligament ($p = 0.098$). There was no difference in sagittal alignment ($p = 0.94$). Surgical approach varied between cohorts ($p = 0.0002$), with posterior approaches favoured in CS (61.1% v. 37.4%). CS patients also had more operated levels (4.3 ± 1.4 v. 3.6 ± 1.2, $p = 0.0002$), and tended to undergo longer operations (196.6 ± 89.2 min v. 177.2 ± 75.6 min, $p = 0.087$). The mean improvement of neurologic function was lower with CS (mJOA: 1.5 ± 3.6 v. 2.8 0177 2.7, $p = 0.003$; Nurick: -0.8 ± 1.4 v. -1.5 ± 1.5, $p = 0.002$), and CS was an independent predictor of worse mJOA recovery ratio at 2 years (B = -0.190, $p < 0.0001$). After propensity matching, the mean improvement of neurologic function was still lower in patients with CS (mJOA: 1.5 ± 3.6 v. 3.2 ± 2.8, $p < 0.01$; Nurick: -0.8 ± 1.4 v. -1.4 ± 1.6, $p = 0.02$). **Conclusion:** CS patients are older and present with worse neurologic and functional impairment. Furthermore, they receive surgery on more levels and more commonly from the posterior. CS may indicate a more advanced state of DCM pathology and is more likely to result in a suboptimal surgical outcome.

93

Minimum clinically important difference in patient reported outcomes for cervical spondylotic myelopathy: an analysis from the Canadian Spine Outcomes and Research Network. *Jetan Badhiwala[1], Jefferson Wilson[1], Bradley Jacobs[2], Michael Johnson[3], Christopher Bailey[4], Sean Christie[5], Raphaele Charest-Morin[6], Jérome Paquet[7], Andrew Nataraj[8], David Cadotte[2], Neil Manson[9], Hamilton Hall[1], Ken Thomas[2], Raja Rampersaud[1], Greg McIntosh[10], Charles Fisher[6], Nicolas Dea[6].* **From the [1]University of Toronto, Toronto, Canada; the [2]University of Calgary, Calgary, Canada; the [3]University of Manitoba, Winnipeg, Canada; [4]Western University, London, Canada; [5]Dalhousie University, Halifax, Canada; the [6]University of British Columbia, Vancouver, Canada; [7]Université Laval, Québec, Canada; the [8]University of Alberta, Edmonton, Canada; the [9]Canada East Spine Centre, Saint John, Canada; and the [10]Canadian Spine Society, Toronto, Canada.**

Background: Patient-reported outcomes (PROs) are increasingly used to assess patients with spinal disorders; however, the numerical scores of PROs lack interpretability. We sought to determine the minimum clinically important difference (MCID) in several PROs, including the EQ-5D Index, Neck Pain Numeric Rating Scale (NRS), and Arm Pain NRS, in patients with cervical spondylotic myelopathy (CSM). **Methods:** Data were derived from the Canadian Spine Outcomes and Research Network (CSORN) prospective, multicentre registry of patients undergoing surgical decompression for CSM. MCIDs were determined by distribution-based (half standard deviation, standard error of measurement [SEM]) and anchor-based (ROC) methods. A satisfaction question asking patients how they feel at 12 months compared with before surgery served as the anchor for the EQ-5D Index; the MCID was defined as the change score with even sensitivity and specificity to distinguish patients who reported "much better" or "better" v. "same," "worse" or "much worse." For the Neck and Arm Pain NRS, anchor questions were those asking patients whether surgery fulfilled their expectations at 12 months with regards to reduced neck and arm pain; the MCID was defined as the change score with even sensitivity and specificity to separate patients who reported "yes completely" or "somewhat" v. "I don't know" or "no, not at all." **Results:** In total 205 patients with complete data were identified. The calculated MCID for EQ-5D Index was 0.11 by all methods. For both the Neck and Arm Pain NRS, the MCID was -1.5 points by half standard deviation and SEM, and -2 points by ROC analysis. **Conclusion:** The MCID is estimated at 0.11 for EQ-5D Index and -1.5 points for both Neck and Arm Pain NRS in patients with CSM. This knowledge will help clinicians identify patients with meaningful improvements in quality of life and pain following intervention and provide a standard for assessing change in PROs in CSM research.

9

The impact of older age on functional recovery after surgical decompression for degenerative cervical myelopathy: results from an international, multicentre, prospective data set in 757 patients. *Jamie R.F. Wilson[1], Jetan Badhiwala[2], Frank Jiang[1], Jefferson Wilson[3], Branko Kopjar[4], Alexander Vaccaro[5], Michael Fehlings[1].* **From the [1]University of Toronto Spine Program, Toronto, Canada; the [2]Department of Neurosurgery, University of Toronto, Toronto, Canada; [3]St. Michael's Hospital, Toronto, Canada; the [4]University of Washington, Seattle, USA; and the [5]Rothman Orthopaedic Institute, Philadelphia, USA.**

Background: Our objective was to determine the effect of older age (> 70 yr) on functional recovery and quality of life (QoL) measures after surgery for degenerative cervical myelopathy. **Methods:** We identified 107 patients older than 70 from the 757 patients enrolled in the prospective, multicentre AOSpine CSM North America and International studies. Functional status (modified Japanese Orthopaedic Association [mJOA]) and QoL (SF-36 questionnaire) outcomes at 6, 12 and 24 months after surgery were compared with unadjusted univariate analysis and multiple linear regression (to model the effect of age without comorbidities, smoking, number of operated levels, surgical approach or baseline mJOA score). **Results:** Baseline mJOA score in the elderly group was significantly lower than in the younger group (11.0, 95% confidence interval [CI] 10.4 to 11.5 v. 12.9, 95% CI 12.7 to 13.1, $p < 0.01$). The unadjusted change in mJOA scores were similar in both groups at 6 months (2.30, 95% CI 1.71 to 2.88 v. 2.21, 95% CI 2.02 to 2.40, $p = 0.75$), 12 months (2.79, 95% CI 2.18 to 3.41 v. 2.50, 95% CI 2.29 to 2.70, $p = 0.30$) and 24 months (2.63, 95% CI 1.99 to 3.27 v. 2.71 95% CI 2.51 to 2.92, $p = 0.77$). After covariate adjustment, the coefficient for change at 6 months in the elderly group was –0.84 ($p < 0.01$), –0.74 at 12 months ($p < 0.01$) and –1.22 at 24 months ($p < 0.01$). Baseline SF-36 physical component summary was unchanged between groups, but the mean change was lower in the elderly group at 6 months, 12 months and 24 months (coefficient of change –3.02, $p < 0.01$; –1.16 at 12 months, $p = 0.27$; and –3.65 at 24 months, $p < 0.01$). SF-36 mental component scores were higher in the elderly group at baseline (43.0, 95% CI 40.6 to 45.5 v. 39.8, 95% CI 38.7 to 40.8, $p = 0.02$), were no different at 6 or 12 months, but were lower at 24 months (2.59, 95% CI –0.028 to 5.47 v. 5.96, 95% CI 4.97 to 6.96, $p = 0.01$; coefficient of change –4.53, $p < 0.01$). **Conclusion:** In this large prospective data set, the elderly group demonstrated significantly worse functional and QoL recovery than the younger cohort after adjusting for the effect of comorbidities, number of operated levels, surgical approach and baseline mJOA score. Elderly patients undergoing surgery for DCM should therefore be counselled appropriately regarding expectations of surgery.

74

Importance of sagittal alignment in cervical spondylotic myelopathy: an observational study from the Canadian Spine Outcomes and Research Network. *Nathan Evaniew[1], Raphaële Charest-Morin[1], W. Bradley Jacobs[2], Michael Johnson[3], Chris Bailey[4], Sean Christie[5], Jérome Paquet[6], Andrew Nataraj[7], David W. Cadotte[2], Jefferson R. Wilson[8], Neil Manson[9], Hamilton Hall[10], Ken Thomas[2], Y. Raja Rampersaud[11], Greg McIntosh[12], Charles G. Fisher[13], Nicolas Dea[1].* From the [1]Combined Neurosurgery and Orthopaedic Spine Program, University of British Columbia, Vancouver, Canada; [2]Department of Clinical Neurosciences, Univeristy of Calgary, Calgary, Canada; [3]Department of Surgery, Section of Orthopaedics and Neurosurgery, University of Manitoba, Winnipeg, Canada; [4]Department of Surgery, Western University, London, Canada; the [5]Division of Neurosurgery, Dalhousie University, Halifax, Canada; the [6]Department of Orthopaedics, Centre Hospitalier Universitaire de Québec, Québec, Canada; [7]Division of Neurosurgery, Faculty of Medicine and Dentistry, University of Alberta, Edmonton, Canada; the [8]Division of Neurosurgery, Department of Surgery, University of Toronto, Toronto, Canada; the [9]Canada East Spine Centre, Saint John Regional Hospital, Saint John, Canada; [10]Department of Surgery, University of Toronto, Toronto, Canada; [11]Division of Orthopaedic Surgery and Neurosurgery, Department of Surgery, University of Toronto, Toronto, Canada; and the [12]Canadian Spine Society, Toronto, Canada.

Background: Recent evidence suggests that sagittal alignment may play a role in the presentation and management of patients with cervical spondylotic myelopathy (CSM), but its importance has not been fully established. In this study, our objectives were to evaluate the extent to which preoperative sagittal alignment is associated with baseline function and symptoms, surgery leads to changes in sagittal alignment, and postoperative sagittal alignment is associated with function and symptoms at follow-up. **Methods:** We performed an observational cohort study using prospectively collected data from the Canadian Spine Outcomes and Research Network (CSORN). We included all patients diagnosed with CSM at 7 participating centres between 2015 and 2017. We measured sagittal alignment using 2 methods: surgeon classification and Ishihara's Cervical Curvature Index (ICCI). We measured function and symptoms with multiple patient-reported outcome measures (PROMs), and we adjusted for age, gender, severity, and comorbidities using multiple linear regression. **Results:** Among 474 patients, baseline alignment was neutral in 196 (41%), lordotic in 190 (40%), and kyphotic in 88 (19%). In comparison to lordosis, baseline kyphosis was associated with significantly worse EQ 5D ($p < 0.05$) and SF-12 mental component summary (SF-12 MCS) scores ($p < 0.05$). Surgical treatment altered alignment toward lordosis in patients who were neutral or kyphotic preoperatively and was associated with significantly improved function and symptoms regardless of baseline alignment (modified Japanese Orthopaedic Association, Neck Disability Index, visual analogue scale, SF-12, and EQ-5D scores; $p < 0.01$). There were no significant associations between postoperative alignment and PROMs at 3 or 12 months. **Conclusion:** Baseline kyphosis appears to be associated with greater impairment in health-related quality of life among patients with CSM. Surgery for CSM improves symptoms and function regardless of baseline alignment, but postoperative sagittal alignment does not seem to be associated with final PROMs. These findings suggest that sagittal alignment restoration may not be important in the surgical management of patients with CSM.

35

Machine learning approaches to predict surgical outcomes in degenerative cervical myelopathy. *Omar Khan, Jetan Badhiwala, Michael Fehlings.* From the Division of Neurosurgery, Department of Surgery, University of Toronto, Toronto, Canada.

Background: Degenerative cervical myelopathy (DCM) represents a series of degenerative changes that compress the cervical spinal cord. While the treatment for moderate to severe cases is surgical, the treatment for mild cases is controversial due to the heterogeneous response to surgery in patients. Here, machine learning (ML) algorithms were used to determine which groups of mild myelopathy patients benefitted most from surgery. **Methods:** In total 193 patients from the AOSpine CSM clinical trials with mild DCM at baseline were enrolled. Patient-reported quality of life outcome scores, particularly the SF-36 mental component summary (MCS) and physical component summary

(PCS), were obtained before and 1 year after surgery. The change between the baseline MCS and PCS scores and the scores at 1 year was dichotomized according to whether it exceeded the minimal clinically important difference (MCID). The 193-patient data set was then divided into training and testing sets (75% training: 25% testing). The training set was used to optimize 4 ML algorithms (classification trees, support vector machines, random forests, k-nearest neighbour), while the testing set was used to evaluate algorithm performance. **Results:** The ML algorithms performed well on the testing set, with areas under the receiver operating characteristic curves (AUCs) ranging from 0.72 to 0.80 and 0.69 to 0.77 for predicting improvements in the MCS and PCS, respectively. Additionally, the classification trees provided insight on which patient phenotypes were likely to achieve meaningful postoperative improvement. For example, female patients with a low MCS preoperatively were less likely to improve in mental health than males. Moreover, patients starting in an intermediate range of PCS improved based on multiple factors, such that younger nonsmokers and patients with lower body mass index (BMI) lacking lower limb spasticity improved more significantly in physical health. **Conclusion:** ML algorithms showed good performance and demonstrated that patient factors such as age, BMI, gender, and smoking history were important in predicting which mild DCM patients were more likely to benefit from surgery. Overall, ML provides a reliable framework for clinicians to make management decisions in mild DCM patients.

50

Predictors for home discharge after degenerative cervical myelopathy decompressive surgery; an analysis of the Canadian Spine Outcomes and Research Network. *Rodrigo Navarro-Ramirez[1], Greg McIntosh[2], Peter Jarzem[1], Nicolas Dea[3], Michael Weber[1].* **From [1]McGill University, Montreal, Canada; the [2]Canadian Spine Outcomes and Research Network, Markdale, Canada; and the [3]University of British Columbia, Vancouver, Canada.**

Background: Our objective was to identify those factors associated with discharge home after degenerative cervical myelopathy surgery. **Methods:** We conducted a retrospective analysis of patients who underwent cervical spinal myelopathy decompressive surgery between 2008 and 2017 using multicentre prospectively collected data from the Canadian Spine Outcomes and Research Network (CSORN) database (*n* = 394). Multivariable logistic regression with a backward selection procedure was used to identify predictors of patient discharge destinations: home v. other facilities. A data-splitting technique was used to develop and test the multivariable models. **Results:** Regression analyses identified 3 significant predictors of home discharge: patients who were working at the time of the surgery (odds ratio [OR] 3.6), those who had anterior cervical discectomy and fusion (ACDF) (OR 5.1), and higher values of baseline modified Japanese Orthopaedic Association (mJOA) score (OR 1.3; odds of home discharge increase by 30% for each 1-point increase in mJOA score). The final model was internally validated and confirmed the same predictors. The receiver operating characteristics curve analysis revealed and area under the curve of 0.791. **Conclusion:** Predictors identified with "home discharge" after degenerative cervical myelopathy decompression surgery were patients working at the time of the surgery, those treated with ACDF, and those with higher baseline mJOA score.

86

Are there gender-based differences in outcomes for elective lumbar spine surgery in Canada? *Henry Ahn[1,2], Abel Davtyan[1], Chris Bailey[3], Sean Christie[4], Eugene Wai[5], Michael Weber[6], Ken Thomas[7], Albert Yee[2], Nicholas Dea[8], Charles Fisher[8], Alex Soroceanu[7], Jerome Paquet[8], Philippe Phan[5], Raja Rampersaud[2], Peter Jarzem[6], Duncan Cushnie[3].* **From [1]St. Michael's Hospital, Toronto, Canada; the [2]University of Toronto Spine Program, Toronto, Canada; [3]Western University, London, Canada; [4]Dalhousie University, Halifax, Canada; the [5]University of Ottawa, Ottawa, Canada; [6]McGill University, Montreal, Canada; the [7]University of Calgary, Calgary, Canada; and the [8]University of British Columbia, Vancouver, Canada.**

Background: The purpose of this study was to determine gender differences in the outcome for lumbar decompression, microdiscectomy, and lumbar decompression and fusion, using a national Canadian spine database. **Methods:** Retrospective analysis was performed on 1316 patients who underwent either a single-level microdiscectomy (*n* = 614), lumbar decompression (*n* = 343) or a single lumbar decompression with fusion surgery (*n* = 259). Patients were prospectively enrolled in a national multicentre database between October 2008 and August 2017. Baseline measurements included Back and Leg Pain scales, Oswestry Disability index (ODI), Health state, SF-36 physical component (PCS)/mental component (MCS) scores, and EQ-5D questionnaire score, along with measurements at 3 and 12 months postoperatively. **Results:** In the microdiscectomy group at baseline (124 females, 135 males), mean MCS score was higher in males (46.2 ± 8.3 v. 44.9 ± 7.9, *p* < 0.05). Significantly more females were on pain medications (97% v. 91.1%, *p* < 0.012). One year postoperatively, males had higher change in the mean PCS value (14.6 ± 9.7 v. 1.7 ± 10.3, *p* < 0.012). Otherwise both groups had similar improvements. In lumbar decompression surgery, there was a higher mean baseline back pain scale score among females (7 ± 2.0 v. 6.3 ± 2.6, *p* < 0.016), and females had a higher baseline ODI score (48.1 ± 13.4 v. 42.0 ± 15.6, *p* < 0.001). There was a larger percentage of female patients on pain medications (95% v. 77%, *p* < 0.05). Twelve months following surgery, females had a larger change in health state score (16.3 ± 23.1 v. 9.4 ± 22, *p* < 0.05) and a trend toward larger PCS score improvement. In decompression and fusion surgery, baseline scores showed higher Patient Health Questionnaire (PHQ9) scores in females (10.9 ± 6.4 v. 7.9 ± 5.6, *p* < 0.001). There was a trend toward higher baseline ODI scores and worse baseline MCS scores for females. There were no significant differences in outcomes after surgery. **Conclusion:** Female patients present with worse baseline scores than male counterparts for all 3 elective lumbar spine operations. Despite baseline differences, lumbar decompression and fusion surgery was effective, with no differences in outcomes, and in lumbar decompression surgery females had better health state change. Only in microdiscectomy operations, male patients improved significantly with higher PCS scores following microdiscectomy surgery. Reasons for these differences need further investigation.

42

Posterolateral versus posterior interbody fusion for the management of lumbar degenerative spondylolisthesis: a feasibility randomized controlled trial. *Christopher Bailey, Jennifer Urquhart, Alyssa Fleming, Joanne Collie, Parham Rasoulinejad.*

From the Division of Orthopaedics, Department of Surgery, Schulich School of Medicine and Dentistry, Western University; Lawson Health Research Institute; and London Health Sciences Centre, London, Canada.

Background: It remains controversial if the use of the interbody fusion (IF) in the treatment of degenerative spondylolisthesis is necessary. The objectives of this study were to assess the acceptability and feasibility of trial procedures, the distribution of scores on the Oswestry Disability Index (ODI) (planned primary outcome), and efficient working of trial components. **Methods:** A noninferiority, single-centre pilot randomized controlled trial (RCT) randomized patients to IF or posterior lumbar fusion (PLF). Inclusion criteria were age ≥ 18 years and diagnosed lumbar degenerative spondylolisthesis at 1 or 2 levels. Feasibility was assessed, including recruitment rate, adherence to allocation, follow-up, and missing data. The ODI score was assessed at 12 months postoperatively for sample size. Time to discharge, patient-rated outcomes and adverse events were also compared. **Results:** We recruited 38 of 48 eligible patients (7 eligible patients declined and 3 were excluded before surgery). No patient was lost to follow-up or deviated from allocation. Data completion was 78% at 1 year. Study participants mostly were female, had grade II spondylolisthesis, single-level, and had symptoms for more than 2 years. At 12 months the ODI had improved from 50.3 ± 15.1 to 27.1 ± 19.5 compared with 51.3 ± 11.2 to 34.3 18.6 for the PLF and IF groups, respectively. The mean difference was –7.2 (95% confidence interval [CI] –20.9 to 6.5) with an upper limit below the noninferiority margin of 10 points, indicating PLF was noninferior to IF. PLF had a mean shorter operation time and intraoperative radiation dose but equal blood loss, adverse events and length of stay. At 12 months the intensity of leg pain was significantly lower in the PLF cohort (1.2 ± 2.2 v.4.1 ± 3.3, mean difference –2.8, 95% CI –5.0 to –0.7). **Conclusion:** Findings from this study provide confidence in the feasibility of a large-scale, multicentre RCT. As the hypothesis was that there would be equivalence between procedures, it was surprising that leg pain was significantly worse at 12 months for IF, suggesting the multicentre RCT should investigate that as the primary outcome.

80

The association between improvements in mental health with pain and disability improvements after thoracolumbar spine surgery: a Canadian Spine Outcomes and Research Network study. *Duncan Cushnie[1], Kenneth Thomas[2]. From [1]McMaster University, Hamilton, Canada; and the [2]University of Calgary, Calgary, Canada.*

Background: Chronic spine disease is associated with substantial morbidity, pain and decreased quality of life and is associated with depression. Thoracolumbar surgery reduces pain and disability for some chronic spine conditions, and several small studies have shown an associated improvement in mental health after surgery. The Canadian Spine Outcomes and Research Network (CSORN) registry provides an opportunity to examine the association between spine surgery and mental health on a large scale. **Methods:** Patients undergoing surgery for chronic thoracolumbar spine disorders were extracted from the CSORN registry. Infection, inflammation, tumours, and fractures were excluded. The primary end point was the change in SF-12 mental component score (MCS) between preoperative and 12-month postoperative assessments. Previous literature identified MCS < 45 as a cut-off sensitive and specific for major depression. Associations were tested with outcome measures including Patient Questionaire-9 (PHQ9), Oswestry Disability Index (ODI), SF-12 physical component score (PCS), and leg and back pain numeric rating scales. **Results:** In total, 3222 patients met inclusion criteria and had preoperative and 12-month outcomes. Mean MCS improved from 48.1 (95% confidence interval [CI] 47.8–48.4) preoperative to 51.7 (95% CI 51.4–51.9, $p < 0.00001$) postoperative, with the improvement significant in every diagnosis separately. In total, 78.3% of patients meeting the depression cut-off preoperatively reached a minimally clinically important difference (MCID) versus 48.3% of those who did not ($p < 0.001$). Overall, there was a 45.7% drop in the proportion meeting the depression cut-off after surgery ($p < 0.001$). Improvement in MCS correlated with improvement in ODI ($r = –0.36$, $p < 0.0001$), PCS ($r = 0.15$, $p < 0.0001$), leg pain ($r = –0.20$, $p < 0.0001$), and back pain ($r = –0.25$, $p < 0001$). **Conclusion:** Patients receiving surgery for chronic spine conditions demonstrated a significant improvement in overall mental health, consistent with previous reports. This was clinically significant in most cases meeting criteria for preoperative major depression. Postoperatively there was a substantial decrease in the overall proportion of depressed patients. Improvements in mental health correlated with improvements in disability and pain suggesting that the benefits of surgery for these conditions may extend to include mental and physical health.

18

The influence of multijoint symptoms on outcome following surgery for lumbar spine osteoarthritis. *Anthony V. Perruccio, Calvin Yip, J. Denise Power, Mayilee Canizares, Elizabeth M. Badley, Stephen J. Lewis, Y. Raja Rampersaud.* **From the Arthritis Program, Krembil Research Institute, University Health Network, Toronto, Canada.**

Background: Up to one-third of patients experience limited benefit following surgical intervention for lumbar spine osteoarthritis (LS-OA); i.e., spinal stenosis. Thus, identifying contributing factors to this is important. People with OA often have multijoint involvement, yet this has received limited attention in this population. We documented the occurrence and evaluated the influence of multijoint symptoms on outcome following surgery for LS-OA. **Methods:** A total of 141 patients undergoing decompression surgery±fusion for LS-OA completed the Oswestry Disability Index (ODI) pre- and 12 months postsurgery. Also captured presurgery were age, sex, education, body mass index (BMI), smoking, depressive symptoms and comorbidities. Any joints with "pain/stiffness/swelling most days of the month" were indicated on a homunculus. A symptomatic joint site count (e.g., 1/both knees = 1 site), excluding the back, was derived (range 0–9) and considered as a predictor of magnitude of ODI change and likelihood of achieving minimally clinically important difference in ODI (MCID = 12.8) using multivariable adjusted linear and log-Poisson regression analyses. **Results:** Mean age was 66 (range 42–90) years and 46% were female. Most (76%) reported 1+ joint site other than the back, 43% reported 3+, and nearly 10% reported 6+. Less than 10% of those with 0–2 joint sites had no improvement in ODI versus 29% of those with 3+ sites. Increasing joint count was associated with less improvement in ODI ($p < 0.01$), as was higher BMI. Predicted mean improvement was 18 units for those with

0 joint sites, 12 units (< MCID) for those with 3 sites, and 4 units for those with 6+ sites. Associated with a greater likelihood of not achieving MCID were increasing joint count (11% increase per site, $p = 0.012$), higher BMI, current/former smoker, and worse baseline ODI. **Conclusion:** Results suggest there is more than just the back to consider to understand patient-reported back outcomes. Multi-joint symptoms directly contribute to disability, but they may contribute to systemic, largely inflammatory effects in OA as well.

90

Patients undergoing surgery for lumbar spinal stenosis experience unique courses of pain and disability: a group-based trajectory analysis. *Jeffrey Hebert[1,2], Edward Abraham[3,4,5], Niels Wedderkopp[6,7], Erin Bigney[3], Eden Richardson[3], Mariah Darling[3], Hamilton Hall[8], Charles Fisher[9], Raja Rampersaud[10], Kenneth C. Thomas[11], Bradley Jacobs[12], Michael Johnson[13], Jerome Paquet[14], Najmedden Attabib[3,5,15], Peter Jarzem[16,17], Eugene K. Wai[18], Parham Rasoulinejad[19], Henry Ahn[20], Andrew Nataraj[21,22], Alexandra Stratton[23], Neil Manson[3,4,5].* **From the [1]Faculty of Kinesiology, University of New Brunswick, Fredericton, Canada; the [2]School of Psychology and Exercise Science, Murdoch University, Perth, Australia; the [3]Canada East Spine Centre, Saint John, Canada; the [4]Division of Orthopaedic Surgery, Zone 2, Horizon Health Network, Saint John, Canada; [5]Dalhousie University, Faculty of Medicine, Halifax, Canada; the [6]Department of Regional Health Research, University of Southern Denmark, Odense C, Funen, Denmark; [7]Orthopedic Department, Hospital of Southwestern Jutland, Esbjerg, Jutland, Denmark; the [8]CBI Health Group Research Department, Toronto, Canada; the [9]Combined Neurosurgical and Orthopedic Spine Program, Department of Orthopedic Surgery, University of British Columbia, Blusson Spinal Cord Centre, Vancouver, Canada; the [10]Division of Orthopaedic Surgery, Toronto Western Hospital, Toronto, Canada; the [11]Section of Orthopedic Surgery Spine Program, Department of Surgery, University of Calgary, Calgary, Canada; the [12]Department of Clinical Neurosciences, Division of Neurosurgery-Spine Program, University of Calgary, Calgary, Canada; the [13]Departments of Orthopedics and Neurosurgery, University of Manitoba, Winnipeg, Canada; the [14]Département Sciences Neurologiques, CHU de Québec, Québec, Canada; the [15]Horizon Health Network/Dalhousie University, Saint John, Canada; the [16]McGill Scoliosis and Spine Research Group, Montreal, Canada; the [17]Division of Orthopaedics, McGill University Health Centre, Montreal, Canada; the [18]Department of Surgery, University of Ottawa, Ottawa, Canada; the [19]London Health Sciences Centre, London, Canada; the [20]University of Toronto Spine Program, Toronto, Canada; the [21]Division of Neurosurgery, Department of Surgery, Faculty of Medicine and Dentistry, University of Alberta Hospital, Edmonton, Canada; the [22]Neuroscience and Mental Health Institute, Faculty of Medicine and Dentistry, University of Alberta, Edmonton, Canada; and the [23]Departments of Community Health Sciences and Surgery, Cumming School of Medicine, University of Calgary, Calgary, Canada.**

Background: We sought to identify patient subgroups defined by trajectories of pain and disability following surgery for degenerative lumbar spinal stenosis (LSS) and investigate the construct validity of the trajectory subgroups by evaluating for meaningful differences in clinical outcome. **Methods:** The study design was a retrospective analysis of prospectively collected data. Patients with LSS and deemed to be surgical candidates were recruited from 13 surgical spine centres that contribute to the Canadian Spine Outcomes and Research Network. Study outcomes (leg and back pain numeric rating scales, modified Oswestry Disability Index [ODI]) were measured before surgery and after 3, 12, and 24 months. Patients were fit to pain and disability trajectory subgroups with group-based trajectory modelling. We examined for differences in the proportion of patients achieving minimum clinically important change in pain and disability (30%) and clinical success (50% reduction in disability or ODI score ≤ 22). **Results:** Data from 548 patients (mean age 66.7 ± 9.1 yr, 46% female) were included. The group-based trajectory models identified 4 unique leg pain trajectories, and 3 trajectories each for back pain and disability. The construct validity of the trajectory subgroups was supported by differences in the proportion of patients meeting thresholds for minimum clinically important change and clinical success ($p < 0.001$). **Conclusion:** Subgroups of patients with LSS can be identified by their trajectories of pain and disability following surgery. These groups may represent useful patient phenotypes. Although most patients experienced important reductions in pain and disability, many patients (29% to 42% depending on outcome) were classified as members of an outcome trajectory subgroup that experienced little to no benefit from surgery. These findings highlight the need for better methods of treatment selection for patients with LSS.

137

Spine surgery outcomes: a comparison of patient versus surgeon expectations from a Canadian perspective. *Ahmed Aoude[1], Madison Litowski[1], Sultan Aldebeyan[1], Raja Rampersaud[2], Greg McIntosh[3], Charles Fisher[4], Alex Soroceanu[1], Ken Thomas[1].* **From the [1]University of Calgary, Calgary, Canada; the [2]University of Toronto, Toronto, Canada; the [3]Canadian Spine Outcomes and Research Network, Markdale, Canada; the [4]Vancouver General Hospital, Vancouver, Canada.**

Background: The objective of this study was to elicit whether any differences exist between patient and surgeon expectations after spine surgery and if age plays a role in these differences. **Methods:** A retrospective study from the Canadian Spine Outcomes and Research Network (CSORN) database was conducted. To begin, 10 common clinical scenarios where generated and sent to Canadian spine surgeons to determine surgeon expectations for standard spine surgeries. Patients in the CSORN database were then identified with matching symptoms and procedures to those in the scenarios. Patient expectation data was then extracted and compared with surgeon responses. A χ^2 analysis was then completed to determine discrepancies between surgeon and patient expectations. **Results:** A total of 51 Canadian spine surgeons completed the survey on expectation, and 876 patients for multiple centres in Canada were identified in the CSORN database to match the clinical scenarios. Our results demonstrated that patients tended to be more optimistic about the expected surgery outcomes than the treating surgeon. Most patients in all clinical scenarios analyzed in this study anticipated improvement in back or neck pain after surgery, which differed significantly from surgeon expectations. Results also highlighted the effect of

age on both patients' and surgeons' expectations. In general, all scenarios with younger patients tended to have higher number of positive expectations by the surgeons, which matched patient expectations, compared with similar scenarios for older patients. Therefore, discrepancies between patient and surgeon expectations were greater for older patients. **Conclusion:** We present data on patient and surgeon expectations for spine surgeries and show that differences exist. We also show that age plays a role in the agreement between the treating physicians and patients in regard to surgical expectations. Furthermore, we show discrepancies between patients and their surgeons' expectations. The reasons for the discrepancies need to be clarified and should encourage spine surgeons to clarify anticipated benefits of surgery with their patients.

