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Canadian Spine Society

20th Annual Scientific Conference
Fairmont Château Whistler
4599 Château Boulevard
Whistler, BC

Feb. 26–29, 2020

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: Every year the Canadian Spine Society (CSS) in conjunction with the Canadian Paediatric Spine Society (CPSS) holds its Annual Scientific Conference. This year the CSS and the CPSS are joined by Spine Societies from the United Kingdom and Brazil. The meeting will cover both adult and paediatric spinal conditions and include etiology, clinical presentation and current treatment, both surgical and non-operative. The format is a CME-approved combination of didactic lectures, symposia, poster presentations and case reviews. There are sessions specifically aimed at surgical residents and fellows debating the appropriate operative management of selected cases with senior clinicians. A particular focus is the natural history of untreated scoliosis, combining insights from both the Canadian and the Brazilian experience. Timely access to care is an ongoing concern worldwide and the knowledgeable participants will advance constructive solutions. The British Association of Spine Surgeons will hold a symposium on the diagnosis and treatment of acute cauda equina syndrome. Spine specialists in all countries face similar clinical problems but employ differing solutions depending on local resources and health care delivery. The program offers ample opportunity for professional contact, sharing ideas and problems. The agenda design promotes comfortable, extended interaction with the exhibitors allowing attendees the chance to inspect and assess the latest surgical equipment and implants. The collegial atmosphere enhances sharing knowledge and discourages aggressive marketing. This Annual Scientific Conference remains the most important spine meeting in Canada.

Disclosure of potential conflict of interest information is available for all speakers presenting abstracts at the 20th 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 Podium Presentations

Presentation CPSS1

Spinal insufficiency fracture in the geriatric pediatric spine. ***Paul Missiuna*, *Mohamed Sarraj*, *Batool Bosakhar*, *Patrick Thornley*, *John Donnellan*, *Waleed Kisbta*, *Peter Darby*. From McMaster University Medical Centre, Hamilton, Ont.**

Background: Regular corticosteroid has become standard for slowing disease progression in Duchenne muscular dystrophy (DMD). However, patients must contend with the insidious side effect of osteopenia and fracture, with bone density quickly approaching that of a geriatric spine. Up to 90% of DMD patients taking daily corticosteroids develop vertebral compression fracture (VCF) by the age of 18 years. The consequent pain and immobility can lead to a downward spiral in clinical course. The objective of this study was to review the evidence for vertebroplasty in the DMD population affected with VCF and to present a case of vertebroplasty for VCF in DMD. **Methods:** We searched 2 databases (Embase and Medline) for any cases reported of vertebroplasty in DMD. **Results:** Our search yielded only 1 reported case of a successful kyphoplasty in an 8-year-old with DMD. The case we present is a 15-year-old boy with DMD being treated with daily deflazacort. He initially presented with vertebral insufficiency fractures and was treated with pain palliation and intravenous bisphosphonate therapy. Though his symptoms initially improved and he became more active, he presented again with severe central low back pain requiring greater narcotic loads. Computed tomographic scan confirmed compression fractures at L1, L3, L4 and L5, with edema from L1 to L5 confirmed by magnetic resonance imaging. As the patient had failed the accepted medical standard of care, he was offered and underwent percutaneous vertebroplasty from T12 to L5. Pretreatment team-mobilization identified the need for postoperative respiratory supportive therapy in the pediatric intensive care unit. Clinical follow-up is enclosed. **Conclusion:** There is a significant gap in the literature regarding the indications for and outcomes of vertebroplasty, with only 1 other reported case. We outline an additional case of vertebroplasty in a 15-year-old boy with DMD. With evidence of improved pain and function, this operative intervention should become part of the management plan for treatment-resistant VCFs in the DMD patient.

Presentation CPSS2

The clinical significance of tether breakages in anterior vertebral body growth modulation: a 2-year postoperative analysis. ***Jesse Shen*, *Imad Nahle*, *Abdulmajeed Alzakri*, *Marjolaine Roy-Beaudry*, *Julie Joncas*, *Isabelle Turgeon*, *Stefan Parent*. From the University of Montreal, Montreal, Que. (Shen, Nahle, Alzakri, Parent); Centre hospitalier universitaire Sainte-Justine, Montreal, Que. (Nahle, Roy-Beaudry, Joncas, Turgeon, Parent); and the King Saud University, King Saud University, Riyadh, Meddle, Saudi Arabia (Alzakri).**