124

Does National Occupation Classification affect time to return-to-work, postoperative opioid use, or pain and disability outcomes in spine surgery patients? *Mike Whitcomb[1], Anil Adisesh[1], Edward Abraham[1,2,3], Erin Bigney[2], Eden Richardson[2], Mariah Darling[2], Shawn Kroetch[2,4], Neil Manson[1,2,3].* **From [1]Dalhousie University, Faculty of Medicine, Halifax, Canada; the [2]Canada East Spine Centre, Saint John, Canada; the [3]Division of Orthopaedic Surgery, Zone 2, Horizon Health Network, Saint John, Canada; and the [4]University of New Brunswick, Saint John, Canada.**

Background: We sought to examine if there are group differences between patient outcomes following spine surgery based on National Occupation Classification (NOC). **Methods:** We performed a prospective observational cohort study. Patients ($n = 199$) recruited were participants in the Canadian Spine Outcomes and Research Network, who in addition to their 24 month follow-up completed an Occupation Recording Form. Participants were coded according to their NOC Major Occupation Group. χ^2 analyses were done for categorical variables of time to return to work and opioid use. A 2-way (baseline, 24-month follow-up) mixed-measures analysis of variance was performed for Oswestry Disability Index (ODI), leg pain and back pain as the dependent variables and NOC category as the independent between-subjects variable. Significance was set at $p \leq 0.05$. **Results:** All patients showed significant improvement in NRS leg/arm pain, NRS back/neck pain and ODI from baseline to follow-up ($F_{1,155} = 12.318$, $p < 0.001$). A statistically significant relationship was found between NOC and total time off work ($\chi^2_{18} = 35.496$, $p = 0.008$). Agriculture/natural resource occupations were associated with higher ODI (39.80) scores at 24 months ($p < 0.05$), and more of these patients (45.5%) required > 24 weeks off work. Manufacturing/utilities occupations were associated with higher NRS-leg/arm scores at 24 months, and also had a higher proportion of patients (50.0%) requiring > 24 weeks off work. Trades/transport occupations, while associated with worse NRS-back/neck and NRS-leg/arm scores, were not associated with larger proportion of patients requiring > 24 weeks off work. There was no significant relationship between NOC and opioid use at 24 months. **Conclusion:** Significant differences in postoperative outcomes were found between NOC groups, including time off work, disability, back/neck pain, and extremity pain. Although this was a relatively small study, the results indicate further research into the role of occupation is warranted.

138

Multilevel decompression/fusions are as effective as single level lumbar spinal stenosis operations. *Henry Abn[1,2], Greg McIntosh[3], Abel Davtyan[1], Chris Bailey[4], Raja Rampersaud[2], Charles Fisher[5].* **From [1]St. Michael's Hospital, Toronto, Canada; the [2]University of Toronto Spine Program, Toronto, Canada; the [3]Canadian Spine Outcomes and Research Network, Markdale, Canada; [4]Western University, London, Canada; and the [5]University of British Columbia, Vancouver, Canada.**

Background: A common hypothesis is that multilevel decompressions with/without fusion have worse clinical outcomes than similar single-level operations. Our objective was to evaluate patient-reported outcomes (PROs), length of hospital stay and complication rates between 2 groups of patients: 3–4 level decompressions with/without fusion and single-level decompressions with/without fusion. **Methods:** We performed an observational cohort study using prospectively collected data from the Canadian Spine Outcomes and Research Network (CSORN). We included all patients diagnosed with stable lumbar spinal stenosis from 18 participating sites, operated between 2008 and 2018. PROs were evaluated at 1 year post-surgery. Length of hospital stay and complication rates were determined at hospital discharge. **Results:** There were 1024 patients who met inclusion criteria (single-level $n = 826$, multilevel $n = 198$); average age of the cohort was 65.9 ± 11.4 (range 24–90) years, with 63% males. Unadjusted, adjusted and propensity score–matched analyses were performed to determine any significant differences. The multilevel group had a significantly longer length of hospital stay (4.5 v. 2.0 d, $p < 0.001$), intraoperative (12.6% v. 7.0%, $p < 0.009$) and perioperative (20.2% v. 10.3%) adverse events. Of the full cohort, 769 were eligible for 1-year follow-up; 575/769 were successfully contacted (follow-up rate 75%). At 1-year follow-up, the multilevel group had a significantly smaller change in SF-12 mental component score between groups (2.9 v. 3.5). There were no statistically significant differences in PROs between groups for visual analogue scale back/leg pain, SF-12 physical component score, EQ-5D questionnaire score, or Oswestry Disability Index score. Analyses using minimal clinically important difference change and propensity score matching did not alter these findings. **Conclusion:** Length of stay and complication rates differ significantly, but long-term, there were no statistically significant differences in PROs between multi- and single-level decompressions with/without fusion for stable lumbar spinal stenosis. Common assumptions that bigger surgery is worse long-term, were not shown in this cohort.

25

Preoperative disability predicts prolonged hospital stay following elective lumbar fusion surgery. *Michael M.H. Yang[1], Daniel Yavin[1], Perry Dhaliwal[2], Stefan Lang[1], W. Bradley Jacobs[1], Steven Casha[1], Stephan DuPlessis[1].* **From the [1]University of Calgary, Calgary, Canada; and the [2]University of Manitoba, Winnipeg, Canada.**

Background: Prolonged length of stay (LOS) after surgery is associated with poor patient outcomes and increased health care costs. Accurate prediction of LOS following elective lumbar fusion may help optimize the utilization of resources and assist with framing physician and patient expectations. The goal of this

study was to identify pre- and perioperative predictors of prolonged LOS following elective posterior lumbar fusion. **Methods:** Data from 150 patients enrolled in a randomized controlled trial evaluating safety and efficacy of intrathecal morphine v. placebo on postoperative pain following elective lumbar fusion was analyzed. The primary outcome was prolonged LOS defined as > 5 days (75th percentile in this series). The influence of preoperative variables (including patient age, sex, American Society of Anesthesiologists [ASA] status, body mass index, Oswestry Disability Index [ODI], and visual analogue scale for pain) and perioperative variables (including number of level fused, surgery type, blood loss, length of surgery and presence of perioperative adverse events) on the odds of prolonged LOS was assessed by a multivariable logistic regression model. **Results:** The mean patient age was 62.0 years, and 64 (42.7%) patients were male. The median LOS was 4 (interquartile range 3–6) days, and 41 (27.3%) patients had LOS > 5 days. Preoperatively, the mean ODI was 37.6 ± 13.6, and the mean VAS for pain was 54.3 ± 22.0 mm. Multivariable analysis showed preoperative ODI ($p = 0.004$), age ($p = 0.001$), length of surgery ($p = 0.005$), and presence of perioperative adverse events ($p = 0.005$) were independently associated with prolonged LOS. When dichotomized, patients with severe disability (ODI > 40/50) had 4.4 times the odds of prolonged LOS compared with patients with mild/moderate disability ($p = 0.002$). Preoperative pain was not found to be associated with prolonged LOS. **Conclusion:** Four pre- and perioperative predictors were found to be significantly associated with prolonged LOS following elective open posterior lumbar fusion. Preoperative disability measured by ODI is a novel modifiable risk factor that may benefit from targeted intervention before surgery.

104

Is a positive nerve root sedimentation sign associated with better outcomes after lumbar laminectomy? *Laura Neuburger, Zachary Huschi, Uzair Ahmed, Yanzhao Cheng, Daryl Fourney.* **From the University of Saskatchewan, Saskatoon, Canada.**

Background: The nerve root sedimentation sign (SedSign) has been correlated with clinically significant lumbar spinal stenosis (LSS) and promoted as a possible prognostic indicator, both for operative and nonoperative outcomes. However, the methods used to distinguish LSS from nonspecific low-back pain were not clearly defined in prior reports, and in most studies, the diagnosis was made by only 1 evaluator. In the Saskatchewan Spine Pathway (SSP), patients are categorized through a multidisciplinary process using clearly defined clinical criteria. The objective of this study was to compare the outcome of lumbar laminectomy for neurogenic claudication with respect to SedSign. **Methods:** This was a retrospective analysis of prospectively collected data in patients with SSP Pattern 4 (intermittent leg dominant) pain who underwent elective lumbar laminectomy between Jan. 1, 2012, and Mar. 30, 2018. Outcomes included Oswestry Disability Index (ODI), visual analogue pain scores (VAS) for back and leg, and EQ-5D questionnaire scores. Inter- and intrarater reliability for SedSign were 73% and 91%, respectively. **Results:** Laminectomy was performed in 106 patients (discectomy in 57.6%, instrumentation in 36.8%, tubular-assisted in 36.8%). SedSign was positive in 60/106 (58.8%) patients. Outcomes did not differ with respect to positive or negative SedSign (mean ODI improvement 9.2 v. 8.3 points, mean VAS back improvement 3.69 v. 3.58 points, mean

VAS leg improvement 4.82 v. 4.05 points, mean EQ-5D improvement 15.15 v. 11.83 points, respectively). Noninstrumented and instrumented cohorts had similar findings. On multivariate analysis, subsection 4 ODI (walking distance) was associated with cross-sectional area of stenosis ($p = 0.02$), but not SedSign. VAS back and leg improvements were associated with back ($p = 0.038$) or leg ($p = 0.0036$) dominance, but not SedSign. **Conclusion:** This is the largest analysis of SedSign with respect to operative outcomes to date and the only study to use validated clinical criteria to define neurogenic claudication. Although several clinical and radiological factors are associated with laminectomy outcome on univariate and multivariate analysis, SedSign did not correlate with outcome.

36

Minimally invasive versus open transforaminal lumbar interbody fusion surgery: an analysis of opioids, nonopioid analgesics, and perioperative characteristics. *Aaron Hockley[1], David Ge[2], Peter Passias[2], Thomas Errico[2], Aaron Buckland[2], Themistocles Protopsaltis[2], Charla Fischer[2].* **From the [1]University of Alberta, Edmonton, Canada; and [2]New York University, New York, USA.**

Background: Our objective was to examine the effect of minimally invasive versus open transforaminal lumbar interbody fusion (TLIF) on long-term postoperative narcotic consumption. **Methods:** Differences between minimally invasive (MIS) and open TLIF, including inpatient opioid and nonopioid analgesic use, discharge opioid use, and postdischarge duration of narcotic use were compared. **Results:** In total, 172 patients (109 open, 63 MIS) underwent primary TLIF. There was no difference in baseline characteristics. The MIS cohort had a significantly shorter operative time (223 v. 251 min, $p = 0.006$) and length of stay (2.7 v. 3.7 d, $p < 0.001$) as well as less estimated blood loss (184 v. 648 mL, $p < 0.001$). MIS TLIF had significantly less total inpatient opioid usage (167 v. 255 mg morphine equivalent, $p = 0.006$) and inpatient oxycodone usage (71 v. 105 mg, $p = 0.049$). Open TLIF cases required more ongoing opiate usage at 3-month follow-up (36% open v. 21% MIS, $p = 0.041$). A subanalysis found that patients who underwent an open TLIF with a history of preoperative opioid use are significantly more likely to remain on opioids at 6-week follow-up (87% v. 65%, $p = 0.027$), 3-month follow-up (63% v. 31%, $p = 0.008$), and 6-month follow-up (50% v. 21%, $p = 0.018$) compared with MIS TLIF. **Conclusion:** Patients undergoing MIS TLIF required less inpatient opioids and had a decreased incidence of opioid dependence at 3-month follow-up. Patients with preoperative opioid use undergoing MIS TLIF are less likely to require long-term opioids.

37

Impact of resident involvement on cervical and lumbar spine surgery outcomes. *Kim Vu[1], Philippe Phan[1], Alexandra Stratton[1], Stephen Kingwell[1], Mohamad Hoda[2], Eugene Wai[1].* **From the [1]The Ottawa Hospital, Ottawa, Canada; and the [2]University of Ottawa, Ottawa, Canada.**

Background: Resident involvement in the operating room is a vital component of their medical education. Conflicting research exists regarding the effects of resident participation on spine surgery patient outcomes. Our objective was to determine the effect of resident involvement on surgery duration, length of hospital

(LOS) stay and 30-day postoperative complication rates. **Methods:** This study was a multicentre retrospective analysis of the prospectively collected American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database. All anterior cervical or posterior lumbar fusion surgery patients were identified. Propensity score for risk of any complication was calculated to account for baseline characteristic differences between the attending alone and trainee present group. Multivariate logistic regression was used to investigate the impact of resident involvement on surgery duration, LOS and complication rates. **Results:** In total, 1441 patients met the inclusion criteria: 1142 patients had surgeries with an attending physician alone and 299 patients had surgeries with trainee involvement. After adjusting for confounding, the multivariate analysis demonstrated that there was no significant difference in complication rates between the 2 groups. Surgery times were found to be significantly longer for surgeries involving trainees. To further explore this relationship, separate analyses were performed for extent of predicted surgery duration, cervical or lumbar surgery, instrumentation and inpatient or outpatient surgery. The effect of trainee involvement on increasing surgery time remained significant for medium and longer predicted surgery duration, cervical surgery, lumbar surgery, lumbar fusion surgery and inpatient surgery. There were no significant differences reported for any other factors. **Conclusion:** We demonstrated in a national database that resident involvement in surgeries did not increase complication rates, LOS or surgical duration of more routine surgical cases. We found that resident involvement in surgical cases that were more complexed resulted in increased surgery time. Further study is required to determine the relationship between surgery complexity and the effect of resident involvement on surgery duration.

51

The efficacy of advanced practice physiotherapy assessment for cervical and lumbar spine pathologies. *Emily Motyka[1], Daniel Banaszek[2], Tom Inglis[2], Vancouver Spine Program Surgeons (VSPS)[1], John Street[1].* **From the [1]Vancouver Spine Institute, Vancouver, Canada; and the [2]University of British Columbia, Vancouver, Canada.**

Background: We developed an advanced practice physiotherapist (APP) spine assessment to improve access and quality of care for patients with cervical and lumbar spine pathologies. To date, other Canadian assessment models have been limited to lumbar pathologies only. We present the results of our 1-year pilot, examining its efficacy and exploring any differences between cervical and lumbar presentations. **Methods:** Two APPs underwent 3 months of training from spine surgeons based on the Interprofessional Spine Assessment and Education Clinics program. Adaptations of CORE cervical and lumbar tools were used for assessment. All consecutive referrals to our quaternary spine program were assessed. Wait times for all referrals (WT1), for emergency department referrals (WTEmerg) and for final surgical consult (WTSurgCon) were compared with the prior 12-month historical. We prospectively recorded referral patterns and agreement between APP and surgeon for both diagnosis and urgency. Patient satisfaction was also examined. Data are presented as means for the first (6M1) and second (6M2) 6 months of the pilot. **Results:** In all, 1576 patients were seen in the 12-month pilot; 34% were cervical cases. WT1 decreased from 687 to 14 days.

WTEmerg decreased from 55 to 7 days. WTSurgCon decreased from 687 to 62 days. The percentage of patients referred monthly to a surgeon remained unchanged for the lumbar group (mean 36%), but decreased for the cervical group (30% to 11%). Percent agreement for diagnosis improved for the lumbar group (82% to 94%) and for the cervical group (77% to 98%). Percent agreement for urgency improved for the lumbar group (81% to 93%) and for the cervical group (74% to 96%). Patient satisfaction was 95% for 6M1 and 97% for 6M2. **Conclusion:** APP assessment provides timely and appropriate triage of patients with both cervical and lumbar spine pathologies. Significant reductions are achieved for all wait-times. Lumbar complaints predominate while there appears to be a learning curve to improved screening of cervical pathology. APP/surgeon agreement increases with APP experience. Patient satisfaction with the process is very high.

100

Can MRI findings in lumbar stenosis predict which patients have neurogenic claudication? What are the clinical and radiologic characteristics of patients with and without a positive nerve root sedimentation sign? *Zachary Huschi, Laura Neuburger, Uzair Ahmed, Yanzhao Cheng, Daryl Fourney.* **From the University of Saskatchewan, Saskatoon, Canada.**

Background: Previous studies have shown varied results with respect the diagnostic utility of a positive nerve root sedimentation sign (SedSign) on magnetic resonance imaging for symptomatic lumbar stenosis. The objective of this study was, for the first time, to analyze the clinical characteristics of SedSign using a reliable, validated classification for low-back and leg pain (Saskatchewan Spine Pathway classification [SSPc]) as well as patient self-reported pain/function scores and several radiologic criteria. **Methods:** This was a retrospective review of prospectively collected data in 367 consecutive adult patients presenting to a spine surgeon with back and/or leg pain between Jan. 1, 2012, and May 31, 2018. We excluded patients with trauma, tumour, infection, cauda equina syndrome and prior lumbar surgery. Baseline clinical characteristics included SSPc, Oswestry Disability Index (ODI), visual analogue pain scores for back and leg, and EQ-5D questionnaire scores. Inter- and intrarater reliability for SedSign were 73% and 91%, respectively (3 examiners). **Results:** SedSign was positive in 111 (30.2%) and negative in 256 (69.8%) patients. On the univariate analysis, a positive SedSign was correlated with age, male sex, several components of ODI, EQ-5D mobility, cross-sectional area (CSA) of stenosis, anteroposterior (AP) diameter of stenosis, and SSPc pattern 4 (intermittent leg-dominant pain). SedSign was more likely to be negative in patients with back-dominant pain (SSPc pattern 1 and 2) and sciatica (SSPC pattern 3). Patients with a positive SedSign were more likely to be offered surgery, particularly noninstrumented decompression. On multivariate analysis, SedSign was associated with age, male sex, CSA stenosis and ODI subscore for walking distance. The sensitivity and specificity of SedSign for detecting neurogenic claudication were 50.3 and 82.9, respectively (positive predictive value 65.8%, negative predictive value 71.9%). **Conclusion:** For every 1 mm reduction in CSA stenosis, the odds of SedSign positivity increased by 4%. For every 1-unit decrease in ODI walking distance, the odds of SedSign positivity decreased by 26%. The SedSign has high specificity for neurogenic claudication, but the sensitivity is poor.

30

Utilization and outcomes for spine surgery in the United States and Canada. *Peter Cram[1,2,3], Bruce E. Landon[4,5], John Matelski[2], Vicki Ling[3], Anthony V. Perruccio[6], J. Michael Paterson[3], Y. Raja Rampersaud[6].* **From the [1]Department of Medicine, University of Toronto, Toronto, Canada; the [2]Division of General Internal Medicine and Geriatrics, Sinai Health System and University Health Network, Toronto, Canada; [3]ICES, Toronto, Canada; the [4]Department of Health Care Policy, Harvard Medical School, Boston, USA; the [5]Division of General Medicine and Primary Care, Beth Israel Deaconess Medical Center, Boston, USA; and the [6]Arthritis Program, Krembil Research Institute, University Health Network, Toronto, Canada.**

Background: Spine surgery is common and costly. Within-country variation in spine surgery utilization is well studied, but there has been little exploration of variation in spine surgery between countries. **Methods:** We used population-level administrative data from Ontario (2011–2015) and New York (2011–2014) to identify all adults who underwent inpatient spinal decompression or fusion surgery. We compared Ontario and New York with respect to patient demographics and the percentage of hospitals performing spine surgery. We compared rates of decompression and fusion surgery (procedures per 10 000 population per year) in Ontario and New York for all procedures, emergent procedures alone, and elective procedures and after stratifying by patient age. **Results:** Patients in Ontario were older than patients in New York for decompression (mean age 58.8 v. 51.3 yr, $p < 0.001$) and fusion (58.1 v. 54.9 yr, $p < 0.001$). A smaller percentage of hospitals in Ontario performed decompression or fusion compared with New York (decompression: 26.1% v. 54.9%; fusion: 15.2% v. 56.7%; both $p < 0.001$). Overall, utilization of spine surgery in Ontario was 6.6 procedures per 10 000 population per year and in New York was 18.0 per 10 000 per year ($p < 0.001$). Ontario–New York differences in utilization were small for emergent cases (2.0 per 10 000 in Ontario v. 2.8 in New York, $p < 0.001$), but large for elective cases (4.6 v. 15.2, $p < 0.001$); differences were particularly large in younger age groups (age < 60 yr) and for elective fusion. **Conclusion:** We found significantly lower utilization of spine surgery in Ontario than New York. These differences should inform policy reforms in both jurisdictions.

39

Surgery versus standardized nonoperative care for lumbar disc herniations with 4–12 months of symptoms: 2 year follow-up. *Christopher Bailey[1], Parham Rasoulinejad[1], David Taylor[1], Keith Sequeira[2], Tom Miller[2], Jim Watson[3], Richard Rosedale[2], Stewart Bailey[1], Kevin Gurr[1], Fawaz Siddiqi[1], M. Patricia Rosas Arellano[1], Jennifer Urquhart[1].* **From the [1]Division of Orthopaedics, Department of Surgery, Schulich School of Medicine and Dentistry, Western University, London, Canada; the [2]Department of Physical Medicine and Rehabilitation, Schulich School of Medicine and Dentistry, Western University, London, Canada; and the [3]Department of Anesthesia and Perioperative Medicine, Schulich School of Medicine and Dentistry, Western University, London, Canada.**

Background: We recently reported on a randomized controlled trial demonstrating microdiscectomy to be superior to nonoperative care at 6 months posttreatment for chronic radiculopathy secondary to a lumbar disc herniation. This study was performed because Canadian patients with chronic sciatica who are surgical candidates frequently have not exhausted nonoperative care. This study reports the clinical outcomes at 2 years posttreatment. **Methods:** Patients were enrolled if they were 18–60 years old with a unilateral, single radiculopathy for 4–12 months from a posterolateral L4–5 or L5-S1 disc herniation. Patients were excluded if they had previous conservative care or they were not a surgical candidate. Nonoperative patients could not cross over to surgery for 6 months. The primary outcomes were the numerical rating scale (NRS) for leg pain (0–10) and Oswestry Disability Index (ODI). Secondary outcome measures included NRS back and leg pain, ODI, SF-36 questionnaire, work status, and satisfaction. A mixed-model of repeated-measures analysis was used according to the intention-to-treat principle. **Results:** At the 2 year time point data were available for 42/64 (66%) patients in the nonoperative cohort and 48/64 (75%) patients in the surgical cohort. The nonoperative cohort had a higher leg pain score than the surgical cohort (4.2 ± 0.4 v. 2.8 ± 0.4, $p < 0.001$), while the ODI score was not different (25.0 ± 2.5 v. 20.9 ± 2.4, $p = 0.238$). All secondary outcomes were similar by 2 years except for the SF-36 physical component score (38.2 ± 1.4 v. 43.5 ± 1.3, $p = 0.006$) and intensity of back pain (4.1 ± 0.4 v. 2.9 ± 0.3, $p = 0.022$) both favouring surgery. The time-weighted treatment effect taking all time points into consideration favoured surgery for all primary and secondary outcomes. Twenty-four patients randomized to nonoperative treatment eventually required surgery. **Conclusion:** Physical function, back pain and leg pain maintained a significant beneficial effect from surgery at 2-year follow-up.

52

Advanced practice physiotherapy spine assessment improves MRI and emergency department resource utilization. *Jennifer Birmingham[1], Tom Inglis[2], Daniel Banaszek[2], Vancouver Spine Program Surgeons (VSPS)[1], John Street[1], Emily Motyka[1].* **From the [1]Vancouver Spine Institute, Vancouver, Canada; and the [2]University of British Columbia, Vancouver, Canada.**

Background: We developed an advanced practice physiotherapist (APP) spine assessment program to improve access to and quality of care for patients with cervical and lumbar spine pathologies. Inappropriate imaging and emergency department (ED) visits are key metrics of triage program efficacy. We hypothesized that the APP clinic would reduce both inappropriate imaging and ED visits for patients with both cervical and lumbar spine pathologies. **Methods:** After 3 months of training, 2 APPs assessed a random 50% of all consecutive referrals to our quaternary spine program. Appropriateness of prereferral imaging was determined based on the Choosing Wisely Canada, the Canadian Spine Society and Canadian Institutes of Health Research guidelines. Additional appropriate imaging ordered by the APP was recorded. Spine-related ED visits were recorded for all pilot and non-APP patients. Annual wasted imaging for incomplete referrals and backlog referrals was recorded for the non-APP arm. **Results:** In all, 1576 patients were seen in the 12-month pilot, with 34% being cervical cases. Of the patients seen at the pilot, 72% of referrals had inappropriate imaging before referral. There were 953 inappropriate magnetic resonance images (MRIs) (CAD$857 700),

1093 computed tomography (CT) scans (CAD$874 400) and 819 x-rays (CAD$114 660), at a total cost of CAD$1 846 760. A total of 8% of non-APP referrals were incomplete with 207 MRIs (CAD$186 300), 111 CTs (CAD$88 800) and 52 x-rays (CAD$7280), total cost CAD$282 380. Expired imaging for backlog non-APP patients was 960 MRI (CAD$864 000), 1290 CTs (CAD$1 032 000) and 540 x-rays (CAD$75 600). Total annual imaging savings from APP clinic was CAD$4.1 million. The APPs ordered 40 MRIs, 4 CTs and 17 x-rays at a cost of CAD$42 780. For the APP group, 53 (3.9%) patients had 69 spine-related ED visits after assessment. For the non-APP group 226 patients (11.9%) had 317 visits while awaiting appointment. **Conclusion:** APP assessment provides timely and appropriate triage of patients with both cervical and lumbar spine pathologies, leading to significant resource savings from elimination of inappropriate and wasted imaging and by reducing spine-related ED visits.

110

Translation of the Interprofessional Spine Assessment and Education Clinic to the New Brunswick population. *Donna Eastwood[1], Mariah Darling[2], Neil Manson[2,3,4].* **From the [1]Saint John Regional Hospital, Horizon Health Network, Saint John, Canada; the [2]Canada East Spine Centre, Saint John, Canada; the [3]Division of Orthopaedic Surgery, Zone 2, Horizon Health Network, Saint John, Canada; and the [4]Dalhousie University Faculty of Medicine, Halifax, Canada.**

Background: We sought to demonstrate the effective establishment, through knowledge translation, of the Interprofessional Spine Assessment and Education Clinic (ISAEC) program in New Brunswick, assessed by examining patient outcome scores, patient activation, and primary care provider satisfaction. **Methods:** Prospectively collected data from the NB-ISAEC database were included for all patients with both intake and 6-week follow-up data as of October 2018 ($n = 75$). Continuous variables were analyzed using a paired samples t test, and 1-way analysis of variance (ANOVA) and categorical variables were analyzed using χ^2 analysis. Significance was $p < 0.05$. **Results:** Six weeks after an NB-ISAEC appointment, participants reported statistically significant improvements in Oswestry Disability Index (ODI) scores ($t_{74} = 7.010$, $p < 0.001$), physical component scores (PCS) ($t_{66} = 6.705$, $p < 0.001$), NRS-B scores during activity ($t_{71} = 4.227$, $p \le 0.001$), NRS-L scores at rest ($t_{69} = 3.417$, $p = 0.001$) and during activity ($t_{68} = 4.853$, $p < 0.001$). There was a statistically significant decrease in number of patients with a clinically relevant PCS (score > 30; $\chi^2_1 = 6.115$, $p = 0.013$), and a significant change in patient's self-reported pain status between intake and follow-up ($\chi^2_2 = 36.053$, $p < 0.001$), with an increase in patients indicating improving pain. At 6 weeks patients reported high compliance with their given exercise plan; 53.3% of patients reported daily exercise, and only 4.0% of patients reported not performing their exercise weekly. A repeated-measures ANOVA was performed for a preliminary look at patients with 3-month outcomes, with changes in ODI ($F_{2,30} = 6.461$, $p = 0.005$) and PCS ($F_{2,30} = 3.891$, $p = 0.044$) being statistically significant. Preliminary primary care provider (PCP) satisfaction results ($n = 11$) show a favourable attitude toward the program with 90.9% of PCPs indicating they believe this program improved patient support and management and 81.8% reporting improved access to care for their patients. **Conclusion:** After participation in NB-ISAEC, the improvements in outcome scores, high patient activation and high

PCP satisfaction suggest the successful translation of the ISAEC program to the New Brunswick population. Future work should quantify longer-term patient health and economic benefits and universal health care cost avoidance and efficiency.

118

Does a multidisciplinary triage pathway facilitate better outcomes after spine surgery? *Adam Wu, Lucy Liu, Daryl Fourney.* **From the University of Saskatchewan, Saskatoon, Canada.**

Background: Retrospective studies have shown the Saskatchewan Spine Pathway (SSP) facilitates timelier magnetic resonance imaging (MRI) and more appropriate surgical referrals. The objective of this study was to compare surgical outcomes after triage through conventional processes or the SSP, with respect to baseline clinical features, indication for surgery, therapies received before surgery, type of surgery, wait times, overall patient satisfaction and outcome. This is the first prospective SSP study and the only study of SSP clinical outcomes. **Methods:** A prospective, nonrandomized matched cohort comparison of 150 patients (SSP group $n = 75$; conventional group $n = 75$) undergoing elective lumbar surgery for mechanical back and leg pain between 2011 and 2016 was performed. Follow-up was 1 year. Patient self-reported outcomes included the Oswestry Disability Index (ODI), visual analogue pain (VAS) for back and leg, and EQ-5D questionnaire scores. **Results:** There were no between-group differences for baseline demographics, body mass index (BMI), SSP classification of pain pattern, pain scores, functional scores, quality of life scores, indication for surgery, or type of surgery (instrumented or noninstrumented). There was no difference with respect to wait times to see the surgeon or wait time for surgery; however, wait time for MRI was significantly shorter for the SSP group (16.8 v. 63.0 d, $p < 0.001$). Patients triaged through the SSP were significantly more likely to utilize nonoperative treatment strategies (physiotherapy, chiropractic, massage, acupuncture) before seeing the surgeon ($p < 0.04$). Although there was a statistically significant difference in VAS leg pain at 1 year favouring the SSP group (2.8 SSP group v. 2.1 conventional group, $p = 0.05$), ODI and EQ-5D scores did not differ significantly between groups. Patient satisfaction was significantly higher for SSP patients before surgical assessment ($p = 0.03$), but did not differ between groups throughout the postoperative period. **Conclusion:** There are minimal differences in surgical outcomes for SSP patients versus conventionally referred patients; however, the SSP facilitates significantly shorter wait times for MRI and nonoperative treatment strategies. Presurgical patient satisfaction is significantly higher among SSP patients.

157

Health status, quality of life and health care utilization in patients with degenerative spine conditions: A pain in the neck or a pain in the back? *Daniel Banaszek[1], Tom Inglis[1], Program Surgeons (VSPS)[2], John Street[2].* **From the [1]University of British Columbia, Vancouver, Canada; and the [2]Vancouver Spine Institute, Vancouver, Canada.**

Background: While the societal burden of back pain is well established, much less is known of patients with neck complaints. Unlike previous Canadian models, our advanced practice physiotherapist (APP) clinic triages patients with both cervical and lumbar spine pathologies. We examined patient demographics, health status,

health care quality of life and health care utilization measures between those with cervical and lumbar presentations. **Methods:** We assessed 1576 patients using CORE Cervical and Lumbar Tools. Of those, 25% had cervical pathology. Data included demographics, health status, health care quality of life and health care utilization measures. Differences between cervical and lumbar presentations were examined using paired and unpaired t tests and the nonparametric analogue of the Wilcoxon rank sum test, as appropriate. **Results:** APP and surgeon agreement was superior for lumbar than cervical conditions for both diagnosis (odds ratio [OR] 3.5, 95% confidence interval [CI] 1.96–6.26, $p < 0.0001$) and urgency (OR 3.1, 95% CI 1.83–5.14, $p < 0.0001$). Lumbar patients were more likely to have had symptoms for < 12 weeks ($p = 0.001$) or > 1 year ($p < 0.0001$); be on modified work duties ($p = 0.01$); have seen another spine surgeon ($p = 0.003$); report primarily axial symptoms ($p = 0.001$); have a diagnosis of osteoarthritis ($p = 0.05$); be currently employed but not working ($p = 0.0009$); be retired ($p = 0.008$); have seen their family doctor more than 10 times ($p = 0.028$); have received a fluoroscopy-guided injection ($p = 014$); and have ranked remaining independent as a treatment priority ($p = 0.005$). Cervical patients were more likely to exercise ($p = 0.007$); have a magnetic resonance imaging scan ($p = 0.023$); take medications for their symptoms ($p = 0.0013$); consider spine surgery ($p < 0.0001$); be involved in litigation ($p = 0225$); be depressed (PHQ-9, $p = 0.001$); have poor EQ-5D questionnaire scores ($p = 0.0227$); be physically disabled (PCS12, $p = 0.005$); and list family doctor recommendations as a reason to want surgery ($p = 0.0225$). **Conclusion:** We identify fundamental differences in health status, quality of life and health care utilization between patients with cervical and lumbar complaints in an APP triage clinic. Understanding of these differences will allow improved patient triage and thus positively impact referral practices, resource utilization and patient outcome.

140

Small area variation in compliance with clinical practice guidelines in the management of acute low-back pain. *Paul Gauthier[1], NhatChinh Le[1], Alexandra Stratton[1], Philippe Phan[1], Stephen Kingwell[1], Eugene K. Wai[1,2]. From the [1]University of Ottawa, Ottawa, Canada; and the [2]Ottawa Spine Collaborative Analytics Network, Ottawa, Canada.*

Background: Compliance with clinical practice guideline (CPG) recommendations could reduce low-back pain (LBP)–related health care costs and improve care. Our study aimed to use provincial administrative data to investigate compliance with CPGs in primary care. Specifically we wished to assess conformity and small area variations related to specific CPG recommendations. **Methods:** We performed a retrospective administrative database analysis of all Ontario residents from 2012 to 2016. The denominator consisted of the number of individuals who presented to a primary care provider with acute nonspecific LBP. The numerator consisted of the number of opioid prescriptions dispensed within 7 days, or computed tomography (CT) or magnetic resonance imaging (MRI) of the lumbar spine performed within 3 and 6 months of the index LBP. Age- and gender-adjusted prevalence ratios (PR) were then calculated to determine small area variations among geographic health regions (Local Health Integration Networks [LHINs]). The 2016 Canadian Census was used to determine population-level sociodemographic information for

each LHIN to inform an ecological analysis. **Results:** There was minimal small area variation in the adjusted rates of acute LBP by LHIN (PR 1.2). However, there was substantially greater small area variations in the rates of early CT (PR 2.9), MRI (PR 3.5) and new opioid starts (PR 1.8). These small area variations became much higher when sub-LHINs were analyzed. LHINs with higher rates of these events were significantly associated with a higher rural index, lower socioeconomic factors and fewer family doctors per capita. **Conclusion:** There is substantial small area variation in the rates of non-CPG conforming practices. Proper CPG primary care of acute LBP requires engagement to educate and reassure the patient instead of reliance on advanced imaging and painkillers. We noted an association between higher rates of non-CPG-conforming practices and various factors related to barriers to engaged primary care.

121

Understanding surgeon decision-making and current surgical practice regarding the DSIC scheme and degenerative lumbar spine treatment: a CSORN study. *Audrey Maher, Philippe Phan, Mohamad Hoda, Alexandra Stratton, Stephen Kingwell, Eugene Wai. From the Ottawa Hospital, Ottawa, Canada.*

Background: This study aims to determine whether surgeons are following DSIC scheme treatment recommendations as well as which radiographic/clinical parameters and surgeon characteristics are most influencing classification and treatment decisions. In order for the treatment of degenerative lumbar spine (DLS) to become standardized, and therefore uniform and cost-effective, we must first understand how current treatment decisions are being made. **Methods:** The data, which included 224 Canadian Spine Outcomes and Research Network (CSORN) DLS cases, were cleaned and analyzed using recursive feature elimination analysis, stability selection analysis, and principal component analysis to determine the correlations between classification and treatment. Machine learning models (support vector machine and logistic regression) built using Python-based libraries were used to test the strength of the correlations found. **Results:** Most cases of DLS were classified as being DSIC type II (52%). However, 61% of cases were treated with a 360° fusion regardless of their stability even though only 18% of cases were classified as type III. For type I cases, the recommended surgical treatment was used 41% of the time. The use of recommended surgical treatment was much lower for type II (17%). For type III, 91% of cases were treated with the recommended procedure. Dynamic translation was found to be the parameter most correlated with the DSIC grade. Meyerding grade and disc angle standing were the 2 parameters the most correlated with treatment decision-making. **Conclusion:** This study presented the demographics of DLS classification and treatment. It demonstrated that most surgeons are choosing the most extensive surgical procedure even when not indicated by the DSIC scheme. The study also found important correlations between patient parameters, classification, and treatment (e.g., dynamic translation most correlated to classification and Meyerding grade to treatment). Further efforts are needed to develop a new scoring algorithm to classify the stability of DLS based on the correlations found in this study. This new scoring algorithm would be clinically significant as it would be more comprehensible and reproducible than the DSIC scheme and able to guide the treatment of DLS.

156

Predictors of surgical referral from an advanced practice physiotherapy rapid access clinic. *Tom Inglis[1], Daniel Banaszek[1], Program Surgeons (VSPS)[2], John Street[2].* **From the [1]University of British Columbia, Vancouver, Canada; and the [2]Vancouver Spine Institute, Vancouver, Canada.**

Background: Our advanced practice physiotherapist (APP) clinics assess patients with both cervical and lumbar spine pathologies, using validated algorithms, to triage potential surgical candidates. We examined the predictors of referral to a surgeon, determining patient characteristic differences between those with cervical and lumbar presentations. **Methods:** In total, 1576 patients were assessed (75% lumbar), and referral to a surgeon was decided, using the validated CORE Cervical and Lumbar Tools. Data collected included demographics, health status, health care quality of life and health care utilization measures. Predictors of referral, correlations and differences between cervical and lumbar presentations were examined using paired and unpaired t tests and the nonparametric analogue of the Wilcoxon rank sum test, as appropriate. **Results:** Factors predictive of surgical referral in both cohorts included Neck Disability Index score (odds ratio [OR] 1.61, 95% confidence interval [CI] 1.2–2.16, $p = 0.0016$); Oswestry Disability Index score (OR 1.85, 95% CI 1.33–2.57, $p = 0.0003$); degree of arm ($p = 0.0001$), neck ($p = 0.0009$), leg ($p < 0.0001$) and back ($p = 0.0037$) pain; use of neuroleptic medication ($p = 0.0178$); EQ-5D questionnaire (cervical: $p = 0.0073$, lumbar: $p < 0.0001$); SF-12 physical component score (cervical: $p = 0.0004$, lumbar: $p = 0.002$). Patients who did not perceive surgery as helpful were less likely to be referred in both cohorts (cervical: $p = 0.012$, lumbar: $p = 0.0001$). Medical comorbidities and measures of recent health care utilization were not predictive of surgical referral in either group. Predictors of surgical referral in the cervical cohort included only PHQ-9, (OR –1.67, 95% CI 1.01–2.75, $p = 0.044$), use of antidepressant medication ($p = 0.02$), change in work status ($p = 0.0004$) and patients taking pain medication ($p = 0.03$). Predictors of surgical referral in the lumbar cohort included only a diagnosis of osteoarthritis ($p = 0.0002$), no litigation involvement ($p = 0.0001$), more than 5 previous family doctor visits ($p = 0.028$), and previous fluoroscopy-guided injection ($p = 0.014$). Exercise frequency ($p = 0.015$), and duration ($p = 0.0375$) were negative predictors of referral in lumbar, but not cervical patients. Patients who highly ranked a desire to remain independent ($p = 0.005$), and to decrease their level of pain ($p = 0.0018$) were more likely to be referred. **Conclusion:** Numerous patient and disease characteristics predict APP to surgeon referral. Significant baseline differences exist between patients with cervical and lumbar presentations. Understanding these factors may improve patient triage and thus positively impact referral practices, resource utilization and patient outcome.

29

Health care utilization and costs for spinal conditions in Ontario. *Y. Raja Rampersaud[1], J. Denise Power[1], Anthony V. Perruccio[1], Michael Paterson[2], Christian Veillette[1], Elizabeth M. Badley[3], Nizar Mahomed[1].* **From the [1]Arthritis Program, Krembil Research Institute, University Health Network, Toronto, Canada; [2]ICES, Toronto, Canada; and the [3]Krembil Research Institute, University Health Network, Toronto, Canada.**

Background: Our objective was to examine the magnitude and costs of physician care and hospital service use for spinal conditions (nontrauma and trauma-related) in Ontario, considering physician types and hospital settings. **Methods:** We analyzed 2013/2014 administrative data for adults aged 18 years and older ($n = 10\,841\,302$). Data sources were the Ontario Health Insurance Plan Claims History Database, with in- and outpatient physician services data; Canadian Institute for Health Information (CIHI) Discharge Abstract Database, with diagnoses and procedures for hospitalizations; and CIHI National Ambulatory Care Reporting System, with data on emergency department (ED) and day surgery encounters. Services for spinal conditions were identified using the single 3-digit ICD-9 diagnosis code on each physician claim for outpatient physician visits and the "most responsible" ICD-10 diagnosis code recorded for hospitalizations, ED visits and day surgeries. Patient visit rates and numbers of patients and visits were tabulated. Direct medical costs were estimated. **Results:** Overall, 822 000 adult Ontarians (7.6%) made 1.6 million outpatient physician visits for spinal conditions in 2013/14; 1.1 million of these visits (69%) were for non-trauma-related conditions. Approximately 86% of outpatient visits for spinal conditions were in primary care. There were 130 000 ED visits for nontrauma spinal conditions, accounting for 2.8% of all ED visits in Ontario. Total costs for spine-related care were $264 million, with 64% of costs ($168 million) due to nontrauma conditions. For these nontrauma conditions, 53% of costs were due to hospitalizations, 19% were for primary care, and 17% were for ED care. For trauma-related conditions, 71% of costs were for hospitalizations, 16% for primary care and 9% for ED care. Spine imaging costs for patients who made musculoskeletal-related physician visits were $66.5 million. Including these costs yields a total of $330 million. **Conclusion:** Spinal conditions place a large and costly burden on the health care system. The significant costs associated with ED care for nontrauma conditions highlight the need for implementation of more clinically and cost-effective models of spinal care.

94

National adverse event profile after lumbar spine surgery for lumbar degenerative disease and comparison of complication rate between hospitals: a CSORN registry study. *Oliver Ayling, Tamir Ailon, Charles Fisher.* **From the University of British Columbia, Vancouver, Canada.**

Background: Most of the previous work investigating the rates of adverse events (AEs) in spine surgery have been retrospective, with data collection from administrative databases, and often from single centres. To date, there have been no reports using a rigorous and prospective analysis to capture AEs in spine surgery on a national level or compare the rates of AEs among centres. **Methods:** The incidence and severity of AEs after spinal surgery was captured using the Spine AdVerse Events Severity system, version 2 (SAVES), in 14 spine centres from the Canadian Spine Outcomes and Research Network (CSORN) prospective registry. Minor and major AEs were defined by SAVES grades 1–2 and 3–6, respectively. **Results:** A total of 3556 patients were enrolled in this cohort. As defined by SAVES, there were 85 (2.4%) patients with major AEs and 682 (19.2%) with minor AEs. There were 25 patients with major intraoperative AEs and 262 with minor intraoperative AEs.

Postoperatively there were 61 patients with major AEs with a total of 80 major AEs and 84 minor AEs. Of the 487 patients with minor AEs postoperatively there were 698 total AEs. The rate of AEs varied by each hospital site. Of the 11 sites with more than 10 patients enrolled in the registry (3 sites had 10 or fewer patients enrolled) the average enrolment was 321 patients per site. The rate of major AEs was consistent among sites (mean 2.9 ± 2.4%, range 0%–9.1%). However, the rate of minor AEs varied widely among sites, ranging from 7.9% to 42.5% with a mean of 18.8 ± 9.7%. **Conclusion:** Among centres, the rate of major AEs is consistent after lumbar spinal surgery, but there is large variation between the rates of minor AEs, and this is likely influenced by the method of reporting AEs. This study has implications for the reporting of AEs as well as implementation of strategies to mitigate AEs.

75

Efficacy and cost-effectiveness of photodynamic therapy in prevention of surgical site infection. *Daniel Banaszek[1], Tom Inglis[1], Titus Wong[2], Program Surgeons (VSPS)[3], John Street[1].* **From the [1]University of British Columbia, Vancouver, Canada; [2]Vancouver Coastal Health Infection Control, Vancouver, Canada; and the [3]Vancouver Spine Institute, Vancouver, Canada.**

Background: Incidence rates of surgical site infection (SSI) following instrumented spine surgery vary from 1% to 9%. We have previously reported significant variability in SSI prevention practice among Canadian Spine Society members. Patient skin and nasal cavity colonization with methicillin-susceptible *Staphylococcus aureus* remains a major risk factor. The purpose of this study was to investigate the efficacy and cost-effectiveness of chlorhexidine skin decolonization (CSD) and nasal photo-disinfection therapy (nPDT) on SSI. **Methods:** Since 2009, as a local quality-improvement initiative at a quaternary referral centre, all patients undergoing high-risk surgery (including instrumented spine, vascular, cardiothoracic and orthopedic trauma surgery) received CSD and nPDT preoperatively. SSI rates, microbiological data, treatment data and costs were prospectively recorded. Among the spine surgery cases, age, body mass index (BMI), comorbidities, spine surgery invasiveness index (SSII), blood loss and adverse events (AE) were recorded using the SAVES2 system. **Results:** From 2009 to 2017 the SSI rate for spine cases decreased from 7.2% to 1.6%, the greatest magnitude of reduction of all surgery types ($p < 0.01$). The absolute risk reduction for spine was 5.6%, and the number needed to treat to prevent 1 infection was 18 patients. This resulted in an average of 53 fewer cases of SSI per year. CSD/nPDT costs CAD$45–55 per person. The estimated annual cost saving was CAD$4.24 million. CSD/nPDT was most effective in patients with diabetes (relative risk [RR] 2.1), BMI > 35 (RR 2.25), midline lumbar surgery versus cervical or thoracic (RR 2.2), cervical versus thoracic (RR 1.9), revision surgery (RR 2.9) and in those undergoing more complex instrumentation (SSII > 21, RR 3.35). The use of CSD/nPDT was not associated with any additional AEs. **Conclusion:** CSD/nPDT is both efficacious and cost-effective in preventing SSI, particularly in complex instrumented cases in the highest risk patients. Given the minimal resource cost, we recommend the routine use of this technology for SSI prevention.

129

Higher adverse events and longer lengths of stay for posterior compared with anterior cervical spinal surgery. Findings from a multivariate adjusted analysis of a multicentre North American prospective database. *Mohammad Alswat[1,2], Stephanie De Vere[1], Alexandra Stratton[1], Philippe Phan[1], Stephen Kingwell[1], Eugene K. Wai[1].* **From the [1]University of Ottawa, Ottawa, Canada; and the [2]Ottawa Spine Collaborative Analytics Network, Ottawa, Canada.**

Background: The evidence supporting anterior or posterior cervical spinal surgery is conflicting. We used a North American database to determine if length of stay (LOS) and adverse events (AEs) are different for anterior compared with posterior cervical spinal surgery procedures. **Methods:** This is a retrospective multivariate adjusted analysis of prospectively collected data using the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database. Two independent reviewers with fellowship training in spinal surgery assessed all procedural and diagnostic codes to standardize their definitions. All elective cervical inpatient spinal surgery between 2005 and 2016 was considered. Infection, tumour, fracture, paraplegia or combined anterior/posterior procedures were excluded. **Results:** In total, 1073 patients underwent posterior procedures and 7925 underwent anterior procedures. There were 189 (17.6%) AEs in the posterior group compared with 322 (4.1%) AEs in the anterior group. The mean LOS was 3.4 days in the posterior group and 1.8 days in the anterior group. Both outcomes were significantly higher in the posterior group ($p < 0.0001$). Using multivariate analyses with adjustments for age, gender, body mass index, American Society of Anesthesiologists score, Charlson Comorbidity Index score, multilevel surgery, myelopathy/radiculopathy, primary/revision, instrumentation and operative time demonstrated significantly ($p < 0.0001$) higher adjusted odds of 3.76 of AEs and adjusted mean of 1.2 days longer LOS for posterior procedures. These difference remained significant ($p < 0.0001$) in subgroup analyses of single or multilevel procedures alone. **Conclusion:** In a prospective outcomes analysis of the ACS NSQIP database of elective inpatient cervical surgery, posterior spinal procedures had significantly higher AE rates and LOS. We were able to adjust for the effects of multiple factors but recognize that unmeasured confounding factors may affect our conclusions.

46

Delayed treatment of spine fractures without spinal cord injury leads to an increase in major complications: a review of nearly 17 000 cases. *Frank Lyons, Matthew Guttman, Avery Nathens, Jeremie Larouche.* **From the Sunnybrook Health Sciences Centre, Toronto, Canada.**

Background: There is a general consensus in the literature that early decompression (defined as < 24 hr) of patients with spinal cord injury (SCI) leads to improved clinical outcomes. There is, however, a lack of high-quality evidence to guide surgeons on the management of patients with a mechanically unstable spine fracture in the absence of an SCI. The aim of this study was therefore to determine if rates of major complications (defined as systemic sepsis, pneumonia, pulmonary embolism, acute respiratory distress syndrome, acute renal failure, cardiac arrest, myocardial

infarction, and cerebrovascular accident) had a temporal association with a delay in surgical fixation of mechanically unstable spine fractures. **Methods:** The American College of Surgeons Trauma Quality Improvement Program database was queried using ICD 9 and ICD 10 procedure codes indicating operative fixation of the cervical, thoracic and lumbar spine. From this group, patients who possessed an ICD9/10 diagnostic code indicating either a complete/incomplete SCI, a penetrating mechanism of injury, and operative fixation more than 14 days after admission were excluded. The study group was then divided into 2 cohorts: those undergoing operative fixation within 24 hours of their admission, and those with delayed fixation beyond 24 hours. We next dichotomized major complications as a binary event and compared the relative risk of sustaining any major complications based on early v. late fixation. **Results:** We included 16 964 patients: 4447 were assigned to the early surgery group and 12 517 to the delayed group. The relative risk of a sustaining a major complication given spinal fixation beyond 24 hours was 1.6151 (95% confidence interval 1.4359–1.8167). When comparing mortality during the initial admission, 1.35% of patients died in the early fixation group compared with 1.81% in the delayed group ($p < 0.05$). **Conclusion:** Early spine fixation demonstrated fewer complications and an overall lower mortality rate. Our data support early intervention within 24 hours for mechanically unstable spine fractures, even in the absence of an SCI.

70

Hypoalbuminemia in elective lumbar spine surgery as a risk factor for increased complications and length of stay: an analysis of the National Surgical Quality Improvement Program (NSQIP) database. *Stephanie de Vere[1,2], Eugene Wai[1,2], Dita Moravek[1], Philippe Phan[1,2], Alexandra Stratton[1,2], Stephen Kingwell[1,2]. From the [1]The Ottawa Hospital Research Institute, Ottawa, Canada; and the [2]University of Ottawa, Ottawa, Canada.*

Background: Serum albumin is a biomarker that reflects nutritional status. It is easily measured and responds to appropriate interventions in a predictable fashion. In multiple studies across several surgical specialties hypoalbuminemia has been associated with increased morbidity and mortality. The purpose of our study is to assess the effect of hypoalbuminemia on surgical outcome and hospital length of stay (LOS) for patients undergoing elective lumbar spine surgery. **Methods:** We performed a retrospective multivariate adjusted analysis of prospectively collected data from the National Surgical Quality Improvement Program (NSQIP) database. We included elective lumbar surgeries performed between 2005 and 2016 while excluding those presenting with infection, tumour, trauma and spinal cord injury. The conditions excluded represent states of high physiologic stress and lead to a rapid drop in serum albumin. **Results:** In total 8698 patients met our criteria and had preoperative serum albumin reported within 2 weeks of their surgery. Of these 548 patients (6.3%) had hypoalbuminemia (serum albumin < 3.5 g/dL). Patients with preoperative hypoalbuminemia had a significantly longer LOS (7.3 v. 3.6 d) than those with normal values. The odds of pre- or postoperative medical or surgical complications was significantly higher in patients with hypoalbuminemia than those with normal values (odds ratio 2.4). These findings remained significant ($p < 0.0001$) after adjustments for age, gender, duration of surgery, American Society of Anesthesiologists grade and Charlson Comorbidity Index score. **Conclusion:** Hypoalbuminemia is independently associated with negative outcome in the setting of elective lumbar spine surgery. Measuring serum albumin preoperatively could help identify malnutrition and a patient at increased risk of complications. Detecting hypoalbuminemia and addressing it with nutritional counselling and optimization before elective surgery could offer an accessible and low-cost intervention to decrease LOS and complication rates.

76

The cost-effectiveness of a quality improvement initiative to minimize minor adverse events after spine surgery. *Tom Inglis, Daniel Banaszek, Nikolas Wong, Lise Belanger, Leanna Ritchie, Program Surgeons (VSPS), John Street. From the Vancouver Spine Surgery Institute, Department of Orthopaedics, University of British Columbia, Vancouver, Canada.*

Background: Minor postsurgical adverse events (AEs) are very common, yet their effects are largely unknown or ignored. Meanwhile they represent the greatest opportunity for quality-improvement initiatives. Medical outreach programs (MOP) are efficacious in reducing medical AEs in nonspinal postoperative populations. The purpose of this study was to examine efficacy and cost-effectiveness of a MOP on minor AEs in postoperative high-dependency spine patients. **Methods:** We conducted a prospective cohort study of all consecutive surgical patients admitted to a quaternary centre from 2008 to 2017. Demographic, surgical and outcomes data were collected on 2 cohorts: pre- (2008–2012) and post-MOP (2013–2017). The frequency of AEs was recorded using SAVES2. Previous work by Rampersaud and The Canadian Patient Cost Database (CPCD) were used to estimate the cost of each event. **Results:** A mean of 984 (range 912–1090) patients were admitted each year. Following introduction of MOP, the annual incidence of all recorded postoperative AEs decreased. Electrolyte imbalance decreased by 35% (451 to 294 annual events). Medication-related events decreased by 70% (402 to 117), ileus/constipation by 46% (255 to 137), nausea by 64% (215 to 78), cardiac complications by 55% (176 to 78), pulmonary by 65% (167 to 59), and delirium/psychiatric by 62.5% (118 to 44) (all $p < 0.001$). The cost estimate of a grade 1 AE is CAD$6370 and a grade 2 AE is CAD$21 500. MOP prevented 285 cases of medication related AE and 157 cases of electrolyte imbalance annually with cost savings of $2 895 884 and $1 595 276 respectively. Total annual cost saving was $9 927 294. **Conclusion:** The introduction of MOP, as a QI initiative to manage postoperative high-dependency spine patients not only reduces the incidence of grade 1 and 2 AEs but can do so with substantial cost savings. This study highlights the leverage that an AE system such as SAVES provides in the development and implementation of quality improvement initiatives.

126

Personalized risk prediction in spinal surgery. *Stephen Kingwell[1], Enea Parimbelli[2], Philippe Phan[1], Alexandra Stratton[1], Eugene Wai[1], Wojtek Michalowski[2]. From the [1]University of Ottawa, Ottawa, Canada; and the [2]Telfer School of Management, University of Ottawa, Ottawa, Canada.*

Background: Personalized risk assessment in spinal surgery may help with shared decision-making (SDM), but is currently lacking. The objective of this study is to develop a personalized risk prediction tool using machine learning and an institutional National Surgical Quality Improvement Program (NSQIP) database for patients undergoing spinal surgery. **Methods:** A single-centre NSQIP database of consecutive patients undergoing spinal surgery was used to develop a 2-stage prediction model for 30-day medical and surgical complications. The 2-stage model used known preoperative and perioperative features. Various machine learning algorithms were compared for both stages of prediction. The 2 models were then combined in a stacking scheme where the output of the first model was used as a covariate by the second model. Seventy percent of patients were used for parameter optimization and 30% of patients were used as an independent test set to evaluate model performance. **Results:** The study included 1542 patients. After comparing the performance of various machine learning algorithms, a gradient boosted decision tree (GBDT) and a support vector machine (SVM) were selected as the best models for the first and second stage, respectively. Given the intrinsic challenge of class imbalance in the data set (only 10% of the patients had complications), a preprocessing stage consisting of under-sampling was also employed before model training. The model at the first stage was able to predict postsurgical complications, with an area under the receiver operating characteristics curve (AUC) of 0.64. Adding perioperative features (second stage), resulted in an improvement in the predictive performance of the final 2-stage stacked model, achieving an AUC higher than 0.70. Explainable artificial intelligence using novel facilities for complementing model predictions will allow the model to produce decision-tree-generated, human-interpretable rules that justify the model prediction and may promote its uptake in clinical practice. **Conclusion:** A personalized risk prediction tool for patients undergoing spinal surgery was developed using an institutional NSQIP database and machine learning. This tool may help with SDM in spinal surgery.

41

Risk factors for surgical site infection following posterior thoracolumbar spinal surgery with drain placement. *Hui-Ling Kerr, Jennifer Urquhart, Parham Rasoulinejad, Lori Nutt, Alyssa Fleming, Linda Kuska, Joanne Collie, Kevin Gurr, Fawaz Siddiqi, Christopher Bailey.* **From the Division of Orthopaedics, Department of Surgery, Schulich School of Medicine and Dentistry, Western University, London, Canada.**

Background: The purpose of this study was to identify risk factors for postoperative surgical site infection (SSI) in a patients undergoing posterior thoracolumbar surgery with instrumentation followed by placement of a closed-suction drain. **Methods:** A retrospective analysis was performed on data that were prospectively collected in a prior randomized controlled trial of 552 patients who were randomized to 24 hours or 72 hours of postoperative antibiotic (to ensure 24 h of antibiotics post-drain removal, as drains were discontinued by postoperative day 2). The SSI rate did not differ between groups. For the current study, A stepwise multiple logistic regression model was used to determine the best combination of predictors of postoperative SSI. The regression coefficients obtained from the multivariate model were used to estimate the probability of an SSI. **Results:** There were a total of 80 SSIs out of 552 procedures

(14.5%). Of the total infections 31 (5.6%) were deep and 49 (8.9%) were superficial infections. In the stepwise regression model, the odds of an SSI were greater when a patient had a body mass index (BMI) ≥ 30 kg/m² (odds ration [OR] 2.34, $p = 0.006$), prophylactic preoperative vancomycin (OR 3.00, $p = 0.020$), prolonged surgery (OR 1.96, $p = 0.033$), worse preoperative mental functioning (OR 1.87, $p = 0.055$), blood loss > 600 mL (OR 2.32, $p = 0.048$) and a revision procedure (OR 1.86, p = 0.077). The area under the receiver operating characteristics curve for the final model was 0.723 ± 0.037, indicating acceptable predictive discrimination. The odds of developing an SSI decreased by 22% for patients who had preoperative prophylactic cefazolin, decreased by 16% for patients who had a BMI < 30 Kg/m², decreased by 12% for patients whose duration of surgery was < 280 min, decreased by 16% for patients who had blood loss < 600 mL, decreased by 11% for patients who had a mental component score > 35 at the preoperative assessment, and decreased by 11% for patients undergoing primary surgery. **Conclusion:** In this study cohort, obesity, antibiotic type, prolonged surgery, blood loss, revision procedure, and preoperative mental functioning were modifiable risk factors for SSI.

48

Application of the Mayo Clinic Mortality Review System to identify opportunities for quality improvement in a spine patient population. *Daniel Banaszek[1], Tom Inglis[1], Lise Belanger[2], John Street[2].* **From the [1]University of British Columbia, Vancouver, Canada; and the [2]Vancouver Spine Institute, Vancouver, Canada.**

Background: The Mayo Clinic Mortality Review System (MRS) is a validated, retrospective model previously used to identify potential quality-improvement opportunities in cases of in-hospital mortality. Opportunity categories include communication, documentation, delayed or missed diagnosis, patient deterioration, diagnosis, end-of-life discussion, hospital-acquired infection, medication/blood, prophylaxis, technology, transition of care, triage, treatment, and hospital-acquired conditions. The Mayo Clinic MRS model has not previously been used in a spine patient population, nor for nonmortality cases. The purpose of this study was determine the inter- and intrarater reliability of the MRS model in a population of traumatic cervical spinal cord injury patients. **Methods:** Two teams, each with 5 health care professionals (1 physician, 1 advanced clinical nurse specialist, 1 occupational therapist, and 2 additional allied health professionals; e.g., nurse, physiotherapist, occupational therapist, speech-language pathologist) performed data abstraction using the MRS methodology from 10 charts of patients with traumatic cervical spinal cord injury having suffered a predefined adverse event (AE; unanticipated reintubation). The categories and number of opportunities for improvement (OFIs) were recorded for both teams. Inter- and intrarater reliability was evaluated using an intraclass correlation coefficient (ICC), and agreement was evaluated using Bland–Altman plots. **Results:** An average of 14 OFIs were identified for each case. The OFIs most frequently identified by MRS were those related to inadequate communication/documentation (34.6%), delayed or inadequate escalation of care or resuscitation (26.8%) and incorrect or delayed diagnosis (17.2%). Inter- and intrarater reliability of MRS was poor/moderate (ICC range 0.4694–0.49520) and excellent (ICC range 0.9720–0.9966), respectively. MRS detected significantly fewer AEs than SAVES2 (mean 1.4 v 3.1 per patient, $p < 0.001$).