Background: Anterior vertebral body growth modulation (AVBGM) is a technique aimed at treating skeletally immature patients with progressive idiopathic scoliosis (IS). Early results are promising, but tether breaking is a concern. Determining whether this subgroup has a different postoperative evolution may allow us to understand and predict failures. The aim of this study was to compare the first 2 postoperative years in patients who have developed tether failures with those of patients without other major complications. **Methods:** A retrospective review of a prospectively maintained database of IS patients who underwent operations with AVBGM from 2013 to 2019 was performed. Inclusion criteria were patients having at least 2-year radiologic data and Scoliosis Research Society questionnaires (SRS-30) completed. Patients diagnosed with tether failures on the basis of radiologic data were included. Patients excluded from this study were those with any diagnosis other than IS and major complications other than tether failure. The Wilcoxon rank-sum test was used to compare results between patients with and without tether failure. **Results:** Sixty-two patients were identified. Twenty-two patients were identified with tether failures. One patient with tether failure required revision surgery and was excluded from this study. Including this patient, a total of 8 patients were excluded. A total of 21 patients with tether failures and

33 patients with minor or no complications were analyzed. Average age for index surgery was 11.9 and 12 years for the 2 groups, respectively. No significant differences ($p > 0.05$) were seen for maximum Cobb angles, kyphosis or lordosis between the 2 groups. Significant differences ($p < 0.05$) were noted in SRS-30 quality of life preoperative scores between the 2 groups, but were not found at 2 years after surgery. **Conclusion:** Patients who develop tether failures may have similar postoperative outcomes to those of patients with no postoperative complications within the first 2 postoperative years. Further analysis is needed to define the natural evolution of tether failures.

Presentation CPSS3

Anterior vertebral body growth modulation for idiopathic scoliosis: early, mid-term and late complications. ***Imad Nahle, Jesse Shen, Abdulmajeed Alzakri, Marjolaine Roy-Beaudry, Julie Joncas, Isabelle Turgeon, Stefan Parent.*** **From the University of Montreal, Montreal, Que. (Nahle, Shen, Alzakri, Parent); Centre hospitalier universitaire Sainte-Justine, Montreal, Que. (Nahle, Roy-Beaudry, Joncas, Turgeon, Parent); and the King Saud University, King Saud University, Riyadh, Meddle, Saudi Arabia (Alzakri).**

Background: Anterior vertebral body growth modulation (AVBGM) is an emerging option with evolving indications for the treatment of idiopathic scoliosis (IS). However, the spectrum and impact of the potential complications are not yet well defined. We aim to show that complications of AVBGM for IS differ from the classic posterior fusion and that they can be clustered as early, mid term and late term. **Methods:** A prospective cohort of 62 patients (mean age 11.8 ± 1.3 yr) who underwent operations for IS with AVBGM between December 2013 and October 2017 was studied; all patients had 2 to 5 years of follow-up (mean 39 ± 9 mo). Prospective analysis of pre- and post-operative data included patient-specific parameters, radiographic measurements and recording complications and their respective management. Statistical analysis used descriptive measures and independent *t* tests. **Results:** Tether breakage was identified in 22 patients (36%). In addition, 12 other complications were noted in 12 patients. Three pulmonary complications and 2 cerebrospinal fluid (CSF) leaks occurred early (median 18.0 ± 30.0 d and 6.5 ± 4.9 d, respectively). Three overcorrections (requiring tether removal) and 1 insufficient correction for a 75° curve (requiring posterior spinal fusion [PSF]) were seen at mid term (median 19.0 ± 7.5 mo and 18.0 mo, respectively). At long term, we identified 22 tether breakages, 2 coronal decompensations and 1 lumbar curve progression (median 32.0 ± 6.9 mo, 32.0 ± 6.9 mo, and 29.0 ± 20.0 months, respectively). Reoperation rate was 13% (8/62). Furthermore, instrumenting closer to the vertebrae touched by the central sacral vertical line (CSVL) correlated significantly with lower overall complications ($p = 0.017$) and a tendency toward lower tether breakage ($p = 0.084$). **Conclusion:** Complications of AVBGM differ from those of PSF in nature and timing. Pulmonary complications and CSF leak may occur in the first 90 days. Over- or under-correction probably happens within 2 years as growth is maximal during this period. Tether breakage, coronal decompensation and lumbar curve progression are rather encountered from 2 to 5 years. Instrumenting distally closer to the vertebrae touched by the CSVL seems to add a protective effect.