Conclusion: The Mayo MRS framework is reliable for investigation of a predefined AE in a traumatic spinal cord injury population. This retrospective tool offers a promising approach for the identification and development of quality-improvement initiatives and is not meant as an AE identification system. The as-expected poor interrater reliability confirms the critical importance of a multidisciplinary team approach.

92

The effect of perioperative adverse events on long-term patient reported outcomes after lumbar spine surgery. *Oliver Ayling, Tamir Ailon, Charles Fisher.* **From the University of British Columbia, Vancouver, Canada.**

Background: Perioperative adverse events (AE) lead to patient disappointment, resource utilization, and increased health care costs. There is a paucity of data on how AEs affect long-term patient reported outcomes (PRO). The purpose of this study is to examine perioperative AEs and their long-term impact on PROs after lumbar spine surgery. **Methods:** A total of 3556 consecutive patients undergoing elective spine surgery for degenerative lumbar spine disorders enrolled in the Canadian Spine Outcomes and Research Network (CSORN) prospective database were analyzed. Major and minor AEs were defined using the validated Spine AdVerse Events Severity system (SAVES). Perioperative AEs were analyzed for lumbar disc disease, degenerative spondylolisthesis, spinal stenosis, and lumbar degenerative deformity. Outcomes at 3 and 12 months postoperatively for physical function (Oswestry Disability Index [ODI] and SF-12 physical component score [PCS]), pain (visual analogue scale [VAS] for leg and back pain) and mental quality of life (SF-12 mental component score [MCS], and EQ-5D questionnaire), and satisfaction were assessed using univariate and multivariable analyses. **Results:** AEs occurred in 767 (21.6%) patients: 85 (2.4%) suffered major AEs, and 682 (19.2%) experienced minor AEs. Patients with major AEs had significantly worse postoperative ODI scores and did not reach minimum clinically important differences at 1 year (Baseline: no AE: 47.5 ± 15.5, major: 48.2 ± 14.8; 1 year: no AE 25.5 ± 19.5, major: 37.3 ± 19.3, $p < 0.001$). On VAS leg and back, EQ-5D, and SF12 PCS, the 1-year PROs were significantly different between the major AE group and the no AE group ($p < 0.01$), but these differences were small and unlikely clinically relevant. MCS scores were not significantly different between the major and no AE cohorts at 1 year. At 1 year postoperatively patients who faced a major AE had significantly lower rates of satisfaction (no AE: 83.5%, major: 71.6%, minor: 82.8%, $p < 0.01$). **Conclusion:** Major AEs during hospital admission after elective lumbar spine surgery lead to significantly worse long-term functional outcomes and lower rates of patient satisfaction. This information highlights the need to implement strategies aimed at reducing in-hospital AEs.

28

Factors associated with an increased risk of developing a postoperative infection following spine surgery. *Mina Aziz[1], Greg McIntosh[2], Michael Johnson[3], Charles Fisher[4], Michael Goytan[3].* **From the [1]McGill University, Montreal, Canada; the [2]Canadian Spine Outcome and Research Network, Markdale, Canada; the [3]University of Manitoba, Winnipeg, Canada; and the [4]University of British Columbia, Vancouver, Canada.**

Background: Postoperative infection is a serious complication of spine surgery and can contribute to the strain on the health care system's resources. The purpose of this study is to determine what factors affect the risk of developing postoperative infection. We hypothesize that female gender, smoking, diabetes, having thoracolumbar procedures, having a neurologic deficit, older age, body mass index (BMI), American Society of Anesthesiologists (ASA) score, blood loss, number of operative levels, operative time and undergoing nonelective surgery will increase the patients' risk of developing a postoperative infection. **Methods:** A retrospective review of prospectively collected data within the Canadian Spine Outcome and Research Network (CSORN) was conducted. Data were analyzed using IBM-SPSS. Multivariable logistical regression analysis was conducted (odds ratios [OR]) to determine any association between the outcome and independent factors. Significance level was $p < 0.05$. **Results:** There were 7747 patients identified from the registry that had completed at least 12 weeks of follow-up. There were 199 infections recorded, representing a 2.6% risk of infection. There were no association found between the risk of developing a postoperative infection and gender, smoking, diabetes, having thoracolumbar procedures, having a neurologic deficit, ASA score, blood loss, number of operative levels and undergoing nonelective surgery. The following were associated with an increased risk of developing a postoperative infection: older age (adjusted OR 1.021, 95% confidence interval [CI] 1.005–1.038, $p < 0.05$), having an elevated BMI (adjusted OR 1.042, 95% CI 1.013–1.072, $p < 0.005$), and longer operative time (adjusted OR 1.002, 95% CI 1.001–1.004, $p < 0.001$). **Conclusion:** There is a 2.6% overall rate of postoperative spine infection across 20 Canadian centres. The factors that were associated with an increased risk of developing a postoperative infection were older age, increased BMI and longer operative time. This study establishes a benchmark against which the effectiveness of future interventions to reduce infection can be compared.

40

The impact of surgical site infection on functional recovery and surgical outcomes after adult posterior thoracolumbar spinal surgery. *Jennifer Urquhart, Parham Rasoulinejad, Lori Nutt, Alyssa Fleming, Linda Kuska, Joanne Collie, Kevin Gurr, Fawaz Siddiqi, Christopher Bailey.* **From the Division of Orthopaedics, Department of Surgery, Schulich School of Medicine and Dentistry, Western University; Lawson Health Research Institute; and London Health Sciences Centre, London, Canada.**

Background: The purpose of the present study was to determine if surgical site infection (SSI) affects functional recovery and surgical outcomes up to 2 years following posterior thoracolumbar spinal surgery. **Methods:** Retrospective analysis was performed on patients enrolled in a previously completed prospective randomized controlled trial (RCT) examining antibiotic use in association with closed-suction drain removal. The trial included 552 patients who were randomized to either 24 or 72 hours of posoperative antibiotics. In the present study, we compared patients who had an SSI ($n = 80$) with those who did not ($n = 472$). Outcome measures included the Oswestry Disability Index (ODI), the numeric rating scale (NRS) for pain, SF12 summary scores (mental [MCS] and physical component scores [PCS]), and satisfaction with treatment, adverse events, readmissions and additional surgery. Outcomes were assessed before surgery and at 1.5, 3, 6, 12 and 24 months. **Results:** The infection rate

was 14.5% (80/552), and the median time to infection was 15 days. Thirty-one (5.6%) were deep and 49 (8.9%) were superficial infections. Patients who had an SSI had a higher body mass index ($p < 0.001$), were more likely to have had preoperative prophylactic vancomycin ($p = 0.048$), be undergoing a revision procedure ($p < 0.001$), and have worse preoperative mental functioning (MCS 43.9 ± 11.0 v. 40.5 ± 12.5). Following surgery they had more emergency department visits (2.5% v. 11.3%), readmissions (0.0% v. 46.3%) and additional surgery (5.5% v. 38.8%) than patients who did not have an SSI ($p < 0.05$ all comparisons). Patients who had an SSI had worse overall ODI ($p = 0.024$) and PCS ($p = 0.038$) scores (averaged over all time points). Comparison between the groups at 2 years showed no difference in functional outcomes, or satisfaction with treatment. **Conclusion:** SSI nearly doubled the readmission and additional surgery rates. Patients with SSI initially (6 mo) had poorer overall physical function, representing the delay to recovery associated with the infection; however, the negative impact resolved during the second postoperative year.

61

Development of clinical prognostic models for postoperative survival and quality of life in patients with surgically treated metastatic epidural spinal cord compression. *Anick Nater[1], Junior Chuang[2], Kuan Liu[2], Nasir Quraishi[3], Dritan Pasku[3], Jefferson Wilson[4], Micheal Fehlings[5].* From the [1]University of Toronto, Toronto, Canada; the [2]Dalla Lana School of Public Health, Toronto, Canada; the [3]Queen's Medical Centre, Nottingham University Hospital NHS Trust, Nottingham, Nottinghamshire, UK; [4]St. Michael's Hospital, University of Toronto, Toronto, Canada; and the [5]Toronto Western Hospital, University of Toronto, Toronto, Canada.

Background: Surgery is generally considered for patients with metastatic epidural spinal cord compression (MESCC) with life expectancy > 3 months. No existing clinical prognostic models (CPMs) of survival are consistently used, and no CPMs exist which predict quality of life (QoL) following surgical treatment. These knowledge gaps are important given the challenges involved in managing MESCC. **Methods:** Using TRIPOD guidelines and data from 258 patients (AOSpine North America MESCC study and Nottingham MESCC registry), we created 1-year survival and QoL CPMs using Cox model and logistic regression with manual backward elimination. The outcome measure for QoL was the minimal clinical important difference (MCID) in EQ-5D scores. Internal validation involved 200 bootstrap iterations; calibration and discrimination were evaluated. **Results:** Longer survival was associated with higher SF-36 physical component score (PCS) (hazard ratio [HR] 0.96), whereas primary tumour other than breast, thyroid, and prostate (unfavourable, HR 2.57; others, HR 1.20), organ metastasis (HR 1.51), male sex (HR 1.58), and preoperative radiotherapy (HR 1.53) were not (c statistic: 0.69, 95% confidence interval [CI] 0.64–0.73). Karnovsky Performance Scale score < 70% (odds ratio [OR] 2.50), living in North America (OR 4.06), SF-36 PCS (OR 0.95) and mental component score (OR 0.96) were associated with the likelihood of achieving an MCID improvement in EQ-5D at 3 months (c statistic: 0.74, 95% CI 0.68–0.79). Calibration for both CPMs was very good. **Conclusion:** We developed and internally validated the first CPMs of survival and QoL at 3 months postoperatively in patients with MESCC using TRIPOD guidelines. A web-based calculator is available (http://spine-met.com) to assist clinical decision-making in this complex patient population.

63

Developing therapeutic guidance for potentially unstable spinal metastases by evaluating health related quality of life outcomes for surgery and/or radiotherapy. *Anne Versteeg[1], Arjun Sahgal[2], Laurence Rhines[3], Daniel Sciubba[4], James Schuster[5], Michael Weber[6], Peter-Pal Varga[7], Stefano Boriani[8], Chetan Bettegowda[4], Michael Fehlings[9], Michelle Clarke[10], Paul Arnold[11], Ziya Gokaslan[12], Charles Fisher[13].* From the [1]University Medical Center Utrecht, Utrecht, Netherlands; [2]Sunnybrook Odette Cancer Centre, Toronto, Canada; [3]MD Anderson Cancer Center, Houston, USA; [4]Johns Hopkins University School of Medicine, Baltimore, USA; [5]Hospital of the University of Pennsylvania, Philadelphia, USA; [6]McGill University and Montreal General Hospital, Montreal, Canada; [7]National Center for Spinal Disorders and Buda Health Center, Budapest, Hungary; [8]GSpine4 Spine Surgery Division, Milan, Italy; [9]University of Toronto and Toronto Western Hospital, Toronto, Canada; [10]Mayo Clinic, Rochester, USA; [11]The University of Kansas Hospital, Kansas City, USA; [12]The Warren Alpert Medical School of Brown University and Rhode Island Hospital and The Miriam Hospital, Providence, USA; and the [13]University of British Columbia and Vancouver General Hospital, Vancouver, Canada.

Background: The objective of this study was to evaluate health-related quality of life (HRQoL) outcomes at 12 weeks posttreatment in patients treated with surgery and/or radiotherapy for potentially unstable spinal metastases. **Methods:** An international multicentre prospective observational cohort study was performed. Demographic, primary tumour, treatment, adverse event, and HRQoL data were collected. The NRS pain score, EQ-5D, SF-36 and Spine Oncology Study Group Outcome Questionnaire (SOSGOQ2.0) were used to evaluate HRQoL. A Spinal Instability Neoplastic Score (SINS) score between 7 and 12 defined potentially unstable spinal metastases. HRQoL scores were modelled and compared within and between treatment groups using mixed-effect models with adjustment for baseline characteristics. **Results:** Between August 2013 and May 2017, 120 patients with potentially unstable metastases were treated with surgery with or without radiotherapy, and 82 patients with radiotherapy alone. At baseline, patients who underwent surgery more often presented with mechanical pain ($p < 0.001$), a lytic tumour ($p = 0.031$), a higher median SINS score (10 v. 8 for radiotherapy alone), and worse baseline performance status, HRQoL and pain scores. Patients treated with surgery with or without radiotherapy also exhibited more often a combination of mechanical pain and a vertebral compression fracture compared with patients treated with radiotherapy alone. At 12 weeks posttreatment, surgically treated patients experienced a 2.7-point decrease in adjusted mean NRS pain (95% confidence interval [CI] –3.9 to –1.5, $p < 0.001$) and a 12-point increase in adjusted mean SOSGOQ2.0 (95% CI 5.1 to 19.0, $p < 0.001$) as compared with a 1.4-point decrease in NRS pain (95% CI –2.9 to 0.0, $p = 0.053$), and a 6.2-point increase in SOSGOQ2.0 (95% CI 2.2 to 14.6, $p = 0.352$) in those treated with radiotherapy alone. **Conclusion:** Profound improvements in pain and HRQoL scores are observed following surgery with or without radiotherapy for potentially unstable spinal metastases as compared with modest improvements following radiotherapy alone. Consultation of a spine surgeon is recommended for patients with a SINS score between 7 and 12, including mechanical pain and a vertebral compression fracture.

22

A phase I trial on the use of photodynamic therapy in vertebral metastases. *Zakariya Ali[1,2], Carl Fisher[3], Jay Detsky[1], Arjun Sahgal[1], Elizabeth David[1], Edward Chow[1], Cari Whyne[1], Shane Burch[4], Brian Wilson[3,5], Albert Yee[1].* From the [1]Sunnybrook Health Sciences Centre, Toronto, Canada; the [2]Royal College of Surgeons of Ireland, Dublin, Ireland; the [3]University Health Network, Toronto, Canada; the [4]University of California San Francisco, San Francisco, USA; and the [5]Princess Margaret Cancer Centre, Toronto, Canada.

Background: The spine is a common site of metastasis. Complications include pathologic fracture and spinal cord compression. Vertebroplasty (VP) and balloon kyphoplasty (KP) are minimally invasive stabilization procedures used in palliative treatment for spinal metastases. Photodynamic therapy (PDT) is a tumour-ablative modality that may complement mechanical stability afforded by VP/KP. This first-in-human study evaluates PDT safety when applied in conjunction with VP/KP. **Methods:** This dose escalation trial involved a light only control group and 4 light-drug doses (50, 100, 150, 200 J; *n* = 6) delivered at 150 mW from a 690 nm diode laser by 800-micron optical fibres. Patients eligible for VP/KP in treating pathologic fracture or at-risk lesions were recruited. Exclusion criteria included spinal canal compromise or neurologic impairment. PDT is a 2-step binary therapy of systemic drug followed by intravertebral light activation. Light was applied via bone trocar before cementation. Drug/light safety, neurologic safety, generic (SF-36) and disease-specific outcomes (visal analogue scale [VAS] and EORTC-QLQ-BM22 and EORTC-QLQ-C15-PAL questionnaires) were recorded through 6 weeks. **Results:** Thirty (10 male, 20 female) patients were treated (13 KP, 17 VP). The average age was 61 years. Primary cancer sites were breast (36.7%) and lung (23.3%). All patients had prior interventions involving a combination of surgery, chemotherapy and radiation therapy before enrolment. All patients completed the study through the 6-week follow-up. No group showed significant increases in pain as defined by the EORTC-QLQ questionnaire. The 50 and 100 J groups showed significant reductions in pain compared with the control group. The 50 J group had the best response, comprised mostly of lytic tumours, an average power density of 12.1 mW/cm^2 measured at various distances ranging from 1.2 to 2.4 cm, and 5/6 lesions located from L2 to L5. Forty percent of patients experienced complications during the study, none of which were drug- or PDT therapy–related. **Conclusion:** Vertebral PDT appears safe from pharmaceutical and neurologic perspectives. The KP/VP failure rate is broadly in line with reported values, and PDT did not compromise efficacy. The 50 J group demonstrated an improved response. Ongoing study determining safe dose range and subsequent efficacy studies are necessary.

107

Can radiomic features differentiate between osteoblastic and healthy bone tissue in metastatically involved vertebrae? *Allison Clement[1,2], Cari Whyne[1,2,3], Phoenix Wilkie[1], Margarete Akens[3,4,5], Albert Yee[1,2,3], Micheal Hardisty[1].* From the [1]Sunnybrook Research Institute, Toronto, Canada; the [2]University of Toronto Institute of Biomaterials and Biomedical Engineering, Toronto, Canada; [3]University of Toronto Department of Surgery, Toronto, Canada; [4]Techna, Toronto, Canada; and [5]University of Toronto Department of Medical Biophysics, Toronto, Canada.

Background: Quantification of osteolytic and osteoblastic metastatic involvement of the bony spine is important for assessing disease progression and treatment response. Metastasis affects bone deposition and quality, resulting in a change in texture within micro-computed tomography (µCT) image data. This investigation aims to develop an automated method to segment osteoblastic lesions in µCT images from a preclinical model of metastatically involved vertebrae using a radiomics approach. We hypothesize that radiomic-based feature extraction will be sensitive to changes in osteoblastic lesion bone texture and that these changes will be useful for automating osteoblastic segmentation. **Methods:** Osteoblastic metastases were generated via intracardiac injection of human ZR-75–1 breast cancer cells into a preclinical athymic rat model (*n* = 3). Four months postinoculation, ex-vivo µCT images (µCT100, Scanco) were acquired of metastatically involved third lumbar vertebra (L3) at 7 µm/voxel and resampled to 34 µm/voxel. The trabecular bone within each vertebra was isolated using an atlas and level-set based approach. Pyradiomics was used to calculate 3D image features at each voxel location within the vertebral bone. Thresholding of radiomic feature maps was used to isolate the osteoblastic lesions. Radiomic feature-based segmentation of osteoblastic tissue was evaluated on randomly selected 2D sagittal and axial slices of the µCT volumes. Feature segmentations were compared with ground truth osteoblastic lesion segmentations by calculating the dice similarity coefficient (DSC). Manually defined ground truth segmentations on the µCT slices were informed by histological confirmation of lesions. **Results:** The radiomic based features that best segmented osteoblastic tissue while optimizing computational time were derived from the Neighbouring Gray Tone Difference Matrix (NGTDM). Measures of coarseness yielded the best agreement with the manual segmentations (DSC 707%) followed by contrast, strength and complexity (DSC 6513%, 5428% and 4826%, respectively). **Conclusion:** This pilot study using a radiomic-based approach demonstrates the utility of the NGTDM features for segmentation of vertebral osteoblastic lesions. In future work, we will explore combining these features using machine learning–based classifiers to improve segmentation performance.

26

3D-printed scaffolds impregnated with doxorubicin and zoledronate for the treatment of spinal bone metastases. *Elie Akoury, Pouyan Ahangar, Ana Sofia Ramirez-Garcia Luna, Antone Nour, Michael Weber, Derek Rosenzweig, Mina Aziz.* From the McGill University Research Institute, McGill University Health Centre, Injury Repair Recovery Program, Department of Surgery, Division of Orthopaedics, Montreal, Canada.

Background: Current nonsurgical therapies of spinal bone metastases focus on chemotherapy and bone preservation with doxorubicin and zoledronate, respectively, being some of the most commonly used drugs. These drugs are usually systemically delivered to patients at high doses, and they can cause multiple adverse effects, limiting their prolonged use and effectiveness. Interestingly, we have investigated the potential of local delivery of zoledronate to the site of bone metastasis and have shown reduced tumour-induced osteolysis compared with systemically treated xenograft animals. Also, we have recently demonstrated the feasibility of 3D-printed scaffolds to deliver low doxorubicin doses locally over a sustained period while inhibiting bone metastasis in

vitro. We aim to develop 3D-printed scaffolds to deliver a combination of zoledronate and doxorubicin that can potentially allow for a synergistic antitumour activity while preventing concurrent bone loss locally at the tumour site and decreasing adverse effects in patients. **Methods:** 3D-printed PORO nano-porous scaffolds were loaded with doxorubicin or zoledronate in aqueous buffer over 7 days. Doxorubicin- or zoledronate-containing supernatants were collected daily and analyzed. The scaffold drug (doxorubicin or zoledronate) release system was tested in vitro on cancer cell lines and bone metastases cells. Treated cells were subject to proliferation, migration and invasion assays. Scaffolds loaded with both doxorubicin and zoledronate are being tested for drug release and on cancer cells. **Results:** We have titrated the drug loading of scaffolds to allow for a release amount of doxorubicin or zoledronate at the effective dose (EC50) over 7 days. We have shown that doxorubicin or zoledronate-loaded scaffolds inhibit cancer cell growth in vitro over 7 days using the above cellular assays. **Conclusion:** 3D-printed nano-porous scaffolds offer a novel and versatile opportunity for delivery of drugs in future clinical settings. These scaffolds can be placed at the tumour site and can be loaded with chemotherapeutics or other bioactive substances to block cancer growth, promote bone repair and decrease systemic side effects in patients.

85

Outcomes following surgery for spinal metastases in Ontario, Canada: population-based cohort study. *Kunal Bhanot[1], Jessica Widdifield[2,3], Anjie Huang[4], Michael Peterson[4], David Shultz[5,6], Joel Finkelstein[1,7].* **From the [1]Division of Orthopaedic Surgery, University of Toronto, Toronto, Canada; [2]Evaluative Clinical Sciences, Holland Bone and Joint Research Program, Sunnybrook Research Institute, Toronto, Canada; the [3]Institute of Health Policy, Management and Evaluation, University of Toronto, Toronto, Canada; [4]ICES, Toronto, Canada; the [5]Princess Margaret Cancer Centre, Toronto, Canada; the [6]Department of Radiation Oncology, University of Toronto, Toronto, Toronto, Canada; and the [7]Sunnybrook Health Sciences Centre, Toronto, Canada.**

Background: Our aim was to evaluate survival and complications for patients undergoing surgery for spinal metastases in Ontario. **Methods:** We performed a population-based, retrospective cohort study using Ontario administrative health data. We identified all patients who underwent surgical treatment of spinal metastases from 2006 to 2016. All patients were followed from surgery until death, out-migration or end of study (Dec 2017). We assessed all-cause mortality, overall and stratified by primary cancer, using Kaplan–Meier survival analysis. Secondary outcomes included hospital readmission, serious perioperative complications and vertebral fractures. Multivariable Cox regression models were fit to evaluate the associations between stereotactic body radiotherapy (SBRT) and conventional radiation (within the 6 mo after surgery), controlling for other risk factors (comorbidity, primary cancer, age, sex, socioeconomic status), and time to death. **Results:** Among 2358 patients undergoing surgery for spinal metastases, the mean age was 62.4 ± 12.3 years and 55% were male. Overall, 411 (17.4%) had breast and 288 (12.2%) had prostate cancer (as the primary lesion). Mortality rates were highest for gastrointestinal, lung and melanoma cancers, with 52.6% of patients with upper gastrointestinal cancers dying within 90 days of surgery (v. 50.6% and 48.5% for melanoma and lung cancers, respectively). The overall mean survival time following surgery was 1.5 ± 1.9 years. Twelve percent experienced a serious complication and 21.2% were readmitted to hospital within 30 days. Overall, 434 (18.4%) patients experienced a vertebral fracture. We identified 1012 (43%) patients who received conventional radiation; 244 (10%) were exposed to SBRT. SBRT exposure was more frequent among breast and thyroid cancers, whereas patients with prostate, lung, and myeloma cancers were more likely to have conventional radiation. In multivariable analyses, SBRT within 6 months postsurgery was associated with lower mortality risk than conventional radiation (hazard ratio 0.73, (95% confidence interval 0.62–0.85). **Conclusion:** Mortality following surgery for spinal metastases was highest for gastrointestinal, lung and melanoma cancers. While we observed an association between SBRT and survival, channeling bias cannot be ruled out.

62

Development and validation of clinical prognostic models of survival and clinical outcomes for patients with metastatic epidural spinal disease: a systematic literature review. *Anick Nater[1], Jetan Badhiwala[1], James Hong[1], So Kato[2], Melanie Anderson[3], Michael Fehlings[4].* **From the [1]University of Toronto, Toronto, Canada; the [2]Department of Orthopaedic Surgery, University of Tokyo, Tokyo, Japan; the [3]University Health Network, Toronto, Canada; and the [4]Toronto Western Hospital, University of Toronto, Toronto, Canada.**

Background: In multivariable prognostic research, the development and external validation are the first phases typically involved toward the establishment of clinical prognostic models (CPMs) in practice. This systematic review aims to identify and assess CPMs created to predict clinical outcomes in patients with metastatic epidural spinal disease (MESD) and their subsequent validation studies. **Methods:** Three electronic databases were searched (Jan. 1, 1990, to Dec. 31, 2017), without language restriction, to identify studies that addressed review question, what are the existing CPMs that have been developed and/or externally validated to predict survival or other clinical outcomes in patients with MESD? Data extraction, reporting and appraisal of the selected studies were conducted following recommended guidance: CHARMS, TRIPOD, and PROBAST (CRD42017072908). **Results:** Among 8077 unique full-text articles, 117 were included. Among the 52 articles describing a CPM (CPM creation n = 44, update of an existing CPM n = 8), 44 did not include any assessment of model performance (calibration and/or discrimination) while 20 reported the number of outcome events and 7 discussed missing data. Among the 5 articles with the term "external validation" or "external validity" in the title or abstract, missing data, number of outcome events, and calibration along with discrimination were discussed in 4, 3 and 2 studies, respectively. **Conclusion:** Since 1990, while over 50 CPMs predicting clinical outcomes in patients with MESD were developed, only 5 studies claimed performing an external validation of any of these tools. Most of the studies included in this review did not report on key methodological and data analysis elements. Greater rigor in the development and validation of CPMs could promote the establishment of CPMs in clinical practice in this patient population.

64

Patient satisfaction after treatment for spinal metastases. *Anne Versteeg[1], Arjun Sahgal[2], Laurence Rhines[3], Daniel Sciubba[4], James Schuster[5], Michael Weber[6], Peter-Pal Varga[7], Stefano Boriani[8], Chetan Bettegowda[4], Michael Fehlings[9], Michelle Clarke[10], Paul Arnold[11], Ziya Gokaslan[12], Charles Fisher[13].* From the [1]University Medical Center, Utrecht, Netherlands; [2]Sunnybrook Odette Cancer Centre, Toronto, Canada; [3]MD Anderson Cancer Center, Houston, USA; [4]Johns Hopkins University School of Medicine, Baltimore, USA; [5]Hospital of the University of Pennsylvania, Philadelphia, USA; [6]McGill University and Montreal General Hospital, Montreal, Canada; the [7]National Center for Spinal Disorders and Buda Health Center, Budapest, Hungary; the [8]GSpine4 Spine Surgery Division, Milan, Italy; the [9]University of Toronto and Toronto Western Hospital, Toronto, Canada; the [10]Mayo Clinic, Rochester, USA; [11]The University of Kansas Hospital, Kansas City, USA; [12]The Warren Alpert Medical School of Brown University and Rhode Island Hospital and The Miriam Hospital, Providence, USA; and the [13]University of British Columbia and Vancouver General Hospital, Vancouver, Canada.

Background: The objective of this study was to evaluate patient satisfaction following either surgery with or without radiotherapy or radiotherapy alone for the treatment of metastatic spine disease. **Methods:** A prospective international multicentre observational study including patients with spinal metastases treated with surgery with or without radiotherapy or radiotherapy alone was performed. Demographic, histologic, treatment, adverse event, and health-related quality of life (HRQoL0 data were collected. Evaluation of HRQoL included the NRS pain score, EQ-5D-3L and the Spine Oncology Study Group Outcome Questionnaire (SOSGOQ2.0). Patient satisfaction was evaluated based on the posttreatment SOSGOQ2.0 questions at 6, 12, and 26 weeks posttreatment. Patients were classified as satisfied, neutral or dissatisfied with the results of their spine treatment. A last observation carried forward method was used in case of missing data. **Results:** At 12 weeks posttreatment, 84% (*n* = 158) of the patients treated with surgery with or without radiotherapy were satisfied and 5% (*n* = 9) were dissatisfied compared with 77% (*n* = 95) being satisfied and 6% (*n* = 7) being dissatisfied after treatment with radiotherapy alone. Decreased leg strength (*p* = 0.031) and worse lower social functioning at baseline were associated with postsurgery dissatisfaction. Patients who were satisfied after surgery experienced significant improvements in pain, physical function, mental health, social function and EQ-5D compared with nonsignificant improvements in dissatisfied patients. Being single (*p* = 0.030) and worse lower social function (*p* = 0.069) at baseline were associated with postradiotherapy dissatisfaction. Postradiotherapy satisfaction was associated with significant improvements in pain, mental health and overall SOSGOQ2.0 scores. **Conclusion:** Both surgery with or without radiotherapy and radiotherapy alone for the treatment of spinal metastases demonstrated high rates of treatment satisfaction. Significant improvements in pain, physical function, social function, mental health and overall HRQoL are associated with posttreatment satisfaction.

151

Predicting mortality following traumatic cervical spinal cord injury in the elderly. *Tom Inglis[1], Marcel Dvorak[1], Daniel Banaszek[1], Nathan Evaniew[1], Dilnur Kurban[2], Nader Fallah[1,2], Vanessa Noonan[1,2], Christopher Bailey[3], Sean Christie[4], Brian Drew[5], Michael Fehlings[6], Joel Finkelstein[6], Charles Fisher[1], Daryl Fourney[7], Andrea Townson[1], Eve Tsai[8], Zeina Waheed[2], Brian Kwon[1], RHSCIR Network[2].* From the [1]University of British Columbia, Vancouver, Canada; the [2]Rick Hansen Institute, Vancouver, Canada; the [3]Western University, London, Canada; [4]Dalhousie University, Halifax, Canada; [5]McMaster University, Hamilton, Canada; the [6]University of Toronto, Toronto, Canada; the [7]University of Saskatchewan, Saskatoon, Canada; and the [8]University of Ottawa, Ottawa, Canada.

Background: As the incidence of traumatic spinal cord injury (tSCI) in the elderly rises, clinicians are frequently faced with difficult decisions regarding the goals of management and the need to discuss prognosis with the patient and their families. The objectives of this study were to determine the specific factors associated with mortality in the elderly following tSCI and to develop a simple clinical tool to predict mortality in the acute setting. **Methods:** Prospectively collected data of all elderly patients (≥ 65 years) within the national Rick Hansen SCI registry from 2004 to 2017 were analyzed using bivariate and multivariate analyses to determine what factors were associated with in-hospital patient mortality. The main outcome measure was in-hospital mortality, with data also collected on patient demographics, injury factors and treatment course. **Results:** A total of 1382 patients were divided into 3 groups: 65–69 years, 70–74 years and ≥ 75 years of age. Overall in-hospital mortality was 15.8%, with 218 deaths. The factors associated with mortality included age, injury severity (American Spinal Injury Association [ASIA] Impairment Scale [AIS] A), level of injury, and Injury Severity Score (ISS). Mortality rates were highest in the oldest patients (65–69 yr 7.8%, 70–74 yr 10.6%, ≥ 75 yr 24%). Those with AIS A injuries had a mortality of 30.6% (odds ratio 6.0, *p* < 0.001). High cervical SCI had a much higher rate of mortality than low cervical SCI (18.4% v. 12.7%, *p* < 0.001), and ISS > 25 was strongly associated with mortality (*p* < 0.0001). In the 614 patients ≥ 75 years, in-hospital mortality was 49% for AIS A, 29% for high cervical injury, and 20% for low cervical injury. Those with an ISS > 25 were twice as likely to die in hospital. Of the survivors, only 37% were discharged home. **Conclusion:** Increasing age, level of injury and AIS grade are strongly associated with mortality in elderly tSCI patients. Using these factors, we can establish a tool for predicting in-patient mortality that may help with decision-making around goals of management and with communication of prognosis to patients and their families.

127

Using national administrative data to determine incidence of traumatic spinal cord injury in Canada and associated in-hospital costs and trends over time. *Carly Rivers, Nancy Thorogood, Barry White, Melody Chen, Dilnur Kurban, Zeina Waheed, Vanessa Noonan.* From the Rick Hansen Institute, Vancouver, Canada.

Background: Existing incidence and health care costs of traumatic spinal cord injury (tSCI) are based on estimates and assumptions that may impair generalizability of research, investigation of aspects within the health care system, and identification

of trends over time for prevention and best practice implementation. Our aim was to use administrative data to ensure representativeness of Canadians experiencing tSCI, investigate in-hospital costs, and examine discharge destination in the elderly population (age ≥ 75 yr). **Methods:** We obtained administrative data from the Canadian Institute for Healthcare Information (CIHI) trauma data sets from 2010 to 2016 for newly injured tSCI patients using standard ICD-10 diagnosis codes. Data include all initial in-patient admissions for all provinces except for Quebec. Incidence by year, age, and sex, total length of stay (LOS) in acute care, and cost, based on resource-intensity weights (RIW), were calculated. **Results:** Incidence of tSCI in Canada from 2010 to 2016 averaged 29 per million (75% male, average age 52 yr). Incidence in the population aged 75 years and older increased from 60 per million in 2010 to 87 per million in 2016. Mean acute LOS from 2010 to 2016 was 37 (median 19, interquartile range [IQR] 10–40) days; no trends over time were identified. Estimated mean and median costs per admission are \$62 095 and \$30 559 (IQR \$16 724–\$70 550), respectively. Eighty percent of elderly patients are transferred to another hospital or long-term care, whereas only 20% return home; no trends over time were identified. **Conclusion:** There is a trend toward increased incidence in the elderly population. The annual incidence of tSCI in Canada based on administrative data is 28 per million, lower than existing estimates using statistical modelling. Work is ongoing to examine RIW by injury severity and level between 2010 and 2016 to determine the impact of an aging population on health care costs. Changes in policy and population characteristics over time using administrative and SCI registry data should inform future research and optimization of health care.

113

Traumatic spinal cord injuries among Aboriginal and non-Aboriginal populations of Saskatchewan: a prospective outcomes study. *Daryl Fourney[1], Lucy Liu[1], Uzair Ahmed[1], Suzanne Humphreys[2].* From the [1]University of Saskatchewan, Saskatoon, Canada; and the [2]Rick Hansen Institute, Vancouver, Canada.

Background: People of Aboriginal ancestry are more likely to suffer traumatic spinal cord injury (tSCI) than other Canadians; however, outcome studies are limited to qualitative (interview) methods. The objectives of this study were to, for the first time, compare Aboriginal and non-Aboriginal populations with acute tSCI with respect to (1) baseline demographics, comorbidities, mechanism and severity of injury; (2) time to surgery, neurologic outcomes, morbidity/mortality, and length of stay in acute care and rehabilitation; and (3) time to discharge to community and outcomes 1 year after discharge (functional independence measures, quality of life scores, secondary health conditions, compensation type, employment status). **Methods:** This was a retrospective analysis of 159 patients with tSCI prospectively enrolled in the prospective Rick Hansen Spinal Cord Injury Registry (RHSCIR), Saskatoon site between Feb. 13, 2010, and Dec. 17, 2016. **Results:** Sixty-two patients consented to the full data set, which includes ethnic background: 21 "Aboriginal" (33.9%); 41 "non-Aboriginal" (66.1%). There was only one "non-Aboriginal" participant who did not self-identify as "white." Transport injuries were the most common mechanism of injury among Aboriginal individuals, followed by assault. For white people, falls and transport injuries were equally common. Aboriginal patients were

younger, had fewer medical comorbidities and had similar severity of neurological injury and similar outcomes as non-Aboriginal patients. However, the time to discharge to the community from acute care or inpatient rehabilitation was significantly longer (median 104.0 d v. 38.5 d, *p* = 0.021). While 35% of white people were discharged home from acute care, all patients of Aboriginal ancestry were transferred from the acute care site to another hospital (inpatient rehabilitation or local hospital). **Conclusion:** This study suggests a need for better allocation of resources for transition to the community for Indigenous Peoples with tSCI in Saskatchewan, such as more timely home assessments and modifications. Future study is needed to assess outcomes from tSCI for Indigenous Peoples across Canada.

49

The effect of frailty on outcome after traumatic spinal cord injury. *Daniel Banaszek[1], Tom Inglis[1], Travis Marion[2], Eryck Moskven[1], Carly Rivers[3], John Street[4].* From the [1]University of British Columbia, Vancouver, Canada; the [2]Thunder Bay Regional Health Sciences Centre, Thunder Bay, Canada; the [3]Rick Hansen Research Institute, Vancouver, Canada; and the [4]Vancouver Spine Institute, Vancouver, Canada.

Background: Frailty, defined as a state of decreased reserve and susceptibility to external stressors, has previously been shown to negatively affect postoperative outcome in an elective spine surgery population. This study sought to determine the effect of frailty on patient outcome after traumatic spinal cord injury (tSCI). **Methods:** All patients with tSCI were identified in our prospectively collected database from 2007 to 2016. We examined correlations between patient age, Total Motor Score (TMS) on admission, and modified Frailty Index (mFI) on patient outcome variables including acute length of stay (LOS), number of adverse events (AEs), and in-hospital mortality. **Results:** Bivariate analysis revealed multiple statistically significant associations. The mFI was a strong predictor of increased acute LOS (corr 0.163, *p* < 0.0001), number of AEs (corr 0.1664, *p* < 0.0001), and in-hospital mortality (corr 0.155, *p* < 0.0001). Age at injury was also significantly correlated with acute LOS (corr 0.0809, *p* = 0.0418), number of AEs (corr 0.0937, *p* = 0.0231), and in-hospital mortality (corr 0.2639, *p* < 0.0001). Lastly, motor score on admission was also predictive of acute LOS (corr –0.4749, *p* < 0.0001), number of AEs (corr –0.3069, *p* < 0.0001), and in-hospital mortality (corr –0.2249, *p* < 0.0001). In patients older than 65, mFI was not predictive of acute LOS (*p* = 0.1533), number of AEs (*p* = 0.2337), or in-hospital mortality (*p* = 0.6593). Age at injury was not predictive of acute LOS (*p* = 0.0571); however, age remained significant for number of AEs (*p* = 0.0058), and in-hospital mortality (*p* < 0.0001). This was also true for TMS on admission, which was predictive of acute LOS (*p* < 0.0001), number of AEs (*p* = 0.0038), and in-hospital mortality (*p* < 0.0001). **Conclusion:** Age, mFI, and TMS on admission are important determinants of outcome in patients with tSCI. Furthermore, mFI is predictive of outcome in the general tSCI population, but not in elderly patients. This suggests that younger "frail" individuals have significantly poorer outcomes than young, healthy individuals; however, the relationship between advanced age and decreased physiologic reserve is not as clear. Identification of frailty in a younger population as a preinjury risk factor may be useful for perioperative optimization, risk stratification and patient counselling.

123

Can health-related quality of life of Canadian patients with traumatic spinal cord injury become normal at 1 year? A prospective cohort study. *Étienne Bourassa-Moreau[1], Andréane Richard-Denis[1], Cynthia Thompson[2], Jean-Marc Mac-Thiong[1].* **From the [1]Hôpital du Sacré-Coeur de Montréal, Montreal, Canada; and the [2]Centre de Recherche de L'Hôpital du Sacrcé Coeur de Montréal, Montreal, Canada.**

Background: The primary objective of this study was to compare the health-related quality of life (HRQoL) of Canadian patients with traumatic spinal cord injury (tSCI) after their physical rehabilitation with Canadian normative data matched for sex and age. **Methods:** A single institution prospective database collected from 2010 to 2016 was screened for the following inclusion criteria: age older than 25 years, tSCI, vertebral trauma from C1 to L2, available 12-month follow-up. HRQoL was measured using the SF-36 questionnaire. Each patient was compared with Canadian normative values of SF-36 questionnaire, matched for age group and sex, considering a normal value of SF-36 being within 1 standard deviation. **Results:** A total of 168 Canadian tSCI patients met our inclusion criteria. Mean SF-36 physical component score (PCS) of our tSCI population was 37.6/7.5 compared with 49.6/3.1 for a normal Canadian age- and sex-matched cohort ($p < 0.05$) and the mean mental component score (MCS) of our tSCI population was 41.7/7.5 compared with 53.2/1.7 for a normal matched cohort ($p < 0.05$). Fifty-one patients (30.4%) reached a normal PCS value and 52 patients (31.0%) reached a normal MCS. Patients who reached normal PCS values were older (61.8 v. 48.9 yr), had less commonly complete SCI (9.8% v. 41.9%) and tended to sustain cervical SCI (80.0% v. 58.9%) (all $p < 0.05$). Patients who reached normal MCS values tended to be younger (46.0 v. 55.9 yr, $p < 0.05$) and to have more commonly complete SCI (44.2% v. 26.7%, $p < 0.05$), but had a similar rate of cervical SCI when compared with those who didn't reach normal MCS. **Conclusion:** Roughly 30% of Canadian patients with tSCI could expect to regain normal HRQoL within 12 months after their trauma. Interestingly, tSCI patients with normal PCS were more commonly older with incomplete cervical SCI, whereas those with normal MCS were younger and had complete spinal cord injury. This study provides high-quality epidemiological data for counselling Canadian patients with tSCI about possibility of achievement of normal HRQoL.

54

Unbiased recursive partitioning to stratify patients with acute traumatic spinal cord injuries: external validity in an observational cohort study. *Nathan Evaniew[1], Nader Fallah[2], Carly Rivers[2], Vanessa Noonan[2], Charles Fisher[1], Marcel Dvorak[1], Brian K. Kwon[1].* **From the [1]University of British Columbia, Vancouver, Canada; and the [2]Rick Hansen Institute, Vancouver, Canada.**

Background: Clinical trials of novel therapies for acute traumatic spinal cord injuries (tSCI) are extremely challenging because variability in spontaneous neurologic recovery can make discerning actual treatment effects difficult. Unbiased recursive partitioning regression with conditional inference trees (URP-CTREE) is a novel approach to stratification that was developed through analyses of a large European SCI database. We performed an external

validation study to determine how well a previously reported URP-CTREE model performed when applied to an independent cohort. **Methods:** We included all eligible patients from an ongoing prospective cohort study with complete American Spinal Injury Association (ASIA) Impairment Scale (AIS) A acute cervical tSCIs and baseline motor levels at C4 to C6. We applied the previously reported URP-CTREE model and evaluated Upper Extremity Motor Score (UEMS) recovery at final follow-up. We tested univariate associations with the Pearson correlation coefficient, and differences between medians with the Mann–Whitney U test. **Results:** We included 101 cervical AIS A patients, whose mean times from injury to baseline and follow-up neurologic examinations were 6.1 ± 17 days and 235 ± 71 days, respectively. The previously reported model partitioned our cohort into 5 stratified groups according to 4 predictors. One of the predictors was not statistically significant, 1 of the groups did not fit a consistent sequence of progressively improving UEMS scores, and 3 of the groups had medians that were not significantly different from their adjacent groups. Overall prediction accuracy was 75%, but varied from 82% among participants whose examinations occurred at less than 12 h, to 64% at 12–24 h, and 58% at > 24 h. **Conclusion:** A previously reported URP-CTREE model had limited ability to stratify an independent cohort into distinct homogeneous subgroups. Overall prediction accuracy was reasonably promising, but sensitive to timing of baseline neurological examinations. Further research is warranted to evaluate URP-CTREE in incomplete injuries, consider the influence of timing of baseline examinations, and investigate additional strategies for accurately stratifying patients with acute SCI.

119

Systemic protein kinase inhibition reduces local inflammation after cervical spinal cord injury. *Mohammad-Masoud Zavvarian[1,2], James Hong[1,2], Jian Wang[2], Michael Fehlings[1,2].* **From the [1]University of Toronto, Toronto, Canada; and the [2]University Health Network, Toronto, Canada.**

Backgrround: Traumatic spinal cord injury (SCI) is a debilitating and multifaceted condition that limits the quality of life for millions of patients worldwide. Despite recent advances in the posttraumatic care, the available treatment options for SCI patients are still limited. The disruption of blood–spinal cord barrier (BSCB) by the mechanical trauma is a major challenge that limits the potency of most SCI treatments. Infiltration of pro-inflammatory immune cells following the BSCB disruption leads to further permanent damage to the injury epicentre. Therapeutic stabilization of BSCB can potentially attenuate the immune cells migration and improve SCI recovery. The aim of this study is to examine the effects of systemic protein kinase inhibition on BSCB integrity and to determine its efficacy as a treatment for SCI. **Methods:** SCI was induced in 12 wistar rats using the clip-compression injury model at C6–7. The injured rats were randomly assigned to 2 cohorts ($n = 6$), receiving either midostaurin or vehicle control. In addition, 6 laminectomized shams were used to constitute a noninjured cohort. All rats were sacrificed 24 h postoperation, and the total RNA and protein were extracted from the spinal cord to evaluate the molecular changes. Western blotting was used to assess the phosphorylation of downstream target molecules. Differentially expressed genes were identified using reverse transcription qualitative polymerase chain reaction. Multiplex Luminex assay was used to examine the

inflammatory response after SCI. **Results:** Administration of 25 mg/kg of midostaurin reduced the phosphorylated *Gsk3* and *Stat3* at the injury epicentre (1 d postinjury). This demonstrates the penetrance of the midostaurin into the spinal cord. The transcriptional analysis reveals downregulation of adhesive and migratory genes including *Jam2*, *Thy1*, and *Itgb1*. This ultimately leads to the mitigation of proinflammatory markers, such as fractalkine, interleukin (IL)-1α, and IL-5 1 day postinjury. **Conclusion:** This study demonstrates that systemic protein kinase inhibition is an effective strategy for preventing secondary SCI damage, which can have a significant impact on the enhancement of neuroprotective regime applied upon traumatic SCI.

152

Does surgical intervention alter outcome in elderly patients with traumatic spinal cord injury? *Tom Inglis[1], Marcel Dvorak[1], Daniel Banaszek[1], Nathan Evaniew[1], Dilnur Kurban[2], Nader Fallah[1,2], Vanessa Noonan[1,2], Carly Rivers[2], Christopher Bailey[3], Sean Christie[4], Brian Drew[5], Michael Fehlings[6], Joel Finkelstein[6], Charles Fisher[1], Daryl Fourney[7], Andrea Townson[1], Eve Tsai[8], Zeina Waheed[2], Brian Kwon[1], RHSCIR Network[2].* From the [1]University of British Columbia, Vancouver, Canada; the [2]Rick Hansen Institute, Vancouver, Canada; [3]Western University, London, Canada; [4]Dalhousie University, Halifax, Canada; [5]McMaster University, Hamilton, Canada; the [6]University of Toronto, Toronto, Canada; the [7]University of Saskatchewan, Saskatoon, Canada; and the [8]University of Ottawa, Ottawa, Canada.

Background: With the rising incidence of traumatic spinal cord injury (tSCI) in the elderly, clinicians are increasingly faced with difficult management decisions regarding operative intervention, acknowledging that significant morbidity and mortality is associated with SCI, regardless of treatment. Here, we sought to determine whether acute surgical intervention altered neurologic recovery and whether it increased the likelihood of discharge home. **Methods:** Prospectively collected data of all elderly patients (≥ 65 yr) within the national Rick Hansen SCI registry from 2004 to 2017 were analyzed. Using bivariate and multivariate analyses, the impact of surgical intervention on mortality, motor score recovery, days in the intensive care unit (ICU), acute and total length of stay (LOS) and final discharge destination was compared between the operative and nonoperative groups. **Results:** Of 1034 patients identified, 856 (83%) underwent surgery for tSCI. Patients managed nonoperatively were slightly older (75.7 v. 73.6 yr, $p < 0.0006$) and had more comorbidities, with a Charlson Comorbidity Index score > 3 in 26% compared with 17% of those who had surgery ($p = 0.0012$). The in-hospital mortality was significantly higher in the nonoperative group (21% v. 9.4%, $p < 0.0001$), but after adjusting for age, level, severity and comorbidity, the surgery status did not predict in-hospital mortality. For the operative group, ICU stays were twice as long (4 v. 2 d, $p = 0.0012$), with both acute LOS (27 v. 16 d, $p < 0.0001$) and total LOS being significantly longer (94 v. 45 d, $p < 0.0001$) than the nonoperative group. There was no significant improvement in motor score recovery between the 2 groups (8.0 v. 9.5, $p = 0.20$) or in the number of those whose final discharge destination was home ($p = 0.65$). **Conclusion:** Acute surgical intervention in tSCI in the elderly leads to longer ICU stay and substantially increases hospital LOS with no statistically significant improvement in motor recovery, likelihood of discharge home or effect on in-hospital mortality.

117

A longitudinal analysis of neurological recovery based on timing of early post-injury neurologic assessment in acute spinal cord injury. *Nader Fallah[1,2], Carly Rivers[1], Vanessa Noonan[1,2], Tova Plashkes[1], Zeina Waheed[1], Tom Inglis[2,3], Nathan Evaniew[2,3], Brian Kwon[2,3], Charles Fisher[2,3], Marcel Dvorak[2,3].* From the [1]Rick Hansen Institute, Vancouver, Canada; the [2]University of British Columbia, Vancouver, Canada; and the [3]Vancouver Spine Surgery Institute, Vancouver, Canada.

Background: The trajectory of early neurologic recovery following traumatic spinal cord injury (tSCI) is not well characterized. A wide range in recommended postinjury exam times (i.e., 72 h to 1 mo) used as "baseline" assessments exists in the literature and the times are based on cross-sectional studies analyzing small sample sizes. Acknowledging the potential for early spontaneous neurologic recovery, differences between baseline exam times can introduce bias in clinical research. Our study objectives were to characterize early neurologic recovery after cervical tSCI using a longitudinal design, to report and compare neurologic recovery by American Spinal Injury Association Impariment Scale (AIS) grade and level (high/low cervical), and to make recommendations for study design and interpretation. **Methods:** Two different longitudinal analyses of motor scores during the first 6 months postinjury were used to generate the trajectory of neurologic recovery in the Vancouver Rick Hansen SCI Registry participants from 2004 to 2012. Data were stratified by AIS and anatomic level (high/low cervical). Age, motor score and time of exam were analyzed. **Results:** Cohort size was 194 patients with tSCI (79% male, mean age 45.1 ± 17.6 yr, 41.7% complete injuries). Results indicate different trajectories of neurologic recovery based on severity and level of injury. Differences in baseline exam time were significantly important in AIS grade C/D injuries, whereas AIS grade A/B injuries had no significant effect in the first 2 weeks. Anatomic region was an important factor depending on AIS grade. Age and gender were nonsignificant. **Conclusion:** No previous longitudinal study has reported on the importance of the timing of neurologic exam based on the spontaneous neurologic improvement trajectory, particularly during the first 2 weeks. Large variations in baseline exam times indicate this phenomenon was underestimated by previous studies. In AIS grade C/D injuries there are significant motor score improvements over the first few days that should be accounted for in research studies. However, in AIS grade A injuries there is little variation in the first 2 weeks. Our results support earlier work emphasizing appropriate controls to minimize heterogeneity and reduce error when analyzing and reporting tSCI research studies.

154

Sarcopenia, independent of age, predicts mortality and acute care adverse events in patients with traumatic spinal cord injury. *Daniel Banaszek[1], Tom Inglis[1], Manpreet Ruprai[1], Raphaele Charest-Morin[2], Program Surgeons (VSPS)[2], John Street[2].* From the [1]University of British Columbia, Vancouver, Canada; and the [2]Vancouver Spine Institute, Vancouver, Canada.

Background: Management of traumatic spinal cord injury (tSCI) is characterized by acute care adverse events (AEs) and an increasingly aging vulnerable population. Sarcopenia, or a loss of muscle mass with age, cachexia or disuse, variably predicts AEs in

a number of surgical populations. The aim of this study was to investigate the nature of sarcopenia in a tSCI population and the relationship, if any, of sarcopenia to early mortality and AEs following tSCI. **Methods:** An ambispective study of all tSCI patients at a quaternary acute care facility from 2009 to 2017 was performed. Data included demographics, American Spinal Injury Association Impariment Scale (AIS) grade, motor score, Charlson Comorbidity Index score, and modified Frailty Index score. AEs, including eath were identified using SAVES V2. Sarcopenia was measured using the total psoas area cross-sectional area (cm²) technique on lumbar computed tomography (CT). Logistic regression with backward stepwise elimination was used to determine the impact of sarcopenia on the occurrence of AEs. Spearman correlation was used to assess the relationship between the number of AEs and the different predictors studied. **Results:** In all, 158 of 734 patients had adequate lumbar spine CT at admission. The mean total psoas area was 16.5 ± 6.2 (interquartile range 12.3–20.0) cm². Mean psoas area decreased with age. Psoas area, age at injury and motor score on admission predicted in-hospital mortality (correlation coefficient 0.32–0.38, $p < 0.0001$). Eighty-five percent of patients had at least 1 acute AE. Patients with lower quartile psoas area had significantly more AEs than those with upper quartile area ($p = 0.037$). Psoas area also predicted the occurrence of postoperative AEs (1.25 ± 0.52 v. 1.07 ± 0.40, $p = 0.031$). Age and degree of neurologic impairment were also predictive of postoperative AEs ($p < 0.001$). **Conclusion:** Sarcopenia, as measured on conventional lumbar CT, predicts both early postinjury mortality and acute care AEs in patients with tSCI, independent of advanced age. This new knowledge provides a potential tool for timely therapeutic decision-making in this complex patient population.

91

Design and biomechanical testing of a novel fusion device for atlantoaxial instability. *Timothy Lasswell[1], Supriya Singh[2], John Medley[1], Jack Callaghan[1], Duane Cronin[1], Colin McKinnon[1], Parham Rasoulinejad[2].* **From the [1]University of Waterloo, Waterloo, Canada; and [2]Western University, London, Canada.**

Background: The objective was to design a less invasive C1 implant to be used as a part of a construct for C1–C2 fusion with the potential to treat more patients surgically. C1–C2 fusion for the treatment of atlantoaxial instability is controversial owing to high intraoperative risks and poor clinical outcomes. Currently, the Harms procedure (C1 lateral mass screws and C2 pedicle screws) is the most popular treatment. A lower-risk alternative with C2 translaminar screws has been used clinically with success, but this construct continues to rely on high-risk C1 lateral mass screws. Design and biomechanical testing are presented for a novel C1 posterior arch clamp, intended to replace C1 lateral mass screws. **Methods:** Design criteria and constraints for the C1 clamp were developed through discussions with clinical experts, reviewing literature and meetings with the engineering team. A combination of computational modelling and benchtop testing was used to develop prototypes that were then biomechanically tested. A spinal loading simulator was used to apply moments and measure the resulting motion for 8 fresh frozen human cadaveric specimens, with each being subjected to 6 conditions: intact state, destabilized state (after a simulated odontoid

fracture), and 4 fusion constructs. Range of motion was compared using paired *t* tests. **Results:** Computational modelling and benchtop testing established tightening specifications that were then used during cadaveric testing. Constructs with the novel C1 posterior arch clamp had significantly less motion ($p < 0.05$) than constructs with C1 lateral mass screws in flexion/extension and axial rotation. No significant difference was detected between the constructs in lateral bending. **Conclusion:** The combination of computational modelling, benchtop testing and biomechanical cadaveric testing has resulted in a novel C1 clamp that is expected to yield a safer C1–C2 fusion procedure by eliminating C1 lateral mass screws. Superior stability of the C1 clamp compared with C1 lateral mass screws has been demonstrated regardless of the fixation method used at C2, potentially reducing intraoperative risks and improving clinical outcomes for patients with atlantoaxial instability.

143

Spinal shock: the functional impact of the absence of a bulbocavernosus reflex in the postoperative period following a motor-complete traumatic spinal cord injury. *Andreane Richard-Denis[1,2], Jean-Marc Mac-Thiong[1,2], Bich-Han Nguyen[2,3], Nicolas Greciet[2].* **From the [1]Hopital Sacré-Coeur de Montréal, Montreal, Canada; the [2]Université de Montréal, Montreal, Canada; and the [3]Institut Gingras-Lindsay de Montréal, Montreal, Canada.**

Background: The absence of the bulbocavernosus reflex (BCR) in the acute phase following a traumatic spinal cord injury (tSCI) is generally associated with spinal shock. Unfortunately, its impact on the functional recovery following a motor-complete injury remains unknown. The main objective of this study was to determine the impact of the absence of the BCR in the postoperative phase on the functional status 6 to 12 months following a motor-complete tSCI. The neurologic recovery was also evaluated as a second outcome. **Methods:** A review of a prospective database was completed among 66 patients sustaining a motor-complete tSCI (American Spinal Injury Association Impariment Scale [AIS] grade A and B). First, the functional and neurologic statuses between individuals with and without a BCR in the postoperative period following TSCI were compared. Then, general linear models were used to investigate the association between the postoperative BCR status and the functional outcome, as evaluated with the Spinal Cord Independence Measure (SCIM-III) considering important confounding factors. **Results:** A total of 45,5% ($n = 30$) patients had no BCR in the postoperative anorectal examination. Individuals sustaining a motor-complete tSCI with and without a BCR in the postoperative period showed a similar total SCIM score and similar SCIM subscores (self-care, respiration/sphincters and mobility) 6 to 12 months postinjury. The degree of completeness and the neurologic level of the injury also showed similar recovery. The BCR status in the postoperative period was not a significant factor associated to functional outcome 6 to 12 months postinjury. **Conclusion:** The absence of BCR, as a clinical manifestation of the spinal shock, is generally associated with worse neurofunctional prognosis following a tSCI, as it is associated with motor-complete injuries. However, the absence of BCR in the postoperative period may not be a predictor of functional outcome in patients sustaining a motor-complete tSCI.

88

The rate of fusion for lumbar degenerative disc disease in Ontario between 2006 and 2015. *James Blackett[1], Andrew Kanawati[1], Andrew McClure[2], Blayne Welk[1], Kelly Vogt[1], Chris Vinden[1], Kevin Gurr[1], Parham Rasoulinejad[1], Fawaz Siddiqi[1], Christopher Bailey[1].* From the [1]London Health Sciences Centre and Western University, London, Canada; and [2]ICES, London, Canada.

Background: Our objectives were to compare the rate and outcome of decompression and fusion versus decompression alone among lumbar degenerative disc disease patients treated in Ontario between 2006 and 2015, and to determine which factors are associated with receiving a spinal fusion over decompression alone. **Methods:** We performed a population-based retrospective cohort study using several databases: physician billings, hospital discharge records, and emergency department records from 2006 to 2015. Patients were identified by physician billing codes and hospital records and categorized into those who received fusion and decompression versus those who received decompression alone. Patients who had previous spine surgery, lumbar disc replacement, a diagnosis other than degenerative disc disease, or were pediatric were excluded. An adjusted logistic regression was used to assess our outcomes. **Results:** We identified 33 912 patients, of whom 9748 (28.74%) underwent fusion. Overall, fusion rates increased from 27.66% to 31.33% over the study period. Factors associated with fusion included older age, female gender, obesity, American Society of Anesthesiologists grade > 3, prior total joint replacement, and surgery by an orthopaedic surgeon. Experienced surgeons were less likely to perform a fusion. Fusion surgery was associated with increased odds of 30-day mortality (odds ratio [OR] 1.77, 95% confidence interval [CI] 1.01–3.09, $p = 0.046$), 30-day (OR 1.94, 95% CI 1.53–2.46, $p < 0.0001$) and 90-day reoperation rate (OR 1.66, 95% CI 1.35–2.05, $p < 0.0001$), and 30-day readmission (OR 1.23, 95% CI 1.02–1.49, $p = 0.027$) when adjusting for confounding variables. The odds of suffering a complication after fusion surgery v. decompression surgery were 4.3-fold higher (95% CI 3.78–5.09, $p < 0.0001$). **Conclusion:** The rates of spinal fusion for degenerative disc disease in Ontario increased between 2006 and 2015. Visiting an orthopedic spine surgeon or having a previous total joint replacement increased the odds of having a fusion. After adjusting for several factors, a patient receiving a decompression and fusion is more likely to have a complication or die in the first 30 days than those undergoing a decompression alone.