Presentation CPSS4

Ovine model of congenital chest wall and spine deformity with alterations of respiratory mechanics: follow-up from birth to 3 months. ***Jesse Shen, Nathalie Samson, Jérôme Lamontagne-Proulx, Denis Soulet, Yves Tremblay, Jean-Paul Praud, Stefan Parent.*** **From the University of Montreal, Montreal, Que. (Shen, Parent); the Université de Sherbrooke, Sherbrooke, Que. (Samson, Praud); Université Laval, Québec, Que. (Lamontagne-Proulx, Soulet, Tremblay); and Centre hospitalier universitaire Sainte-Justine, Montreal, Que. (Parent).**

Background: The adverse effects of spinal and thoracic deformities (STD) on respiratory mechanics have been suggested in the literature. However, most animal studies have evaluated respiratory mechanics in a STD model created postnatally. We developed an ovine model of STD induced surgically in utero to assess its consequences on lung mechanics and development. **Methods:** An STD was induced in utero at 70–75 days of gestation in 14 ovine fetuses by resection of the seventh and eighth left ribs. Each untouched twin fetus was taken as control. Respiratory mechanics was studied in the first week of life and at 1, 2 and 3 months postnatally. Furthermore, postmortem respiratory mechanics and lung histomorphometry were assessed at 3 months. Mann–Whitney *U* tests were performed to evaluate statistical significance. **Results:** Eight out of 14 STD lambs (57%) and 14 control lambs survived the postnatal period. The causes of death included abortion ($n = 3$), prematurity ($n = 1$), respiratory insufficiency at birth ($n = 1$) and stillbirth ($n = 1$). One severe (51° Cobb angle) and 5 mild deformities were induced (2 with 13°, 2 with 10° and 1 with 7.5° Cobb angle). The inspiratory capacity was decreased at birth in STD lambs (32 v. 35 mL/kg in controls, $p = 0.02$), as well as the static respiratory system compliance (2.0 v. 2.5 mL/cmH_2O/kg, $p = 0.005$). No significant differences in respiratory mechanics were seen thereafter. Finally, the alveolar surface area was significantly ($p < 0.05$) decreased in the 5 STD compared with the 4 control lambs studied at 3 months of life. **Conclusion:** This is the first study to evaluate the effects of a STD induced in utero on respiratory mechanics in an ovine model from birth to 3 months of age that shows substantial alterations in lung histomorphometry. Our ovine model allows a closer replication of congenital spine and chest deformities.

Presentation CPSS5

Test–retest reliability and minimum detectable change of the English translation of the Italian Spine Youth Quality of Life questionnaire in adolescents with idiopathic scoliosis. ***Malik Alanazi, Stephan Parent, Doug Gross.*** **From the Department of Physical Therapy and Health Rehabilitation, Prince Sattam Bin Abdulaziz University Hospital, Al-Kharj, Saudi Arabia (Alanazi); the Department of Physical Therapy, University of Alberta, Edmonton, Alta. (Alanazi, Parent, Gross); and the Department of Surgery, University of Alberta, Edmonton, Alta. (Parent).**

Background: Scoliosis significantly affects quality of life (QOL). Establishing measurement properties is a prerequisite for outcome measures evaluating the effects of scoliosis treatments. Current quality of life questionnaires for adolescents with idiopathic scoliosis (AIS) have limitations. The SRS-22r has ceiling

effects and the SAQ asks patients to express how they look from behind, which they cannot see. A new questionnaire for measuring QOL in AIS called the Italian Spine Youth Quality of Life (ISYQOL) questionnaire has been developed to address these limitations, but test–retest reliability for the English translation has not yet been determined. The objective of this study was to determine the test–retest reliability of the ISYQOL questionnaire. **Methods:** One hundred consecutive girls with AIS, aged 10–18 years, treated nonoperatively were recruited from a Canadian urban pediatric scoliosis clinic. Questionnaires were computer-administered using Research Electronic Data Capture (REDCap) before specialist consult. Participants completed the English translation of the ISYQOL online 1 and 2 weeks after visiting their clinician. Test–retest reliability should meet acceptable standards suggested by COSMIN for measuring groups of patients (intraclass correlation coefficient [ICC] 0.7) and for individual patients (ICC 0.90). **Results:** Participants included 100 girls aged 13.9 ± 1.8 years with 29° ± 14° curve angles. Test–retest reliability of the ISYQOL score 60.3 ± 12.4 was above the minimum standards for use in groups but below the standards for use in individuals (ICC 0.88; 95% confidence interval 0.79–0.93). The standard error of the mean of the ISYQOL was 5.2 and the minimum detectable change (95% confidence) was 14.4. **Conclusion:** According to the COSMIN criteria, results support the suitability of ISYQOL for QOL research in AIS. Because of the confidence interval of the reliability of the ISYQOL, it may still be suitable for use in individuals, taking into consideration the consequences of its use. Future research should formally examine the ability to detect changes over clinically relevant follow-up durations.

Podium Presentations

Presentation B1
Abstract 31

Incidence of delayed spinal cord injury in pediatric spine deformity surgery seems to be higher than previously assumed. ***Joost Rutges*, *Jeroen Renkens*, *Thomas Schlösser*, *Agnita Stadhouder*, *Michael Kruyt*, *Adriaan Mostert*, *Jin Tee*, *Luuk de Klerk*, *Marinus De Kleuver*, *René Castelein*. From the Erasmus Medical Centre, Rotterdam, the Netherlands (Rutges, Renkens); the Utrecht University Medical Centre, Utrecht, the Netherlands (Schlösser, Kruyt, Castelein); the Amsterdam University Medical Centre, Amsterdam, the Netherlands (Stadhouder); the Isala Klinieken, Zwolle, the Netherlands (Mostert); The Alfred Hospital, Melbourne, Australia (Tee); the Sint Maartenskliniek, Nijmegen, the Netherlands (De Klerk); and the Radboud Medical Centre, Nijmegen, the Netherlands (De Kleuver).**

Background: Delayed spinal cord injury (SCI) hours or days after completion of pediatric spine deformity surgery, with initial normal neurologic examination, is a rare complication, with an estimated incidence ranging from 1:1000 to 1:10 000 surgeries. However, on the basis of anecdotal evidence the suspicion arose that the incidence of this complication might be higher than previously assumed. The aim of this study was to determine the incidence of delayed SCI in patients undergoing pediatric spine deformity surgery between 2007 and 2017 in the Netherlands. **Methods:** All Dutch hospitals that perform pediatric deformity surgery were contacted. From the identified patients with a delayed SCI, the following data were obtained: patient characteristics, surgical procedure, details of the SCI and management. Additionally, from the Dutch Hospital Database all surgical procedures linked to the International Classification of Diseases, Ninth Revision and 10th Revision (ICD-9 and ICD-10) codes for pediatric deformity (scoliosis/kyphosis) were obtained to determine the number of surgeries performed between 2007 and 2017. **Results:** In total, 2703 pediatric deformity surgeries were performed in the Netherlands between 2007 and 2017. In this period, 6 patients with delayed SCI were identified: 2 with idiopathic, 2 with neuromuscular and 2 with secondary scoliosis. Median age was 15 (range 7–17) years, and median Cobb angle was 70° (range 51°–130°). All 6 patients had a documented normal neurologic examination directly after surgery; neurologic deficits were first diagnosed a median of 14 hours after surgery, ranging from 6 to 40 hours. Five patients had an incomplete SCI (range AIS B-C) and 1 patient had a complete SCI (AIS A). The calculated incidence of delayed SCI was 1:763 in idiopathic scoliosis, 1:269 in secondary scoliosis and 1:160 in neuromuscular scoliosis. **Conclusion:** The current study indicates that the incidence of delayed SCI after pediatric deformity surgery might be higher than previously assumed. Strict postoperative observation for late neurologic deficit (onset often in the middle of the night, a median of 14 h after surgery) is crucial for timely diagnosis and management of this devastating complication.

Presentation B2
Abstract 155

What is the optimal surgical method for achieving successful symptom relief in pediatric high-grade spondylolisthesis? ***Brett Rocos*, *Reihard Zeller*, *Stephen Lewis*, *Tony Tan*, *David Lebel*. From the Hospital for Sick Children, Toronto, Ont.**

Background: Options for the surgical management of pediatric high-grade spondylolisthesis include reduction with arthrodesis or fusion in situ. Which strategy yields the most successful outcome or the lowest rates of complication or revision surgery remains unclear. **Methods:** We conducted a retrospective consecutive case-series investigation of high-grade spondylolisthesis treated surgically at our hospital between October 2006 and August 2017. Patients with an L5–S1 slip greater than or equal to 50% treated with either posterior partial reduction and fusion (PRF) or posterior reduction and interbody fusion (RIF) between the ages of 0 and 18 years were included. Records were evaluated to assess postoperative complications, revision surgery, postoperative symptoms and change in radiologic parameters to a minimum of 2 years. **Results:** Thirty-one eligible patients were identified. The average age was 13.6 years (9–17 yr). Mean follow-up was 41 months. At presentation, the 2 groups showed no significant difference in age, Meyerding grade, slip angle (p = 0.27, 95% confidence interval [CI] –19 to 1), pelvic tilt (p = 0.07, 95% CI –4.6 to 15.7) or C7 sagittal vertical axis (p = 0.27, 95% CI –13.2 to 44.9). Presenting symptoms were similar