72

Differences in surgical practices between salaried and fee-for-service surgeons for degenerative lumbar conditions in a universal health payer system. *Daniel Banaszek[1], Tom Inglis[1], Raphaele Charest-Morin[2], Gregory McIntosh[3], Charles Fisher[2], Nicolas Dea[2], Surgeons (CSORN)[3].* From the [1]University of British Columbia, Vancouver, Canada; the [2]Vancouver Spine Institute, Vancouver, Canada; and the [3]Canadian Spinal Outcomes Research Network, Markdale, Canada.

Background: Optimal surgical treatment for some spinal disorders remains controversial. By offering different procedures, surgeons are a central driver of health care costs. Even within a universal health payer system, surgeons may offer different treatments for similar conditions on the basis of their compensation mechanism. The purpose of this study was to examine differences in surgical practice for 2 common degenerative spine conditions between fee-for-service and salaried physicians. The second goal was to investigate if there were any differences in baseline characteristics between patients based on surgeon remuneration. **Methods:** Differences in operative practices based on remuneration scheme (fee for service or salaried) were assessed among registered surgeons in the Canadian Spinal Outcomes Research Network (CSORN) for 2 lumbar conditions: stable spinal stenosis and degenerative spondylolisthesis. The primary outcome was the difference in type of procedures performed between the 2 groups. Other studied variables included use of minimally invasive surgery, operative time, and baseline patient characteristics (age, body mass index [BMI]). **Results:** Sixty-four surgeons across 8 Canadian provinces were examined in this study; 39 surgeons were fee for service and 25 were salaried. For stable spinal stenosis ($n = 2141$), salaried surgeons performed significantly more decompressions only ($p < 0.05$), and fewer interbody fusion procedures ($p < 0.05$) than fee-for-service surgeons. Salaried surgeons tended to operate on fewer spinal levels ($p < 0.01$) and performed fewer minimally invasive procedures ($p < 0.001$) than their fee-for-service counterparts. For degenerative spondylolisthesis ($n = 1228$), salaried surgeons performed significantly more instrumentation plus interbody fusions ($p < 0.05$), endured significantly longer operative times ($p < 0.001$) and performed fewer minimally invasive procedures ($p < 0.001$). Baseline patient characteristics were similar for both groups. **Conclusion:** Surgeon compensation was associated with different approaches to stable lumbar spinal stenosis and degenerative lumbar spondylolisthesis. Salaried surgeons tended to treat spinal stenosis more conservatively, and degenerative spondylolisthesis more aggressively. More than just patient-related factors seem to influence surgical decision-making and should be thoroughly explored.

44.

Cost–utility of revisions for cervical deformity correction warrants minimization of reoperations. *Aaron Hockley[1], Peter Passias[2], Samantha Horn[2], Renaud Lafage[3], Virginie Lafage[3], Hamid Hassanzadeh[4], Jason Hrowitz[4], Cole Bortz[2], Frank Segreto[2], Justin Smith[4], Dan Sciubba[5], Greg Mundis[6], Michael Kelley[7], Douglas Burton[8], Rob Hart[9], Frank Schwab[2], Shay Bess[10], Chris Shaffrey[4], Richard Hostin[11], Chris Ames[12].* From the [1]University of Alberta, Edmonton, Canada; [2]New York University, New York, USA; the [3]Hospital for Special Surgery, New York, USA; the [4]University of Virginia, Charlottesville, USA; [5]John Hopkins Hospital, Baltimore, USA; the [6]Scripps Surgical Center, La Jolla, USA; [7]Washington University, Chesterfield, USA; the [8]University of Kansas, Kansas City, USA; [9]Swedish Neurosciences, Seattle, USA; [10]Rocky Mountain Hospital, Denver, USA; the [11]Baylor Scoliosis Center, Dallas, USA; and the [12]University of California, San Francisco, San Francisco, USA.

Background: Cervical deformity (CD) surgery has become increasingly more common and complex, which has led to reoperations for complications such as distal junctional kyphosis. Cost–utility analysis has yet to be used to analyze CD revision surgery in relation to primary CD surgeries. The aim of this study was to determine the cost–utility of revision surgery for CD

correction. **Methods:** We performed a retrospective review of a multicentre prospective CD database. CD was defined as at least 1 of the following: C2–C7 Cobb angle > 10°, cervical lordosis (CL) > 10°, cervical sagittal vertical axis (CSVA) > 4 cm, chin-brow vertical angle (CBVA) > 25°. Quality-adjusted life-years (QALY) were calculated with the EQ-5D questionnaire and Neck Disability Index mapped to 6-dimension health state short form index and used a 3% discount rate to account for residual decline to life expectancy. Medicare reimbursement at 30 days assigned costs for index procedures and revision fusions. Cost per QALY gained was calculated. **Results:** Eighty-nine CD patients were included (mean age 61.6 yr, 65.2% female). CD correction for these patients involved a mean 7.7 ± 3.7 levels fused, with 34% combined approach surgeries, 49% posterior only and 17% anterior only, 19.1% 3-column osteotomy. Costs for index surgeries ranged from \$20 001–\$55 205, with the average cost for this cohort of \$44 318 and cost per QALY of \$27 267. Eleven revision surgeries (mean levels fused 10.3) occurred up to 1 year, with an average cost of \$41 510. Indications for revisions were distal junctional kyphosis (DJK) (n = 5), neurologic impairment (n = 4), infection (n = 1), and prominent/painful instrumentation (n = 1). Average QALYs gained was 1.62 per revision patient. Cost was \$28 138 per QALY for reoperations. **Conclusion:** Cervical deformity revisions had a cost of \$28 138 per QALY, in addition to the \$27 267 per QALY for primary CD surgeries. For primary CD patients, CD surgery has the potential to be cost effective, with the caveats that a patient livelihood extends long enough to have the benefits and durability of the surgery is maintained. Efforts in research and surgical technique development should emphasize minimization of reoperation causes such as DJK that significantly affect cost–utility of these surgeries to bring cost–utility to an acceptable range.

146

Canadian Spinal Outcomes Research Network data quality analysis 2016–2018: a review of a Canadian spine registry. *Eden Richardson[1,2], Edward Abraham[1,3,4], James Fowler[4], Erin Bigney[1], Mariah Darling[1], Joshua Shanks[1], Neil Manson[1,3,4]. From the [1]Canada East Spine Centre, Saint John, Canada; the [2]Canadian Spine Society, Markham, Canada; the [3]Division of Orthopaedic Surgery, Zone 2, Horizon Health Network, Saint John, Canada; and [4]Dalhousie Medicine New Brunswick, Saint John, Canada.*

Background: Our objectives were to determine current follow-up rates and data completeness within the Canadian Spine Outcomes and Research Network (CSORN) and to compare current 2018 data with 2016 data for sites that were active at both time points. **Methods:** We performed a retrospective study of previously collected cervical and thoracolumbar patient data from 20 CSORN sites across Canada. Completeness of data and follow-up rates were assessed via CSORN study extract reports and Canadian Spine Socity (CSS0 CSORN data quality reports. Data quality was operationally defined as poor (< 60% complete), moderate (60–80% complete), good (> 80% complete) and excellent (> 90% complete). Descriptive statistics and paired samples t tests for completeness of data were conducted. Repeated-measures analysis of variance assessed follow-up rates for 12-week, 12-month and 24-month time points. Significance was set at $p < 0.05$. **Results:** From 2016 to 2018 4795 new patients were enrolled for a total

database population of 11 028. CSORN captures approximately 78% of all patients seen at participating centres for elective spine surgery. Overall, thoracolumbar data quality is excellent (94.81% complete). Cervical data quality is also excellent (94.80% complete). Data quality significantly improved for cervical 24-month data (65.05% in 2016 to 93.32% in 2018, $p < 0.05$). Follow-up rates for 2018 were 90% at 12 weeks, 74.12% at 12 months and 57.41% at 24 months. Follow-up rate significantly improved from 2016 to 2018 for the 12-month follow-up (14.86% increase, $F_{1,13}$ = 5.2, p = 0.04); there was a 12.07% increase for the 24-month follow-up. **Conclusion:** CSORN is a rapidly growing national spine registry that demonstrates excellent data quality and is showing excellent 12-week and 12-month follow-up rates. Improvement demonstrated with 24-month follow-up rates is promising.

8

The opinion of Canadian spine surgeons on medical assistance in dying (MAiD): a cross-sectional survey of Canadian Spine Society (CSS) members. *Erika Leck[1], Sean Barry[1], Chris Ekong[2], Brian Wheelock[3], Richard Moulton[4], Peter Gorman[5], Kesh Reddy[6], Sean Christie[1], Ian Fleetwood[7]. From [1]Dalhousie University, Halifax, Canada; [2]University of Saskatchewan College of Medicine, Regina, Canada; [3]Dalhousie Medicine New Brunswick, Saint John, Canada; the [4]University of Ottawa, Ottawa, Canada; [5]Dalhousie Medicine New Brunswick, Moncton, Canada; [6]McMaster University, Hamilton, Canada; and [7]Victoria General Hospital, Victoria, Canada.*

Background: On Feb. 6, 2015, the Supreme Court of Canada rendered a decision striking down the Criminal Code absolute prohibition on providing assisted dying. By June 6, 2016, the new law, Bill C-14, came into effect that allowed for medical assistance in dying (MAiD). The objective of this study was to determine the attitudes and opinions of Canadian neurosurgeons and orthopedic spine surgeons regarding MAiD. **Methods:** A cross-sectional survey was sent out to members of the Canadian Spine Society (CSS). The survey included 21 questions pertaining to opinions and attitudes regarding MAiD and different facets of the legislation. Responses were collected between May and June 2016. **Results:** A total of 51 surgeons practicing across the country responded to the survey: orthopedic surgeons (68.6%), pediatric orthopedic surgeons (5.9%), and neurosurgeons (21.6%). The majority of surgeons supported MAiD (62.8%) and supported the right of physicians to participate in MAiD (82.4%). Most surgeons supported the right to conscientious objection (90.1%), but also believed in the mandatory duty to refer (49.0%). Only 37.2% said they would refer to a MAiD service, and 3.9% felt they could ever see themselves actively involved in MAiD. The conditions that respondents most frequently felt to be appropriate to consider MAiD included metastatic spine tumour (76.5%), malignant intramedullary tumour (64.7%), primary malignant spine tumour (54.9%), cervical spinal cord injury with tetraplegia (49.0%) and multiple myeloma (33.3%). **Conclusion:** This study highlights the complex landscape that exists when discussing MAiD, but also shows the overall support that most physicians within the CSS have for it. This study also shows the need for ongoing conversations, in particular with respect to the some of the issues that haven't been addressed with the current legislation, and the importance of physicians to stay informed and up to date so they can be best educated when speaking with their patients.

67

Radiostereometric analysis as a diagnostic for assessing vertebral fusion: a phantom study. *Sara Parashin[1], Trevor Gascoyne[1], Mohammad Zarrabian[2]. From the [1]Orthopaedic Innovation Centre, Winnipeg, Canada; and the [2]University of Manitoba, Winnipeg, Canada.*

Background: The purpose of this research was to determine the feasibility of radiostereometric analysis (RSA) as a diagnostic tool for assessing nonunion following spinal arthrodesis procedures. Further, we sought to estimate clinical thresholds for precision and accuracy of the proposed method in the cervical and lumbar spine. **Methods:** Three-level lumbo-sacral and 4-level cervical posterior arthrodesis procedures were performed on an artificial spine model and a cadaveric spine. Using a spring-loaded inserter, RSA markers were placed within each of the L4–S1 and C3–C6 vertebra. Titanium screws and rods were applied to the spinal segments. RSA imaging consisted of 12 double exams (24 exams) of the cervical and lumbar regions for both the Sawbones and cadaveric spine to assess precision of measurement under zero-displacement conditions, defined as the 95% confidence interval of error. Accuracy assessment was performed on the Sawbones model in which the middle vertebrae (L5 and C4–C5) were moved relative to the superior (L4 and C3) and inferior (S1 and C6) vertebrae by known, incremental displacements. RSA images were obtained at each displacement. Accuracy was defined as the mean difference between known and measured displacements. **Results:** The rate of RSA bead detection was high with 5–8 implanted beads being visible in both the lumbar and cervical regions of the artificial and cadaveric spines. Translational RSA precision for both spines was better than 0.25 mm and 0.82 mm for the lumbar and cervical regions, respectively. Rotational precision was better than 0.40° and 1.9° for the lumbar and cervical regions, respectively. RSA accuracy for the artificial spine overall demonstrated less than 0.11 mm translational bias (margin < ± 0.02 mm) and less than 0.22° rotational bias (margin < ± 0.15°). **Conclusion:** This study demonstrates that RSA achieves sufficient precision and accuracy to detect intervertebral micromotion for the purpose of assessing arthrodesis. Well-dispersed bead placement is critical to achieving sufficient accuracy and avoiding occlusion by metal hardware. The results of this work will aid in the development of a clinical study to assess arthrodesis in patients.

16

Dynamic instability in lumbar spondylolisthesis: comparison of flexion-extension radiographs versus recumbent-standing imaging. *Vivien Chan[1], Alessandro Marro[2], Jeremy Rempel[1], Andrew Nataraj[1]. From the [1]University of Alberta, Edmonton, Canada; and the [2]University of Toronto, Toronto, Canada.*

Background: The purpose of this study is to compare the proportion of patients with lumbar spondylolisthesis detected to have dynamic instability on flexion–extension radiographs versus standing–supine imaging. **Methods:** This is a single-centre retrospective study of all consecutive adult patients diagnosed with spondylolisthesis from January to July 2018 with the required imaging for analysis. Two independent observers measured the amount of translation, in millimetres, on supine magnetic resonance imaging (MRI) and standing flexion, extension, and neutral radiographs using the Meyerding technique. Interobserver and intraobserver correlation coefficients were calculated. The difference in amount of translation was compared between 1) flexion and extension radiographs and 2) neutral-standing radiograph and supine imaging. The proportion of patients with dynamic instability, defined as ≥ 3 mm difference, detected in each group was reported. Correlation between amount of dynamic translation and change in back pain 1 year after decompression and instrumented fusion was analyzed using univariate regression. **Results:** Fifty-six patients were included in this study. The mean age was 57.1 years, and 55.4% were female. The most commonly affected levels were L4/5 (60.7%) and L5/S1 (30.4%). A total of 76.8% had grade 1 spondylolisthesis. The average translation measured on flexion–standing radiograph, extension–standing radiograph, neutral–standing radiograph, and supine imaging was 12.5 mm, 11.9 mm, 10.1 mm, and 7.2 mm, respectively. The average difference between flexion and extension radiograph was 0.58 mm, with dynamic instability detected in 21.4%. The average difference between neutral–standing radiograph and supine imaging was 3.77 mm with dynamic instability detected in 60.7%. The intraobserver variability ranged from 0.77 to 0.90. The interobserver variability ranged from 0.79 to 0.86. In 25 patients who received decompression and instrumented fusion, the amount of dynamic translation between standing and supine imaging was significantly correlated with greater improvement in back pain ($p < 0.001$). This correlation was not seen in amount of dynamic translation between flexion and extension radiograph ($p = 0.60$). **Conclusion:** More patients were found to have dynamic instability on standing–supine imaging. There was a significant correlation between dynamic translation on standing–supine imaging and postoperative improvement in back pain.

101

Development and validation of a surgical clinical decision support tool for lumbar spinal stenosis. *Kala Sundararajan[1], Konstantin Shestopaloff[1], Kelly Lane[2], Wesley Leong[2], J. Denise Power[1], Mayilee Canizares[1], Christian Veillette[1,3,4], Y. Raja Rampersaud[1,3,4]. From the [1]Arthritis Program, Krembil Research Institute, University Health Network, Toronto, Canada; the [2]Techna Institute, University Health Network, Toronto, Canada; the [3]Division of Orthopaedics, Toronto Western Hospital, University Health Network, Toronto, Canada; and the [4]Department of Surgery, University of Toronto, Toronto, Canada.*

Background: Up to 40% of patients undergoing surgery for lumbar spinal stenosis (LSS) may not achieve a clinically meaningful outcome. Our objectives were to use machine learning methodology to predict surgery outcomes for LSS patients, and to apply the prediction models in a user-friendly clinical decision support tool (CDST). **Methods:** Model training used data from 430 surgical LSS patients from a tertiary hospital in Toronto, and considered over 100 potential predictors, including sociodemographic, physical and mental health, clinical, pain, and function data. Several classification algorithms were tested; the final model used was elastic net logistic regression, which provided the best performance across outcomes. Since surgical treatment goals may vary across patients/clinicians, models were developed for a range of possible 1-year postsurgical goals relating to pain (numeric pain rating), function (Oswestry Disability Index [ODI]), and patient satisfaction. The models were validated using external

LSS data (*n* = 1545) from the Canadian Spine Outcomes and Research Network (CSORN). Model performance was primarily assessed using area under the receiver operating characteristics curve (AUC). To produce a practical CDST, a web service incorporating the final models was configured using Microsoft Azure Machine Learning Studio, and an interactive Microsoft Power BI dashboard was developed to visualize both patient characteristics and the predictions. The web service and dashboard were integrated into the existing UHN-DADOS (DAta-Driven Outcome System) clinical data collection platform. **Results:** Performance varied across outcomes; for example, the model predicting ODI < 20 (i.e., minimal disability) 1 year postsurgery had AUCs of 0.77and 0.68, 72% and 67% accuracy, and 78% and 62% positive predictive value in the training and test samples, respectively. Our model predicted that 27% of the validation sample had a high likelihood (i.e., 75%–100% probability) of 1-year ODI < 20, 47% had moderate likelihood (50%–75% probability), and 26% had low likelihood (0%–50%). In comparison, the true proportion of patients with 1-year ODI < 20 was 40%. **Conclusion:** The final product was an end-to-end clinical decision support tool for data collection, outcome prediction, and visualization, which can improve the patient–surgeon shared decision-making process by providing personalized predictions for meaningful patient goals.

105
Predictors of clinical outcome following surgery for lumbar spinal stenosis: a study of postoperative pain and disability trajectories. *Jeffrey Hebert[1,2], Erin Bigney[3], Edward Abraham[3,4,5], Niels Wedderkopp[6,7], Eden Richardson[3], Mariah Darling[3], Neil Manson[3,4,5].* **From the [1]Faculty of Kinesiology, University of New Brunswick, Fredericton, Canada; the [2]School of Psychology and Exercise Science, Murdoch University, Murdoch, Australia; the [3]Canada East Spine Centre, Saint John, Canada; the [4]Division of Orthopaedic Surgery, Zone 2, Horizon Health Network, Saint John, Canada; [5]Dalhousie University Faculty of Medicine, Halifax, Canada; the [6]Department of Regional Health Research, University of Southern Denmark, Odense C, Funen, Denmark; and the [7]Orthopedic Department, Hospital of Southwestern Jutland, Esbjerg, Jutland, Denmark.**

Background: Our objective was to identify predictors of poor outcomes for disability, leg pain and back pain following surgery for lumbar spinal stenosis (LSS). **Methods:** We conducted a retrospective analysis of prospectively collected data. Patients with LSS (*n* = 548) from 13 centres participating in the Canadian Spine Outcomes and Research Network (CSORN) were classified by postoperative pain and disability trajectories. Generalized linear mixed models adjusted for age and sex were used to identify associations between postoperative clinical outcome and preoperative demographic, clinical history, health status, and surgical factors. The subgroup with excellent outcomes was used as the reference group; associations were reported with relative risk ratios (RR). **Results:** Factors predicting membership in postoperative trajectories indicating poor outcomes for disability, leg and back pain were comorbid depression (RR 3.70, 95% confidence interval [CI] 1.53–8.90; RR 3.79, 95% CI 1.11–12.94; RR 3.78, 95% CI 1.11–12.88, respectively), scoring moderate to severe on the Patient Health Questionnaire (RR 4.02, 95% CI 1.99–8.15; RR 2.40, 95%CI 1.09–5.63; RR 2.60, 95% CI 1.04–6.98, respec-

tively) and previous drug use. Preoperative opioid use was associated with 2.51 (95% CI 1.22–5.20) times the risk of belonging to the poor outcome subgroup for disability and 3.77 (95% CI 1.40–10.18) times the risk for poor back pain outcome. Preoperative neuroleptic use was associated with 3.78 (95% CI 1.02–6.93) times the risk of poor leg pain outcome. Patients with higher mental health component summary scores (MCS-12) had 48% less risk of belonging to the subgroup with poor disability (RR 0.52, 95%CI 0.40–0.68) and leg pain (RR 0.52, 95% CI 0.37–0.72) outcomes and 32% less risk of poor back pain outcomes (RR 0.68, 95% CI 0.50–0.93). Additional risk factors were identified for poor disability outcomes: previous surgery (RR 2.08, 95% CI 1.23–3.54), having fusion surgery (RR 2.45, 95% CI 1.51–3.99) and being female (RR 1.92, 95% CI 1.20–3.06). **Conclusion:** It is time to look beyond pathology/surgical factors only and include mental health variables as an integral part of the surgical decision-making process in an effort to avoid patients at increased risk for surgical failure.

78
A Canadian Spine Outcomes and Research Network study of the change in lumbar lordosis and sagittal alignment with operative treatment for lumbar degenerative spondylolisthesis. *Jennifer Urquhart[1], Brian Kwon[2], Steve Casha[3], Edward P. Abraham[4], Neil Manson[4], Charles Fisher[2], John Street[2], Ken Thomas[3], Marcel Dvorak[2], Michael Boyd[2], Nicholas Gelinas-Phaneuf[5], Nicholas Dea[2], R. Andrew Glennie[6], Y. Raja Rampersaud[7], Raphaele Charest-Morin[8], Scott Paquette[2], Tamir Ailon[2], Greg McIntosh[9], Christopher Bailey[1].* **From the [1]London Health Sciences Centre and Western University, London, Canada; [2]Vancouver General Hospital and University of British Columbia, Vancouver, Canada; [3]Foothills Medical Centre and University of Calgary, Calgary, Canada; [4]Canada East Spine Centre and Saint John Regional Hospital, Saint John, Canada; [5]Montreal Neurological Institute and McGill University, Montreal, Canada; the [6]QEII Health Sciences Centre and Dalhousie University, Halifax, Canada; the [7]Toronto Western Hospital and University Health Network, Toronto, Canada; the [8]Centre Hospitalier Universitaire de Québec, Québec, Canada; and [9]Research Operations, Canadian Spine Society, Markdale, Canada.**

Background: The objective of this study was to evaluate the change in lumbar lordosis and sagittal vertical axis from the operative treatment of patients with lumbar degenerative spondylolisthesis. **Methods:** Consecutive patients at 9 spinal centres were prospectively enrolled in a study evaluating the assessment and management of lumbar degenerative spondylolisthesis using the Canadian Spine Outcomes and Research Network (CSORN) database. Pelvic parameters included sacral slope, pelvic tilt (PT), pelvic incidence (PI), sagittal vertical axis (SVA), lumbar lordosis (LL), and thoracic kyphosis. Primary outcome was change in LL and SVA at 6–18 weeks after surgery. Secondary objectives evaluated the effects of preoperative imbalance (SVA ≥ 50 mm and LL < PI 9°) and surgery type (decompression, fusion or interbody fusion) on postoperative spinopelvic alignment. **Results:** A total of 341 patients were enrolled between January 2015 and September 2018. Cases not yet receiving surgery or with no radiographic measures were excluded, leaving 195 patients. The average age was 65.7 years and most patients were female (60.0%), had grade I spondylolisthesis (73%), and had a single

operated level (83%). Missing data ranged from 22% to 36%. Mean preoperative LL was 46.1 ± 13.5°, PI was 56.7 ± 13.1°, PT was 23.9 ± 9.5°, and SVA was 31.8 ± 40.5 mm. At 6–18 weeks, the mean LL increased by 2.3 ± 10.9° ($n = 176$, $p < 0.001$) and SVA decreased by –8.5 ± 33.5 mm ($n = 117$, $p = 0.003$). All other measures did not differ after surgery. Preoperatively, 52% had PI to LL mismatch (LL < PI 9°) and 26% had significant sagittal imbalance (SVA ≥ 50 mm). Postoperatively, 41% had LL < PI 9° and 19% had SVA ≥ 50 mm. Of the total cohort, 7.3% developed de novo PI to LL mismatch (LL < PI 9°), 33.9% had persistence of a LL < PI 9°. Malalignment developed in 3.4% (SVA ≥ 50 mm) and 15.4% with SVA ≥ 50 mm preoperatively remained imbalanced. Surgery type had a similar effect on spinopelvic alignment ($p < 0.05$ for all parameters). **Conclusion:** Mean SVA and LL improved after surgery. Most patients that had spinopelvic sagittal balance before surgery maintained balance.

108
Development CT–ultrasound fusion for spinal surgery. *Normand Robert[1], Jérémie Larouche[2], Michael Hardisty[1], Joel Finkelstein[2], Cari Whyne[1].* **From the [1]Sunnybrook Research Institute, Toronto, Canada; and the [2]Sunnybrook Health Sciences Centre, Toronto, Canada.**

Background: Computed tomography (CT)–based navigation is the standard of care in spinal surgery. However, CT has limited ability to discern soft tissues, which can be altered and displaced during procedures. This investigation seeks to develop a spine-focused navigation workflow including ultrasound (US) images providing soft tissue discrimination in the context of CT images, thereby overcoming challenges of US interpretation and localization paired with a rapid US beam universal pose calibration procedure. **Methods:** A Philips iU22 US system with an L9–3 transducer was instrumented with a custom infrared tracker for navigation with a StealthStation S7. The live US images were obtained using a video capture device (Epiphan DVI2USB 3.0). We developed an US plane calibration procedure whereby a optically tracked instrumented pointer intercepted the US beam at multiple locations, determining the ultrasound beam position in space. Our visual interface includes a real-time 3D view showing the US plane moving/slicing CT-generated bony anatomy (O-Arm, Medtronic). Live US images are shown fused with corresponding CT image planes. System performance was evaluated in a cadaveric porcine model. A posterior surgical approach was simulated with a midline dorsal incision exposing the spinal column and a laminectomy exposing soft tissues. The accuracy of the system was assessed by identifying 5 features on the dorsal side of the vertebral body in both modalities. **Results:** The spine surgery workflow exhibited US–CT fusion intraoperatively, simultaneously displaying hard and soft tissue information. The accuracy of the system yielded a mean distance error of 1.6 ± 0.6 mm. **Conclusion:** Visually the fused CT–US images showed good spa-

tial correspondence of anatomic features of the bony spine. Given the sub-mm voxel spacing of CT, pixel spacing of US and accuracy of the navigation system, we expect inter-modality spatial correspondence can be further improved via a calibration procedure that better accounts for the US plane's finite thickness. The accuracy and visualization demonstrated within this investigation are consistent with utility for disc resection, spinal cord decompression and visualization of pathology, ossification and burst fractures.

89.
Comparing baseline characteristics of a prospective cohort of patients stratified by the degenerative spondylolisthesis instability classification (DSIC): Are all slips the same? *R. Andrew Glennie[1], Chris Bailey[2], Nicolas Dea[3], Raja Ramperasaud[4], Charles Fisher[3].* **From the [1]Dalhousie University, Halifax, Canada; [2]Western University, London, Canada; the [3]University of British Columbia, Vancouver, Canada; and the [4]University of Toronto, Toronto, Canada.**

Background: Recent randomized control trials have questioned whether spinal fusion surgery confers a significant therapeutic advantage to laminectomy alone in patients with degenerative spondylolisthesis. Many have challenged that patients are unique and that more of an individualized approach to surgical decision-making is indicated. A degenerative spondylolisthesis instability classification (DSIC) was proposed to help guide this decision-making. The purpose of this project was to determine whether the baseline characteristics of patients varied depending on the DSIC classification. **Methods:** A prospective cohort of patients were enrolled from 16 different sites across Canada. Baseline demographic, patient-reported outcome measures (PROMs), radiographic data were collected and global stability ratings were assessed based on the DSIC. The DSIC stratifies patients into 3 groups with degenerative spondylolisthesis: type 1 (stable), type 2 (potentially unstable) and type 3 (unstable). Baseline data were then compared using SPSS software. **Results:** There were 307 patients available for review. Type 1 patients were significantly older than type 2 or 3 patients (68 v. 65 v. 63 yr, $p = 0.018$). There were also a higher proportion of females in the type 3 cohort (74% v. 28%). Type 3 patients had significantly different/inferior SF-12 mental component summary, EQ-5D questionnaire, PHQ-9 questionnaire and Oswestry Disability Index scores. There were no differences in SF-12 physical component summary, Neck Disability Index leg or back pain scores. There were no significant differences in radiographic parameters between groups. **Conclusion:** There are potentially significant baseline clinical differences in patients with degenerative spondylolisthesis. Although the postoperative surgical outcomes were beyond the scope of this study, there is some early evidence that future trials should account for these unique patient characteristics by appropriate stratification based on stability.

POSTER PRESENTATIONS

15
Morphological variations within the posterior arch of the C1 vertebrae of elderly patients. *Nicole Schneider[1,2], Tim Lasswell[3], Parham Rasoulinejad[1,2], Stewart McLachlin[3].* **From the [1]Western University, London, Canada; the [2]London Health Sciences Centre, London, Canada; and the [3]University of Waterloo, Waterloo, Canada.**

Background: Implant fixation to the C1 vertebra remains a significant challenge for safe surgical intervention of atlantoaxial instability in the elderly population. There is a renewed interest in using the posterior arch for fixation to avoid critical neurovascular structures. The primary objective of this study is to examine the sagittal plane morphology of the posterior arch of C1 along the midline and lateral end points with the addition of slope in the

coronal plane to identify anatomic variations and symmetries. **Methods:** We evaluated 100 computed tomography (CT) scans of the cervical spine from patients aged ≥ 65 years visiting the emergency department (ED) of Victoria Hospital from Nov. 1, 2017, to May 9, 2018. In total, 77 CT scans of the cervical spine met the criteria for inclusion and were evaluated. Medical imaging and visualization software (3D Slicer-version 4.8.1) was used for measurement analysis. Measurements of height and width were taken at 8 mm and 15 mm from the midline of the posterior arch. Additionally, the superior slope angles of the left and right sides of the posterior arch in the coronal plane were also calculated. Statistical analysis was performed using Minitab. The mean and standard deviation were calculated for each measurement, and paired t tests with a 95% confidence level were used to determine the symmetric relationships, if any. **Results:** The measurement analysis did reveal lateral symmetry in height, width and slope angle of the posterior arch ($p > 0.05$). However, significant variability in the height and width of the posterior arch in the sagittal plane was observed among patients. Three common shapes of the posterior arch were observed, including tall and narrow, short and wide, as well as a more uniformly shaped posterior arch of C1. **Conclusion:** This investigation identified morphological measurements and patterns in the anatomic variation of the C1 posterior arch not currently described in the anatomic literature including the new morphometric feature of slope. Atlantoaxial stabilization techniques may benefit from these findings.

142

Is depression a barrier to achieving full benefit from surgical intervention in chronic thoracolumbar spine disease? A Canadian Spine Outcomes and Research Network study. *Duncan Cushnie.* **From McMaster University, Hamilton, Canada.**

Background: Chronic spine disease is an increasing source of morbidity and pain. There are successfull surgical interventions for some of these conditions. However, some reports describe worse outcomes after spine surgery in depressed patients. It is possible that depression prevents achievement of full pain or disability reduction benefit from surgical intervention. Therefore, the Canadian Spine Outcomes and Research Network (CSORN) registry was examined for differences in outcome after thoracolumbar surgery in degenerative spine patients with and without baseline depression. **Methods:** Chronic spine disease is an increasing source of morbidity and pain. There are successfull surgical interventions for some of these conditions. However, some reports describe worse outcomes after spine surgery in depressed patients. It is possible that depression prevents achievement of full pain or disability reduction benefit from surgical intervention. Therefore, the CSORN registry was examined for differences in outcome after thoracolumbar surgery in degenerative spine patients with and without baseline depression. **Results:** A total of 3222 patients met inclusion criteria and had preoperative and 12-month outcomes. Although Oswestry Disability Index (ODI) score was worse in depressed patients at baseline (54.6, 95% confidence interval [CI] 53.7 to 55.5) compared with nondepressed patients (43.7, 95% CI 43.1 to 44.3, $p = 0.0002$), net ODI improvement was slightly better postoperatively for depressed (–21.9, 95% CI –23.3 to –20.6) rather than nondepressed patients (–18.9, 95% CI –19.8 to –18.1) and was not inferior in any diagnosis subanalysis. While back pain was worse at all time points and diagnoses in depressed

patients ($p < 0.1$), net back pain improvement did not differ between depressed and nondepressed patients ($p > 0.1$). Leg pain did not differ between depressed and nondepressed patients at any time point or diagnosis ($p > 0.1$). **Conclusion:** Patients with a baseline mental health state consistent with major depression had worse disability and pain preoperatively, and at all time points postoperatively, consistent with the theory that these patients represent a different population than nondepressed patients. However, they also had a similar net improvements in disability and back and leg pain compared with nondepressed patients, indicating that they benefit similary from surgical intervention.

116

The effect of perioperative dexmedetomidine on analgesic outcomes in adult patients undergoing elective spine surgery: a systematic review and meta-analysis of randomized controlled trials. *Alexandra Stratton[1,2], Faraj Abdallah[1,2], Eugene Wai[1,2], Philippe Phan[1,2], Stephen Kingwell[1,2], Dita Moravek[2].* **From the [1]University of Ottawa, Ottawa, Canada; and the [2]Ottawa Hospital Research Institute, Ottawa, Canada.**

Background: Opioid use remains a significant problem in spine surgery patients in Canada and the United States. Specifically, 52% of patients undergoing elective thoracic and lumbar spine surgery have been shown to take opioids preoperatively. Perioperative administration of dexmedetomidine is emerging as a promising alternative to standard anesthetic protocols with opioid-sparing and sedative effects. The aim of this systematic review and meta-analysis was to investigate the effect of perioperative dexmedetomidine on opioid requirements and pain scores in patients undergoing spine surgery. **Methods:** Electronic databases, including MEDLINE, EMBASE and the Cochrane Library, were searched for randomized controlled trials (RCTs) that evaluated the effects of perioperative dexmedetomidine on analgesic requirements intra- and postoperatively, and postoperative pain scores in adult patients undergoing elective spine surgery. Risk of bias was assessed using the Cochrane Tool. **Results:** Eighteen studies enrolling a total of 1067 patients were included. Dexmedetomidine administration protocols included a preoperative bolus followed by intraoperative infusion with or without postoperative infusion in patient-controlled analgesia pump up to 48 h postoperatively. Reported outcomes captured included 0–10 pain rating scales up to 48 h postoperatively (8 studies), intra-operative analgesic requirement (6 studies) and postoperative analgesic requirement up to 48 h postoperatively (5 studies). **Conclusion:** Dexmedetomidine is efficacious in spine surgery patients as a sedative and analgesic with opioid-sparing effects. Further study to investigate the spine surgery subpopulation in which dexmedetomidine has the greatest benefit and ideal administration protocol is required to optimize the effect of this medication and minimize opioid use in spine surgery patients.

97

Discrimination of functional limitations in patients with lumbar spinal stenosis using the Oswestry Disability Index. *Anastasios Charalampidis[1,2], Pratipal Singh Kalsi[1], Y. Raja Rampersaud[1].* **From the [1]Toronto Western Hospital, University Health Network, Toronto, Canada; and the [2]Department of Clinical Sciences, Intervention and Technology (CLINTEC), Karolinska Institute and Department of Orthopaedics, Karolinska University Hospital, Stockholm, Sweden.**

Background: The Oswestry Disability Index (ODI) is the most commonly used assessment of functional outcome in spine surgery. The purpose of this study was to determine the ability of the ODI to discriminate the functional impact of lumbar spinal stenosis (LSS) and the impact of surgery on different functional limitations. **Methods:** We performed a retrospective analysis of prospectively collected data on 237 LSS patients. The difference at baseline and the pre-to-post (1-yr) surgical change of the ODI individual questions were assessed. Analysis of variance, the Pearson χ^2 test or the Fisher exact test was used for group comparisons. A 2-tailed paired sample Student t test was used for within-group comparisons. Cohen d was used as an index of effect size, defined as "large" when $d \geq 0.8$. **Results:** Fifty-one percent of the patients were male with a mean age of 67 (range 33–88) years. At baseline, highest functional limitations were noted for standing, walking, lifting and social life (median 4, 3, 3 and 3/5, respectively). At 1-year follow-up, there was a significant decrease in all individual questions and the overall ODI (mean pre/post 42.5/32.2, all $p < 0.001$). The greatest effect of surgery was noted in the standing, walking and social life domains (all $d \geq 0.84$), while lifting, personal care, sitting and sleeping showed the least improvement (all $d \leq 0.52$). Preoperatively, females had a significantly higher score for lifting, sitting, sleeping, employment/homemaking and total ODI compared with males (all $p \leq 0.043$). However, these differences were largely attenuated by surgery and the only significant difference remaining was a higher score for sleeping ($p = 0.014$). **Conclusion:** The results of this study support the ability of the ODI to discriminate the different self-reported functional effects of LSS and the changes associated with surgical intervention. Disaggregated use of the ODI could be a simple tool to aid in preoperative education regarding specific areas of dysfunction and potential for improvement by surgery.

98

A comparison of functional and quality of life improvement in six different types of surgery in a pan-Canadian database. *Peter Jarzem[1], Adrienne Kelly[2], Michael Weber[1], Mina Aziz[1], Greg McIntosh[3]* .From [1]McGill University, Montreal, Canada; the [2]Northern Ontario School of Medicine, Sault Ste. Marie, Canada; and the [3]Canadian Spine Outcomes and Research Network, Markdale, Canada.

Background: Patient-centred outcomes can be used to rank surgical indications by rate of success for improving patient quality of life (QoL) and function. The objective of this study is to compare the outcomes of common lumbar spinal surgical procedures. **Methods:** To determine the efficacy of different types of surgical indications across Canada, we examined patient improvement on the EQ-5D questionnaire and Oswestry Disability Index (ODI) for 6 common lumbar surgical indications in the Canadian Spine Outcomes and Research Network (CSORN) database. The surgeries included 1) discectomy for radiculopathy, 2) artificial disc for degenerative disc disease, 3) spinal fusion for degenerative disc disease, 4) decompression and fusion for degenerative spondylolisthesis, 5) simple decompression for spinal stenosis, and 6) spinal fusion for degenerative scoliosis. Improvements from baseline were assessed at 3, 12 and 24 months. We used t tests to determine patient improvement. EQ-5D questionnaire outcomes were compared with published data for total hip and knee replacement. **Results:** See the Table. **Conclusion:** While surgical outcomes vary widely, within this study, discectomy was found to be the statistically superior surgery for restoring quality of life and function. Simple decompression for spinal stenosis and spinal fusion for degenerative scoliosis consistently demonstrated the poorest outcomes. Total hip and total knee typically demonstrate QoL improvements of 0.31 and 0.22 on the EQ-5D questionnaire. The majority of spine surgeries in our list produce results similar to hip and knee arthroplasty. Careful patient selection is required for decompression and adult scoliosis surgery.

38.

Variability in minimal important difference in spinal surgery outcome measurement. *Joel Finkelstein[1], Carolyn Schwartz[2], JIe Zhang[3], Bruce Rapkin[4].* **From [1]Sunnybrook Health Sciences Centre, Toronto, Canada; [2]Tufts University, Boston, USA; the [3]Deltaquest Foundation, Boston, USA; and the [4]Albert Einstein College of Medicine, New York, USA.**

Background: Our objective was to investigate changes in patients' minimally important differences (MID) over recovery from spinal surgery and how cognitive appraisal processes are implicated in the change trajectories. **Methods:** We conducted a longitudinal cohort study with up to 12 months follow-up after spinal surgery. Patient-reported outcome (PRO) measures included the Rand-36 physical and mental component scores (PCS and MCS), Oswestry Disability Index (ODI), Numeric Rating Scale pain items (at rest, with activity, back and leg), PROMIS Pain Impact, and Global Assessment of Change (GAC). The QOL Appraisal Profile standards of comparison measured cognitive appraisal processes. MID was determined with both a distribution-based (Cohen effect size) and anchor-based technique (GAC). Mean MID change was determined at

Table 1. Improvement in QOL (EQ-5D) and function (ODI) with 6 surgical indications								
	Improvement in EQSD				Improvement in ODI			
Surgical indication	3 mo	12 mo	24 mo	N (12 m)	3 mo	12 mo	24 mo	N (12 m)
1 - Discectomy for radiculopathy*	0.289	0.312	0.3258	199	25.5	29.6	31.8	228
2 - Artificial disc for degenerative disc disease	0.203	0.231	0.242	70	16.7	19.6	21.5	73
3 - Spinal fusion for degenerative disc disease	0.181	0.217	0.234	66	14.5	19.7	20.7	76
4 - Decompression and fusion for degenerative spondylolistesis	0.255	0.251	0.226	118	17.6	21.3	20.2	124
5 - Simple decompression for spinal stenosis	0.197	0.18	0.183	156	17	18.4	16.8	176
6 - Spinal fusion for degenerative scoliosis	0.1687	0.236	0.149	23	-2.2	16.3	9.7	24

*p < = 0.05
Sample size varied depending on time point and were as low as 12 for group 6 at 24m.

each follow-up time point for "somewhat better" patients determined by GAC and was measured compared to last time point and to baseline. Patients were grouped by pattern of GAC at each time point into 3 trajectories of outcome: better (i.e., better, better, better), worse (i.e., worse, worse, worse), bouncers (e.g., better, worse, better; worse, better, worse). Linear slope (trajectory) scores over time for each PRO and appraisal score were computed using regression models. Z-score comparison of correlation coefficients tested the hypothesis that GAC groups differed in the relationships between QOL change and appraisal change over time. **Results:** Among spine surgery patients experiencing improvement over time, moderate to large changes are recognized as clinically important in the early stages of recovery (i.e., 6 weeks postsurgery).Over time smaller and smaller changes become important. The better group had larger slopes across all PROs, compared to the worse and bouncer groups. Trajectory groups emphasized and de-emphasized different standards of comparison over time. Group differences translated to differential relationships between PRO change and appraisal changes over time. **Conclusion:** Soon after surgery, MID is moderate to large. With time from surgery, smaller and smaller changes become clinically significant. Underlying differences in appraisal may influence how patients experience the same change over time creating instability in MID.

7

Impact of pre-surgical self-reported exercise on post-surgical outcomes in patients with cervical pathology. *Mark Xu, Michael Johnson, Mohammad Zarrabian.* **From the University of Manitoba, Winnipeg, Canada.**

Background: It is unknown if preoperative self-reported exercise frequency is a predictor of cervical spine surgery outcomes. We hypothesize that patients who report exercise before cervical spine surgery will demonstrate less pain, improved health state and/or less disability following surgery than patients who do not exercise. **Methods:** We performed a retrospective review of prospectively collected data from the Canadian Spine Outcomes and Research Network (CSORN) registry. Inclusion criteria were elective adult cervical surgery patients with degenerative pathology. Outcome measureswere visual analogue scales (VAS) for neck and arm pain, Neck Disability Index (NDI), and EuroQOL health state at baseline and 3, 12 and 24 months postoperative (*n* = 460). Exercise frequency was self-reported as "none" (*n* = 212) versus "some" (*n* = 248), and further subcategorized into "none" secondary to physical limitations or not, and exercising "≤ 1/week" or " ≥ 2/week." We used Student *t* tests to compare mean scores of the outcome measures, and analysis of variance for subgroup comparisons (*p* < 0.05). **Results:** Those who reported "some" exercise had more favourable VAS neck and arm pain scores preoperatively (neck: 5.55 v. 6.11, *p* < 0.001; arm: 5.69 v. 6.04, *p* = 0.011), but no difference at 3 and 24 months postoperatively. Significantly lower NDI scores and higher EuroQOL Index scores were seen in the exercise group compared with the no exercise group preoperatively (NDI: 39 v. 48, *p* < 0.001; EuroQOL: 0.60 v. 0.50, *p* < 0.001) as well as at 3, 12, and 24 months postoperative (NDI: 24 v. 31, *p* = 0.007; EuroQOL: 0.75 v. 0.68, *p* = 0.001). Further subgroup analysis demonstrated that compared with the "no exercise due to physical limitation" group, the "≥ 2/week" exercise group showed favourable NDI and EuroQOL scores up to 24 months postoperative (NDI: 24.32 v. 32.33,

p = 0.001; EuroQOL: 0.76 v. 0.66, *p* = 0.001), whereas the "≤ 1/week" group no longer demonstrated any significant difference at 24 months. **Conclusion:** Self-reported exercise before cervical spine surgery does not predict improved long-term neck and arm pain 2 years postoperative. However, self-reported exercise does demonstrate less disability and improved health state at baseline and up to 2 years postoperative, and this relationship is dose dependent.

23

Comparing the efficacy of 3 types of spinal orthoses on balance and walking ability in patients with thoracic kyphosis secondary to osteoporosis. *Farzad Farmani.* **From the Hamadan University of Medical Sciences, Hamadan, Iran.**

Background: Osteoporosis is a common orthopedic condition, mostly in elderly women, that could lead to many clinical problems such as increased risk of vertebral fracture, hyperkyphosis, poor balance, and decreased functional mobility and quality of life. Most often, different spinal orthoses are prescribed for rehabilitation after vertebral fracture and spinal kyphosis. The aim of this study was to evaluate the influence of 3 widely used orthoses on postural stability and gait in people with postosteoporosis thoracic kyphosis. **Methods:** Twenty-nine women (aged 55–75 yr) participated in this study. Two force platforms (KISLER) were used to collect data. Outcome measures included centre of pressure (COP) mediolateral and posterior–anterior displacement, step length, step width and cadence. Tests were performed in 4 conditions in random sequences: 1) no orthosis, 2) Spinomed orthosis, 3) posture training support (PTS) and 4) posterior shell thoracolumbosacral orthosis (TLSO). **Results:** All orthoses resulted in decreased COP displacement in mediolateral and anterior–posterior directions and increased step length, step width and cadence (*p* < 0.05). Also, no significant difference was seen in gait characteristics while patients used 3 types of orthoses (*p* > 0.05). However, COP displacement in both directions was significantly less using posterior shell TLSO than with Spinomed orthosis and PTS. **Conclusion:** The present study showed that all 3 types of orthoses could improve posture, stability and gait ability in elderly patients with postosteoporosis thoracic kyphosis, although posterior shell TLSO may affect the postural control more than the 2 others.

130

Pediatric spinal cord injury in Canada. *Nancy Thorogood, Jennifer Lee, Carly Rivers, Melody Chen, Penny Clarke-Richardson, Vanessa Noonan.* **From the Rick Hansen Institute, Vancouver, Canada.**

Background: The objective of this project was to describe pediatric spinal cord injury (SCI) in Canada; examine the state of pediatric SCI research; identify knowledge gaps, priorities and opportunities; and estimate pediatric incidence for future research. **Methods:** Stakeholders were recruited as informants on the Canadian pediatric SCI research landscape using snowball sampling. Informants were interviewed or completed a questionnaire regarding awareness, priorities and gaps in pediatric SCI research. Both traumatic (tSCI) and nontraumatic pediatric SCI were included. A thematic analysis was performed by coding key points and collating them into themes. Administrative data from the Canadian Institute for Health Information were used to identify incident tSCI cases. **Results:** The response rate was 54%

(61/114); 33 participants completed an interview or questionnaire. Participants represented 5 provinces and included clinicians, administrators, researchers (including clinician researchers), consumers (parents) and community organizations. Very few centres conduct research in pediatric SCI. Of those conducting research, topics included ambulation/mobility, adaptive equipment, wheelchair skills, and urological studies. There are no multicentre studies; single-centre studies include participants with other neurologic conditions and adults. The incidence of tSCI in children under 4 years of age was estimated to be 1.6/million, increasing to 28.3/million in adolescence 15–19 years of age. Priority areas for research included standards to classify injury level and severity, creation of a Canadian pediatric registry, creation of pediatric-specific outcome measures and determining impact of treatment on long-term outcomes. Acute care priorities included research on functional recovery of the cord, timing of surgical interventions and tissue engineering. **Conclusion:** No pediatric SCI network exists; most individuals are unaware of what others are doing in Canada. A pan-Canadian, multistakeholder platform, similar to what is available for adult SCI, is needed to drive evidence-based research and care. It is intended that the project will serve as a call to action for the pediatric SCI community.

120

Predicting the DSIC scheme grade using machine learning: a Canadian Spine Outcomes and Research Network study. *Audrey Maher, Philippe Phan, Mohamad Hoda, Alexandra Stratton, Eugene Wai, Stephen Kingwell.* **From the The Ottawa Hospital, Ottawa, Canada.**

Background: Degenerative lumbar spondylolisthesis (DLS) is a common condition with many available treatment options. The Degenerative spondylolisthesis instability classification (DSIC) scheme was proposed by Simmonds and colleagues in 2015 and proposes that the stability of the pathology be determined by a surgeon based on clinical and radiographic parameters. The purpose of this study is to classify DLS patients according to the DSIC scheme using machine learning, offering a novel approach in which an objectively consistent system is employed. **Methods:** The data, which included 224 DLS Canadian Spine Outcomes and Research Network (CSORN) cases, was cleaned by 2 methods: deletion and imputation. The machine learning models, namely, logistic regression, boosted trees, random forests, support vector machines, and decision trees, were built, trained, and tested using Python-based, sklearn-learn and pandas libraries respectively. Both data sets were tested. The matplotlib library was used to graph the receiver operating characteristics (ROC) curves, including the area under the curve (AUC). **Results:** The machine learning models were all able to predict the DSIC grade. Of all the models, the support vector machine model was best, achieving an AUC of 0.82. This model achieved an accuracy of 63% and an F1 score of 0.58. When comparing both data cleaning methods, the imputation method had higher AUC overall; however, their accuracies, recalls, precisions, and F1 scores were similar. **Conclusion:** The models were able to effectively predict physician decision-making and score patients based on the DSIC scheme. The support vector machine model was able to achieve an AUC of 0.82 compared with physician classification. Since the data set was relatively small, the results could be improved with training on a larger data set. The use of machine learning models in DLS classification could prove to be an efficient

approach to reduce human bias and error. Further efforts are necessary to test the inter- and intraobserver reliability of the DSIC scheme as well as to determine if the surgeons using the scheme are following DLS treatment recommendations.

112

Surgical simulator for spinal decompression. *Hikmat Sahak[1], Michael Hardisty[1], Joel Finkelstein[2], Cari Whyne[1].* **From the [1]Sunnybrook Research Institute, Toronto, Canada; and the [2]Sunnybrook Health Sciences Centre, Toronto, Canada.**

Background: Spinal stenosis is a condition resulting in the compression of the neural elements due to narrowing of the spinal canal. Spinal decompression surgery requires appropriate planning and strategies depending on the specific situation. Given the potential for neural complications, there are significant barriers to residents and fellows obtaining adequate spinal decompression experience. Virtual surgical teaching tools exist but they do not simulate the many challenges of spinal decompression. The aim of this work was to develop a spinal decompression specific open-source 3D virtual simulator as a teaching tool to improve orthopedic training. **Methods:** A spinal decompression simulator was built using 3D Slicer, an open-source software platform for medical image visualization and processing. The procedural steps include import of patient-specific imaging, fusion of computed tomography (CT) and magnetic resonance imaging (MRI), bone threshold-based segmentation, soft tissue segmentation, surgical planning, surgical field simulation, simulation of laminectomy, and spinal decompression. Bone and soft tissue resecting tools were developed by customizing manual 3D segmentation tools. Laminectomy simulation was enabled through bone and ligamentum flavum resection at the site of compression. Neural element decompression was simulated by interpolation of the undeformed anatomy above and below the site of compression. **Results:** The completed workflow allows patient-specific simulations of decompression procedures by staff surgeons, fellows and residents. Procedural accuracy, the surgical exposure, the design of resecting tools, and modelling of the impact of bone and ligament removal was found to adequately encompass important challenges encountered in decompression surgery. Visualization of decompression, tissue resection and positioning can be evaluated after completing the virtual procedure. **Conclusion:** This software development project has resulted in a well-characterized accessible tool for simulating spinal surgery that a trainee can review alone or with a preceptor to improve their skills. Future work will integrate and evaluate the simulator within existing orthopedic resident competency-based curriculum and fellowship training instruction. Best practices for effectively teaching decompression in tight areas of spinal stenosis using virtual simulation will also be investigated in future work.

155

Design, development and testing of a novel stand-alone interbody fusion device. *John Matheson, Fahad Al Halal, Parham Rasoulinejad, Chris Bailey, Kevin Gurr, Fawaz Siddiqi, Matthew Teeter.* **From Western University, London, Canada.**

Background: The gold standard for posterior lumbar fusion (PLIF) involves an invasive procedure requiring 4 pedicle screws, 2 rods and 2 interbody cages. We have developed a

novel device for fusion, eliminating the need for pedicle screws with the aim of achieving a comparable degree of fusion inserted through minimally invasive technique. **Methods:** A team of experts consisting of biomedical and biomechanical engineers and surgeons was assembled to undertake this project and the stand-alone cage was designed using computer-assisted drawings and manufactured in titanium by 3D printing. Biomechanical testing comparing the stand-alone cage with standard PLIF was carried out both in Sawbones ($n = 6$) and cadavers ($n = 8$), with each model being composed of one functional spinal unit (FSU). Three range of motion (ROM) loading protocols were subsequently applied to the FSUs in the form of a flexion/extension moment, an axial rotation moment, and a lateral bend moment with a constant axial load throughout. An optical tracking system was used to quantify the ROM in response to the force applied. **Results:** Compared with PLIF, the stand-alone cage demonstrated no significant difference in ROM for flexion, lateral bend or axial rotation in Sawbones; however, significant increase in range of extension was observed. Among cadavers, the stand-alone cage demonstrated a significant increase in ROM for flexion, extension, lateral bending to the right and total lateral bend ROM, but no significant increase to ROM in axial rotation. **Conclusion:** Biomechanical comparability to PLIF was achieved in Sawbones testing with the exception of extension; however, the significantly increased ROM observed in cadaveric testing has driven further design modifications to improve construct stability.

136

A Canadian experience with halo-vest treatment for cervical spine trauma, risk factors and complications. *Ahmed Aoude, Sultan Aldebeyan, Steve Casha.* **From the University of Calgary, Calgary, Canada.**

Background: Halo-vest treatment for cervical spine problems can help avoid surgery for the appropriate patients. However, the literature is unclear about the complication rate and risk factors associated with halo-vest treatment. Here we present our experience for halo-vest treatment at our institution. **Methods:** We conducted a retrospective analysis of prospectively collected data for all patients treated with halo vest as definitive treatment at our institution between January 2000 and December 2018. All complications were analyzed and documented as patient characteristics that can account for high risk for complication such as past medical history, age, gender and fracture type. Logistic regression was used to identify risk factors and a Student t test was used to compare means. **Results:** This section presents preliminary results to finalize. A total of 750 patents were identified in our database; 347 were males and 403 females with average age of 63 (range 18–91) years. The average complication rate was 19%; 16% were minor and 3% were major. The majority of minor complications were pin site infection and pin loosening in (approximately 50%). Failure of halo-vest treatment requiring surgical intervention was seen in approximately 10% of reviewed cases. Different risk factors were analyzed with logistic regression and will be presented at the conference. Age and comorbidities were analyzed. **Conclusion:** Here we present results for halo-vest treatment used as definitive management at our institution. At our institution we have biweekly follow-ups for patients

with halo-vest treatment and show that complication rates can be lower than shown in the literature (19% in our study, with the majority being minor complications). Therefore, although no definite conclusion can be made, our results show that halo-vest treatment can be used routinely with low complication rates if adequate follow-up is maintained.

83

Comparing the prognostic performance of area under the curve and F1-score using a national surgery database. *Zachary DeVries[1], Mohamad Hoda[1], Stephen Kingwell[2], Alexandra Stratton[2], Eugene Wai[2], Philippe Phan[2].* **From the [1]University of Ottawa, Ottawa, Canada; and the [2]Ottawa Hospital, Ottawa, Canada.**

Background: Commonly, the receiver operating characteristics curve with the associated area under the curve (AUC) is used to assess the performance of prediction models developed on large, multicentric databases. However, it has been found that a precision-recall curve with the associated F1-score could provide a more realistic analysis for these models. The purpose of this project was to determine if there are any differences between the AUC v. F1-score using a national surgical database for the prediction of complications during spine surgery. **Methods:** In order to develop the logistic regression (LR) model used to predict a complication during spine surgery, 26 variables were selected by 3 orthopedic spine surgeons from the National Surgical Quality Improvement Program (NSQIP) registry. Diagnostic performance of the model was then assessed by determining both the AUC and the F1-score, which were then compared with the AUC and F1-score for the down-sampled data set. **Results:** Within the NSQIP database, 52 787 spine surgery cases were identified in which only 10% of these cases had complications during surgery. Applying the LR model, there was a statistically significant difference between the AUC (0.86) and the F1 score (0.45) for the original data set ($p < 0.05$). However, there was no statistically significant difference between these 2 values when we balanced the data set and then reapplied the LR model ($p > 0.05$). **Conclusion:** The F1-score was found to have a significantly lower performance for the prediction of complications when using the imbalanced data, but improved to the AUC level when balancing techniques were used. This is most likely due to a low precision score when there are a lot of false-positive classifications, which is not identified when using the AUC value. Therefore, it is the recommendation of this paper to use the F1-score on large, prospective databases when the data are imbalanced due to a large amount of negative classifications.

114

Exposure to a motor vehicle collision and the risk of future neck pain: a systematic review and meta-analysis. *Paul Nolet[1,2,3], Peter Emary[4], Vicki Kristman[2,5,6], Kent Murnaghan[3], Maurice Zeegers[1], Michael Freeman[1,7].* **From the [1]Maastricht University, Maastricht, the Netherlands; [2]Lakehead University, Thunder Bay, Canada; the [3]Canadian Memorial Chiropractic College, North York, Canada; [4]McMaster University, Hamilton, Canada; the [5]University of Toronto, Toronto, Canada; the [6]Institute for Work and Health, Toronto, Canada; and the [7]Oregon Health Sciences University, Portland, USA.**

Background: Neck injury resulting from a motor vehicle collision (MVC) is associated with a high rate of chronicity, with 50% still reporting neck pain (NP) a year after initial injury. These statistics are difficult to interpret due to the high prevalence of NP in the general population without a history of MVC-related injury. The purpose of this study is to review the literature that has examined the association between an MVC-related neck injury and future NP in comparison with the population that has not been exposed to neck injury from an MVC. **Methods:** We performed a systematic review of the literature using 5 electronic databases, searching for NP risk studies published from 1998 to 2018, describing adults 16 years of age and older exposed to an MVC. The outcome of interest was future NP. Eligible risk studies were critically appraised using the Quality in Prognosis Studies (QUIPS) instrument. The results were summarized using best-evidence synthesis principles, and a random-effects meta-analysis was performed with the pooled data. **Results:** The search resulted in the identification of 8955 potentially related articles, of which 8 were sufficiently relevant for critical appraisal, and 7 of these were found to have low risk of bias. Six of the 7 studies reported a positive association between a neck injury in an MVC and future NP. Pooled analysis of the 6 studies indicated an unadjusted relative risk of future NP in the MVC-exposed population with neck injury of 2.3 (95% confidence interval [CI] 1.8–3.1), which equates to a 57% attributable fraction. In 2 of the 7 studies that examined exposure to a rear-end collision in which the participants were either not injured or injury status was unknown, there was no increased risk of NP in comparison with the control group. **Conclusion:** There was a consistent positive association among studies that have examined the association between MVC-related neck injury and future NP. These findings are of potential interest to clinicians, insurers, patients, governmental agencies, and the courts.

145

Patterns and predictors of functional recovery from the subacute to the chronic phase following a traumatic spinal cord injury: a prospective study. *Andreane Richard-Denis[1,2], Jean-Marc Mac-Thiong[1,2], Rami Chatta[2]. From the [1]Hopital Sacré-Coeur de Montréal, Montreal, Canada; and the [2]Université de Montréal, Montreal, Canada.*

Background: Our objectives were to determine the extent of functional recovery between 6 and 12 months following a traumatic spinal cord injury (tSCI) and to identify individuals achieving a small clinical functional improvement during that period. **Methods:** We conducted a prospective cohort study of 125 patients with tSCI at a single level-1 trauma centre specialized in SCI care. Main measures were the Spinal Cord Independence Measure (SCIM) version III at 6 and 12 months postinjury. **Results:** The observed functional improvement for the total cohort did not reach a clinically significant level between 6 and 12 months postinjury. However, 30.4% of individuals achieved this level (≥ 4 points in the SCIM-III total score) during that period. A significant number of them (50.6%) sustained a motor-complete SCI (American Spinal Injury Association grade A or B). Longer duration of intensive functional rehabilitation was the main factor associated with reaching a small clinically important improvement in the SCIM-III total score. **Conclusion:** Functional status between 6 and 12 months following a tSCI may be considered clinically similar, regardless of the level of injury. However, many patients showed a small clinical functional improvement in the return to community phase, particularly individuals sustaining severe deficits, which may highlight the importance of functional compensation and support during that period.

115

Machine learning to predict a single patient clinical course: How will your life change after a diagnosis of degenerative cervical myelopathy? *Sasha Rogers[1], Bradley Jacobs[1], Jacques Bouchard[1], Steven Casha[1], Roger Cho[1], Stephan Duplessis[1], John Hurlbert[2], Peter Lewkonia[1], Paul Salo[1], Alexandra Soroceanu[1], Ganesh Swamy[1], Kenneth Thomas[1], Frederick Nicholls[1], Nicolas Dea[3], Nils Forkert[4], Pauline Mouches[4], David Cadotte[1]. From the [1]University of Calgary Spine Program, Calgary, Canada; the [2]University of Arizona College of Medicine, Division of Neurosurgery, Tucson, USA; the [3]Combined Neurosurgery and Orthopaedic Spine Program, University of British Columbia, Vancouver, Canada; and the [4]Department of Radiology and Hotchkiss Brain Institute, Calgary, Canada.*

Background: Machine learning (ML) algorithms provide a powerful conceptual and analytic framework capable of integrating multiple data types and sources that may more effectively model neurobiological components of the pathophysiology of degenerative cervical myelopathy (DCM). We have developed an ML algorithm to predict the clinical course of 120 patients with DCM. **Methods:** Patients with DCM were enrolled in the prospective Canadian Spine Outcomes Research Network (CSORN) registry, limited to a single centre (Calgary) over the past 2 years. An ML algorithm was developed using CSORN patient-derived clinical data. Due to the small sample size, a leave-one-out cross-validation approach was implemented. The performance of several ML algorithms were compared, including random forest, support vector machine, neural network and decision tree. The analysis was then run to attempt to predict improvement (score difference > 1) v. stable (score difference between 0 and 1 included) v. deterioration (score difference < 0) in the modified Japanese Orthopaedic Association score (mJOA). **Results:** Of 158 patients (107 male; mean age 59.54 ± 12.64 yr), 125 (79%) underwent surgery. Baseline assessment showed a mean mJOA of 13.25 (95% confidence interval [CI] 12.88–13.63). At 3-month follow-up, 120 (76%) patients were available for functional assessment. Forty-seven percent of the patients improved, 37% stayed stable and 16% deteriorated. Preliminary results favour the neural network algorithm with a performance accuracy of 50%. Subsequent attempts at refining the model resulted in a predictive capability of 59%, suggesting that the current model is unable to differentiate sufficiently between patients who improve and those who remain stable. **Conclusion:** We have developed an ML algorithm using only baseline clinical characteristics. Clinical features and operative details alone do not reliably predict clinical course in DCM. To improve our ability to predict clinical course, we are in the process of extracting features from baseline clinical images. This will include image segmentation and extracting metrics from the segmented regions.

66

Anterolateral cervical kyphoplasty for metastatic cervical spine lesions. *Amer Sebaaly[1,2], Ahmed Najjar[1], Fidaa Al-Shakfa[1], Zhi Wang[1], Ghassan Boubez[1], Laura Masucci[1], Daniel Shedid[1], Van Truong[1].* **From the [1]CHUM, Montreal, Canada; and [2]Saint Joseph University, Beirut, Lebanon.**

Background: Even though the spine overall is the third most common site of metastasis, the cervical spine is affected the least, with an incidence of 10%–15%. Surgical decompression is highly challenging because of the proximity of neural and vascular elements. Kyphoplasty for cervical spine metastasis was described in small case reports with promising results. The objective of this retrospective study is to evaluate the clinical and radiological efficacy of anterolateral kyphoplasty for cervical spinal metastasis. **Methods:** Retrospective analysis of prospectively collected data from a single-centre spine metastasis database was done for cervical kyphoplasty cases. Demographic data included age, sex and origin tumour diagnosis. Other variables included modified Tokuhashi score, spinal instability neoplastic score (SINS), preoperative visual analogue scale (VAS) score, analgesic medication and opioid use. Postoperative data included postoperative day 1 VAS, duration of hospitalization, self-reported functional outcome, and last follow-up VAS. **Results:** Eleven patients (mean age 62.5 yr) with cervical spine metastases were treated with 15-level kyphoplasty. Tokuhashi score was 8.1 and SINS score was 7.85. Preoperative pain was 7.1 and the number of preoperatively consumed analgesics was 1.8, with 82% of patients using opioids. Total bleeding volume was 100 mL. Mean complication-free length of stay was 2.6 days with a decrease of postoperative pain (VAS 2.8, $p < 0.05$). There was a 56% decrease of opioid dosage and number of consumed analgesics (1.09, $p = 0.004$). In all, 82% of the patients reported excellent improvement on last follow-up self-assessment. **Conclusion:** This series represents the largest series of vertebral augmentation using balloon kyphoplasty for cervical spinal metastasis. This technique is associated with low postoperative complication, significant decrease in pain and opioid use, and shorter hospital length of stay. The main indications for vertebral kyphoplasty are lytic lesions of the cervical spine and painful lesions refractory to medical treatment.

109

Pedicle screw resistance: a crucial component for intraoperative electromyographic neuromonitoring. *Johnathan Norton, Daryl Fourney.* **From the University of Saskatchewan, Saskatoon, Canada.**

Background: Evoked ("triggered") electromyographic (EMG) monitoring of pedicle screws has been shown to be an effective adjuvant to image guidance or direct visualization of pedicle screw placement. In this technique, electrical stimulation is delivered to the head of the pedicle screw at various intensities until a compound muscle action potential is evoked. This practice is based on the fact that the electrical resistance of bone is greater than that of fluid or soft tissue, such that an intact pedicle effectively shields nerve roots from the electrical stimulus. Several factors have been debated that may affect the interpretation of results; however, to the best of our knowledge, the electrical resistance of modern manufactured pedicle screws and stimulation devices has not been studied. The objective of this study was to determine if pedicle screw resistance allows

for triggered EMG to be a useful test. **Methods:** Samples of the most commonly implanted pedicle screws in Canada were obtained, with diameters ranging from 4.5 to 7 mm. The resistance between the screw head and thread and core at the midpoint and tip of the screw was recorded using a Fluke Multimeter (Fluke Corporation, Singapore) in accordance with Institute of Electrical and Electronics Engineers standards. For screws with variable threads, the midpoint was considered the point at which the thread pitch changed. We also tested 5 types of pedicle probes, including the associated cables. The average of 5 measurements was used to determine the resistance in ohms. **Results:** All screws had low impedances when tested at the point of the screw, but much higher impedances when the cup was tested. The resistance of different manufactures' screws was significantly different, ranging from 0.514 to 2156 ohms. The probes and cables also have some resistance, each tested low (about 0.01 ohms), and differences were not significant. **Conclusion:** Despite differences in resistance, most screws had resistances in ranges that allow for triggered EMG pedicle integrity testing.

17

Prognostic factors of lumbosacral spinal metastasis: single centre experience. *Francis Abed Rabbo[1], Fidaa Al-Shakfa[2], Ghassan Boubez[2], Sung-Joo Yuh[2], Daniel Shedid[2], Zhi Wang[2].* **From the [1]CHU Gabriel Montpied, Clermont Ferrand, Auvergne, France; and [2]CHUM, Montréal, Canada.**

Backgrround: Spinal metastases are seen in 10%–30% of cancer patients. Twenty percent of these metastases occur in the lumbosacral spine. Lumbosacral spine has different mechanical properties and encloses the cauda equina. Few studies take interest in this spinal segment. The objective of this study is to evaluate prognostic factors of lumbosacral spinal metastasis treated in our centre. **Methods:** We retrospectively reviewed 376 patients who were operated in our centre from 2010 to 2018. Eighty-nine patients presented lumbosacral metastases and thus were included. Data collected included age, smoking, tumour histology, American Spinal Injury Association (ASIA) score, modified Tokuhashi score, modified Bauer score, ambulation status and adjuvant treatment. **Results:** The mean population age was 60.9 (range 35–85) years. The tumour histology was predominantly lung (19 patients, 21.3%), breast (13 patients, 14.6%), kidney (11 patients, 12.4%) and prostate (9 patients 10.1%). Twenty-two patients (24.7%) were unable to walk preoperatively. Seventy-nine patients (88.8%) underwent a posterior open approach, with corpectomy in 65 patients (73%). Eighteen patients regained ambulation postoperatively (81.8%). The mean survival was 24.03 months (95% confidence interval [CI] 17.38–30.67, range 0–90 months), and the median of survival was 9 months (95% CI 4.38–13.62). Better preoperative ASIA score had a significant favourable effect ($p = 0.03$) on survival. Patients who regained their ability to walk had better survival (25.1 mo, 95% CI 18.2–32.0 v. 0.5 months, 95% CI 0–1.1). Postoperative radiotherapy had a beneficial effect on survival ($p = 0.019$): survival increased from 10.5 months (95% CI 2.4–18.7) to 27.6 months (95% CI 19.5–35.8). The modified Tokuhashi and the modified Bauer scores underestimated the survival of the patients with lumbosacral metastases. **Conclusion:** Lumbosacral spinal metastases patients have better survival than expected based on Tokuhashi and Bauer score. Surgical procedures have an important impact on survival and the ability to walk.

84

Development of an unsupervised machine learning algorithm for the prognostication of walking ability in spinal cord injury patients. *Zachary DeVries[1], Mohamad Hoda[1], Stephen Kingwell[2], Alexandra Stratton[2], Eugene Wai[2], Carly Rivers[3], Vanessa Noonan[3], Tova Plashkes[3], Jerome Paquet[4], Nader Fallah[3], Philippe Phan[2].* **From the [1]University of Ottawa, Ottawa, Canada; the [2]The Ottawa Hospital, Ottawa, Canada; the [3]Rick Hansen Institute, Vancouver, Canada; and the [4]CHU de Québec, Québec, Canada.**

Background: The van Middendorp logistic regression model for the prediction of walking recovery following spinal cord injury (SCI) has been validated within multiple different countries. However, it has been found that this model's prognostication is lower for American Spinal Injury Association Impairment Scale (AIS) grade B and C patients. Also, unsupervised machine learning algorithms have improved predictive performance compared with logistic regression. The purpose of this project was to develop an unsupervised machine learning algorithm for the prediction of walking recovery using a Canadian multicentre database. **Methods:** All patients enrolled between 2004 and 2017 with complete neurologic examination and functional independence measure (FIM) outcome data at $\geq$ 1 year follow-up or who could walk at discharge were included. The prognostic variables included were age (dichotomized at $\geq$ 65 yr); AIS grade; and individual motor, light touch, and pinprick score from L2–S1. Performance of this algorithm was assessed using k-mean clustering to determine the confusion matrix, and the diagnostic performance of the model was assessed by determining the associated AUC and F1-score. Comparison was made to the van Middendorp model. **Results:** The area under the receiver operating characteristics (AUC) scores for all AIS grades, AIS A+D, B+C, A, B, C, and D were 0.89, 0.95, 0.73 0.79, 0.69, 0.72, and 0.46, respectively, and for F1-scores were 0.89, 0.96, 0.74, 0.67, 0.70, 0.79, and 0.87, respectively. There were no statistical differences between the AUC or F1-scores between our model and the van Middendorp model ($p > 0.05$). Also, no differences were found when comparing the AUC to the F1-score ($p > 0.05$). **Conclusion:** There is no difference when adding more neurologic information and using an unsupervised learning algorithm for the prediction of walking recovery in spinal cord injury patients, as compared with the current standard. Future work should focus on determining if using other clinically relevant features would improve the prediction accuracy for all AIS grades.

102

Initial Canadian evaluation of a novel system for lumbar herniated disc repair. *Albert Yee[1], Cari Whyne[2], Ali Faqeeh[3], David Yen[3].* **From the [1]Sunnybrook Health Sciences Centre, Toronto, Canada; the [2]Sunnybrook Research Institute, Toronto, Canada; and [3]Queen's University, Department of Surgery, Kingston, Canada.**

Background: Repair of anulus fibrosus defects at the time of discectomy has been proposed as a potential means of reducing the rate of recurrent disc herniations. Our translational bench-to-clinic research group previously validated ex- and in-vivo pre-clinical (animal) performance of a 2–0 nonabsorbable polyethylene suture-based implant designed for this purpose. In the present study we report initial clinical feasibility of the technology on Canadian patients. **Methods:** Procedures were completed at 2 Canadian surgical centres between Jan. 29, 2017, and May 16, 2018. Eligible patients were offered the suture repair or not based on clinical considerations, including patient and magnetic resonance imaging factors. Intraoperatively, repair was attempted using the AnchorKnot Tissue Repair Kit if the anulus fibrosus tissue defect appeared competent and accessible for functional repair. Repair was considered successful if the defect margins were approximated and the suture was knotted in place. Routine postsurgical follow-up was completed at 6 weeks to assess for symptoms or other complications. **Results:** Twenty-eight patients were considered for herniated disc repair. Implant delivery was attempted in 18 patients and was successful in 15 (83%). Repair was not attempted for 10 patients based on intraoperative assessment of the defect. Reasons for not attempting or failing to complete a repair included narrow disc height, annular detachment from the end plate, inaccessible defect margins, and friable tissue at the defect margin. There were no adverse events reported through 6 weeks. **Conclusion:** Anatomic, tissue and defect characteristics appear to be key considerations during intraoperative assessment of potential reparability. The average time to deploy the implant was approximately 5 (6 ± 3) minutes. Our initial Canadian experience suggests that this herniated disc repair strategy is feasible when applied to appropriate patients based on preoperative and intraoperative evaluation. We recognize that a comprehensive evaluation will require ongoing clinical follow-up to assess disc reherniation rates from both an imaging and clinically relevant perspective in regards to recurrent radicular leg symptoms. Further study is planned to investigate the impact of this technology on imaging, re-herniation and surgical revision rates.

106

Neck and arm pain after surgery for cervical myelopathy: outcomes and predictors of improvement. *Ayoub Dakson[1], Sean Christie[1], Bradley Jacobs[2], Michael Johnson[3], Christopher Bailey[4], Raphaële Charest-Morin[5], Jérôme Paquet[5], Andrew Nataraj[6], David Cadotte[2], Jeff Wilson[7], Neil Manson[8], Hamilton Hall[7], Ken Thomas[2], Raja Rampersaud[7], Greg McIntosh[7], Charles Fisher[9], Nicolas Dea[9].* **From [1]Dalhousie University, Halifax, Canada; the [2]University of Calgary, Calgary, Canada; the [3]University of Manitoba, Winnipeg, Canada; [4]Western University, London, Canada, [5]Université Laval, Québec, Canada; the [6]University of Alberta, Edmonton, Canada; the [7]University of Toronto, Toronto, Canada; [8]Dalhousie Medicine New Brunswick, Saint John, Canada; and the [9]University of British Columbia, Vancouver, Canada.**

Background: This study aims to describe the change in neck and arm pain in response to surgical decompression in patients with cervical spondylotic myelopathy (CSM). **Methods:** This is an ambispective study of data collected through the Canadian Spine Outcomes and Research Network, including patients with CSM who underwent surgical decompression. Outcome measures were the visual analogue scales for neck and arm pain (VAS-NP and VAS-AP) and the neck disability index (NDI) at baseline as compared with 3 and 12 months postoperatively. The thresholds for minimum clinically important differences

(MCIDs) for VAS-NP and VAS-AP were determined to be 2.6 and 4.1, respectively, as per the literature. **Results:** We included 402 patients (mean age 59.7 ± 12.3 yr, 35.6% female). VAS-NP improved significantly from a mean score of 5.6 ± 2.9 at baseline to 3.6 ± 2.4 and 3.8 ± 2.7 at 3 and 12 months, respectively ($p < 0.001$). Similarly, VAS-AP improved from 5.8 ± 2.9 to 3.3 ± 2.8 and 3.5 ± 3.0, respectively ($p < 0.001$). The MCIDs for VAS-NP and VAS-AP were also reached at 3 and 12 months. Based on the NDI ($n = 370$), patients were grouped into those with mild pain/no pain (33%) v. moderate/severe pain (67%). NDI data were available for 331 and 213 patients at 3 and 12 months, respectively. At 3 months, a significantly high proportion of patients with moderate/severe pain (45.8%) demonstrated an improvement to mild/no pain, whereas 27.2% of patients with mild/no pain had worsening to moderate/severe pain ($\chi^2 = 20.5$, $p < 0.001$). At 12 months, only 17.4% with mild/no pain experienced worsening of their NDI v. sustained improvement in 45.3% of patients with moderate/severe pain ($\chi^2 = 26.3$, $p < 0.001$). Male gender and higher baseline VAS-NP were significant predictors for 1 point improvement in VAS-NP at 12 months. **Conclusion:** This study suggests that neck and arm pain responds to surgical decompression in patients with CSM and reaches the MCIDs for VAS-AP and VAS-NP at 12 months postoperatively.

122

Surgical intervention for patients with spinal metastasis from lung cancer. *Van Tri Truong, Lotfi Hattou, Fidaa Al-Shakfa, Daniel Shedid, Ghassan Boubez, Sung-Joo Yuh, Zhi Wang.* **From CHUM, Montreal, Canada.**

Background: The spine is the most common site of metastatic lesions in patients with lung cancer. The prognosis of these patients is worse than for other cancers. There were few studies about prognostic factors and benefits of surgical intervention in lung cancer patients with spinal metastases. The objective of this study is to evaluate prognostic factors of spinal metastasis from lung cancer treated in our centre. **Methods:** we retrospectively reviewed 74 lung cancer patients with spinal metastases who were operated in our centre from 2008 to 2018. Forty-five patients with full follow-up were included. Data collected included age, smoking, American Spinal Injury Association (ASIA) score, modified Tokuhashi score, ambulation status and adjuvant treatment. **Results:** The mean population age was 62.38 (range 36–79) years. Thirty-sex patients (80%) underwent a posterior open approach with corpectomy, and 9 patients (20%) underwent laminectomy and resection of the tumour without corpectomy. The mean survival was 11.12 ± 6.76 (range 0.33–97.63) months. Better preoperative ASIA score had a significant favourable effect ($p = 0.015$) on survival. Fourteen patients (31.1%) improved their walking ability postoperatively. Patients who were independent in walking postoperatively had better survival (25.70 v. 5.45 mo, $p < 0.001$). Better spinal instability neoplastic score (SINS) had better prognosis on survival time ($p = 0.049$). Better modified Tokuhashi score had better prognosis on survival time ($p < 0.001$). **Conclusion:** The modified Tokuhashi score and SINS may be useful tools for the prognosis of survival in patients suffered from spinal metastases from lung cancer. Surgical intervention may help to improve their survival and walking ability.

71

Factors influencing the restoration of lumbar lordosis in adult degenerative scoliosis treated with lateral transpsoas interbody fusion. *Sultan Aldebeyan[1,2], Sarup Sridharan[1], Ahmed Aoude[1], Saurabh Rawall[1], Roger Cho[1], Kenneth Thomas[1], Ganesh Swamy[1].* **From the [1]University of Calgary, Calgary, Canada; and the [2]King Fahad Medical City, Riyadh, Saudi Arabia.**

Background: Lateral lumbar transpsoas interbody fusion (LLIF) has been used with success as a surgical option to generate lumbar lordosis (LL) and does so with fewer complications than a traditional open procedure. The aim of this study was to determine whether variability in patient or surgeon factors affected ability to generate LL in LLIF during multiple cage insertion in adult degenerative scoliosis (ADS). **Methods:** ADS patients undergoing LLIFs of L1–L5 (± T12) who had second-stage percutaneous instrumentation and a minimum 6-month follow-up were included in our study. All LLIFs implants used were of a fixed anterior-posterior width and lordosis (6°). Digital Cobb technique was used for measuring segmental and regional angles. We studied whether LLIF improved segmental sagittal balance (SSB) and decreased the mismatch between pelvic incidence (PI) and LL. Second, we determined the role of degree of anterior cage placement (DACP), disc height, and the ratio of cage to vertebral body length (CL:VB) in lordosis creation though multivariate regression analysis. **Results:** LLIF significantly increased LL (–36.5 ± 12.5° preoperatively; –47.6 ± 10.5° postoperatively) and decreased the mismatch between PI and LL (21.8 ± 13.6° preoperatively; 11.0 ± 12.5° postoperatively). Preoperative SSB ($p = 0.036$), CL:VB ($p = 0.015$) and DACP ($p = 0.003$) were all significant variables in change in SSB, as per regression analysis. Modelling the variables in combination resulted in increased DACP and decreased preoperative SSB as the most significant factors correlating to increased change in SSB. When SSB was held at zero and DACP was assumed to be zero (maximum anterior placement of the cage), the model predicted the maximum lordosis at every level was greater than 6° ($p < 0.05$). **Conclusion:** LLIF in combination with percutaneous instrumentation can increase LL and decrease PI–LL mismatch in primary ADS. The most significant technical factor under the surgeon's control is cage placement. Increasing anterior placement of the cages was the most significant variable in increasing lordosis postoperatively, particularly at the lower lumbar levels.

135

Chronic hip abductor tendon tears and pelvic obliquity in patients with adult degenerative scoliosis. *Sahil Kooner[1], Khaled Almansoori[2], Ganesh Swamy[1].* **From the [1]University of Calgary, Calgary, Canada; and [2]University of Alberta, Edmonton, Canada.**

Background: The objective of this study was to evaluate the association between chronic hip abductor tears (HATs) and adult degenerative scoliosis (ADS). HATs are common among patients with degenerative lumbar disease; however, their role as a contributing or consequential factor of the pelvic obliquity among scoliosis patients has yet to be recognized or established. **Methods:** A retrospective observational study was performed to evaluate the association among patients with chronic abductor

tendon tears (diagnosed using magnetic resonance imaging) and ADS. Twelve patients were identified with chronic hip abductor tears and pelvic obliquity. Clinical and radiographic factors were collected to characterize their hip and spinal pathologies. Statistical analysis was performed using SPSS (IBM, V22.0). **Results:** Average patient age was 73 years, average follow-up was 5.9 years, most patients were female (83%). Approximately two-thirds of patients (*n* = 8) had documented scoliosis before their hip pathology or symptoms. The average Cobb angle was 57°, with an average apex at L2 to the left (levoscoliosis), a truncal shift of 3.9 cm, pelvic obliquity of 8.3°, lumbar lordosis of 35.7°, and a pelvic incidence of 59.6°. Approximately 83% of patients received steroid hip injections, and the right hip was more commonly involved (relative risk 34%, *p* > 0.05). Myotomal weakness of L5 or S1 nerve root was found in only 17% of patients, but the presence of a Trendelenburg gait or sign was present among half of the patients. No relationship was identified between the type of scoliosis curve, location of the truncal shift, pelvic obliquity, and hip side involved. **Conclusion:** Hip abductor tears may be an underrecognized cause of chronic hip pain and abductor weakness among degenerative scoliosis patients. While easily attributed, Trendelenburg weakness in ADS patients may not always be due to L5 root weakness, but commonly due to HAT. The effect of spinopelvic fusions in ADS patients with HATs deserves clarification and may contribute to dysfunction by limiting compensatory mechanisms.

128

Robotic assessment of sensorimotor and postural control in patients with cervical stenosis. *Faizal Kassam[1], Ron Levy[1], Stephen Scott[2], Josh Hobson[1], David Yen[1], Ryan Alkins[1].* **From the [1]Kingston Health Sciences Centre, Kingston, Canada; and [2]Queen's University, Kingston, Canada.**

Background: Cervical spondylotic myelopathy (CSM) is a clinical condition arising from chronic compression of the spinal cord, which can result in neurologic deterioration. Surgical decompression has been associated with improved outcomes; however, guidelines for treatment are difficult to institute given variations in the natural history of CSM when managed nonoperatively. Robotic assessment has shown promise in evaluating neurologic dysfunction. KINARM is a tool that has been used previously to quantify neurologic disturbances in patients with stroke. KINARM has not been used to assess such alterations in patients with cervical stenosis. Our objective is to compare clinical assessment with KINARM sensorimotor and postural assessment in a series of patients with cervical stenosis. The goal is to ascertain whether the KINARM robot can predict the course of cervical stenosis and quantify the effects of treatment. **Methods:** Participants underwent KINARM robotic assessment before surgical treatment and 6–9 months postoperatively. In nonoperative cases, patients were assessed at initial referral and again 6–9 months later. All patients underwent clinical assessment by a spine surgeon and were tested using a modified Japanese Orthopaedic Association (mJOA) assessment tool at both assessment intervals. **Results:** Initial data show a trend between lower mJOA scores, indicating severe myelopathy, and decreased KINARM performance. Subgroup analysis will be used to determine which cluster of KINARM tasks will be most

useful in detecting neurologic deficits within this patient population. Perfect correlation between KINARM testing and mJOA scores is not expected given that the mJOA tool includes lower extremity and gait scores whereas the KINARM utilizes the upper extremities exclusively for its assessment. **Conclusion:** KINARM is a rapid and objective tool that can quantify sensorimotor and postural control abnormalities in patients with cervical stenosis, including measuring response to surgical treatment, detection of subclinical myelopathy, and in monitoring for deterioration when managed nonoperatively. Preliminary results show that the KINARM is a feasible and objective tool for rapid quantification of neurologic abnormalities in patients with cervical stenosis.

11

Effect of tobacco smoking on outcomes of complex spine deformity correction: analysis of 270 patients from the prospective, multi-centre SCOLI-RISK-1 study of complex adult spinal deformity surgery. *Jamie Wilson[1], Frank Jiang[1], Jetan Badhiwala[2], Christopher Shaffrey[3], Justin Smith[4], Leah Carreon[5], Kenneth Cheung[6], Benny Dahl[7,8], Stephen Lewis[1], Lawrence Lenke[9], Michael Fehlings[1].* **From the [1]University of Toronto Spine Program, Toronto, Canada; the [2]Department of Neurosurgery, University of Toronto, Toronto, Canada; the [3]Department of Orthopaedic Surgery, Duke University, Durham, USA; the [4]Department of Neurosurgery, University of Virginia, Charlottesville, USA; the [5]University of Louisville, Louisville, USA; the [6]Department of Orthopaedics and Traumatology, The University of Hong Kong, Hong Kong; the [7]Division of Orthopedic Surgery, Texas Children's Hospital, Baylor College of Medicine, Houston, USA; the [8]Rigshospitalet, National University of Denmark, Copenhagen, Denmark; and the [9]Department of Orthopedic Surgery, The Spine Hospital, Columbia University Medical Center, New York, USA.**

Background: Our objective was to determine the effect of tobacco smoking on the baseline and postoperative functional and quality of life (QoL) outcomes in patients undergoing complex adult spinal deformity surgery in the SCOLI-RISK 1 study. **Methods:** The Scoli-RISK-1 study enrolled 272 patients from 15 centres who underwent surgery for high-risk adult spinal deformity, with a 2-year follow-up. Outcome measures (SF36 questionnaire, Scoliosis Research Society Outcomes Questionnaire, Oswestry Disability Index [ODI] scores, and Numerical Rating Scale [NRS] back/leg pain scores) in smokers (*n* = 26) were compared with nonsmokers (*n* = 244) using a mixed-effects model for repeated-measures with an unstructured covariance or the Wilcoxon rank sum test. **Results:** Number of levels or complexity of surgery were matched in both cohorts. At 6 weeks postsurgery nonsmokers demonstrated a significantly higher SF36 mental component score (44.6, 95% confidence interval [CI] 42.8–46.4) compared with the smoking group (37.7, 95% CI 32.2–43.3, *p* = 0.021), but this effect was not maintained at 6 or 24 months (*p* = 0.248 and *p* = 0.605, respectively). ODI scores were not significantly different between the groups at 6 weeks (*p* = 0.802), 6 months (*p* = 0.377) and 24 months (*p* = 0.281). The mean change in scores from baseline between groups for all outcome measures

was not significantly different at any follow up interval. Median leg pain NRS scores were significantly lower in non-smokers at 6 weeks (1.00 v. 3.50, $p = 0.020$), but this effect was not present at 6 or 24 months ($p = 0.103$ and $p = 0.206$, respectively). The median change in leg pain NRS scores was not significant between the groups at any follow up interval. **Conclusion:** Both groups reported similar outcome scores at baseline and all follow-up intervals. At 6 weeks smokers had significantly worse scores for 2 outcome measures, but the changes in scores from baseline for all measures were not significant at any follow-up interval. Short-term outcomes may be adversely affected by smoking, whereas long-term outcomes appear similar between the groups.

77

Trends in opioid usage 2 years following thoracolumbar spine surgery. *Mina Aziz[1], Peter Jarzem[1], Michael Johnson[2], Greg McIntosh[3], Michael Weber[1].* **From [1]McGill University, Montreal, Canada; the [2]University of Manitoba, Winnipeg, Canada; and the [3]Canadian Spine Outcomes and Research Network, Markdale, Canada.**

Background: Opioid overdose results in 116 deaths per day in the United States. It is estimated that 21%–29% of patients misused opioids prescribed for chronic pain. The Canadian Orthopaedic Association released a statement that stressed the importance of timely access to musculoskeletal care in order to address the underlying causes of pain and curb the epidemic of opioid misuse. This study aims to evaluate the effect of under-

going surgery on patient opioid usage. We hypothesize that patients who undergo surgery to address their underlying spine pathology will reduce their opioid usage and improve their quality of life. **Methods:** We conducted a retrospective review of prospectively collected data within the Canadian Spine Outcomes and Research Network (CSORN) database for patients who underwent thoracolumbar procedures by the McGill Spine group. All adult patients who underwent thoracolumbar procedures and completed their 2-year follow-up were included. Fisher exact test was used to analyze categorical variables. Analysis of variance was used to analyze continuous variables, and significance was set at $p < 0.05$. **Results:** Forty-five patients met the inclusion criteria. Twenty-nine patients reported that they did not use opioids on initial assessment. Of the 29 patients who were not using opioids at initial assessment, 1 patient reported usage at 2-year follow-up. Of the 16 patients who were using opioids at initial assessment, 7 had completely stopped all usage, representing a 37.5% reduction in the number of patients using opioids ($p = 0.0016$). Opioid users reported a reduction of 2.69 ± 2.09, 2.94 ± 3.42 and 18.50 ± 15.28 points, whereas non-opioid users reported a reduction of 4.17 ± 3.12, 3.62 ± 3.94 and 17.55 ± 18.91 points on the back-pain scale, leg pain scale and Oswestry Disability Index, respectively. There were no statistically significant differences in these measures between the groups. **Conclusion:** Chronic pain and opioid misuse continue to be significant challenges that are affecting the quality of life of patients. This study highlights the significant impact that addressing patients' underlying pathology can have on quality of life and opioid usage.