between the groups. Of 11 patients in the PRF group, 4 showed intraoperative neuromonitoring changes of which 2 had documented postoperative weakness. All patients showed normal neurology at discharge. None underwent further surgery. Slip angle reduced by a mean of 9° (p = 0.02), pelvic tilt (PT) and sacral slope were unchanged and C7 SVL reduced by a mean of 42 mm (p = 0.17). In the RIF group, 4 sustained dural tears and 1 a laminar fracture. Nine patients showed neuromonitoring changes, of whom 7 had postoperative weakness and numbness, 4 of whom had resolved at discharge. Eight patients underwent unplanned further surgery, 3 for pseudarthrosis. Slip angle reduced by a mean of 15° (p < 0.001), PT and sacral slope were unchanged and C7 SVL reduced by a mean of 27 mm (p = 0.016). **Conclusion:** There are several ways to manage spondylolisthesis, with either strategy being associated with an appreciable risk of early and late complications.

Presentation B3
Abstract 47
Vertebral body tethering: Truly motion preserving or rather limiting? ***Firoz Miyanji*, *Paul Rushton*, *Maty Petcharaporn*, *Amer Samdani*, *Peter Newton*, *Michelle Marks*. From the B.C. Children's Hospital, Vancouver, B.C. (Miyanji, Rushton); the University of British Columbia, Vancouver, B.C. (Miyanji); Setting Scoliosis Straight, San Diego, Calif. (Petcharaporn, Marks); the Harms Study Group, San Diego, Calif. (Petcharaporn, Marks); the Shriners Hospitals for Children, Philadelphia, Pa. (Samdani); and the Rady Children's Hospital, San Diego, Calif. (Newton).**

Background: The objective of this study was to evaluate implications of anterior vertebral body tethering (AVBT) on intervertebral motion (IVM) of tethered segments in a cohort of postoperative patients. **Methods:** In this institutional review board approved study, motion was assessed by standardized radiographs acquired in maximum right, left and forward bending positions. An independent observer measured the intervertebral angles via digital radiographic measuring software at each instrumented and tethered segment. The IVM in the coronal/sagittal planes was measured by the summation of the static angle on the upright posterioranterior/lateral radiographs with the static angle on the right/left bending posterioranterior radiographs and forward bending lateral radiographs, respectively. **Results:** Twenty-five patients were included with a mean follow-up of 26.5 months (12–42 mo). There were 21 thoracic tethers compared with 4 lumbar tethers with mean major coronal Cobb angle of 52.7°± 8.6° correcting to an average of 19° (0° to 38°) and further correction to 12° (–9° to –32°) at most recent follow-up. Average operation time was 305 ± 74 min with mean estimated blood loss of 231.7 ± 82.9 mL. Mean number of levels tethered was 7.1 ± 0.9. Total forward flexion (FF) motion of the tethered thoracic segments averaged 12.5° ± 3.6° and of the tethered lumbar segments averaged 16° ± 6.5°. Total mean tethered IVM in FF was 1.9° ± 0.6° per level for thoracic tethers and 3.5° ± 1.6° per level for lumbar tethers. Total average IVM in lateral bend of the tethered segments was similar in bending toward the tether (right bend 10.95° ± 2.2°) and away from the tether (left bend 10.14° ± 3.0°) with a mean of 1.7° ± 0.4° of motion per level bending toward the tether and a mean 1.6° ± 0.5° of motion per level tethered bending away from the tether. **Conclusion:** Following AVBT, motion is preserved within the tethered segments in forward flexion, and lateral bending both toward and away from the tether. Greater IVM per level in FF is seen in lumbar tethered segments compared with thoracic, probably because of inherent differences in motion between these spine segments. AVBT may be an attractive alternative to fusion.

Presentation B4
Abstract 180
Fusion rates in pediatric patients after posterior cervical spine instrumentation. ***Laura Lobkamp*, *James Drake*, *Peter Dirks*, *James Rutka*, *Abhaya Kulkarni*, *George Ibrahim*, *Michael Taylor*, *Michael Dewan*, *Reinhard Zeller*. From the Hospital for Sick Children, Toronto, Ont.**

Background: Conditions leading to cervical instability are variable and their management in children remains technically challenging. The aim of posterior cervical spine instrumentation and application of cancellous bone graft is to provide stability and avoid nonunion via solid bone fusion. We describe our interdisciplinary experience with cervical spine fusion techniques and their qualitative outcome. **Methods:** We performed a retrospective chart review including 36 children younger than 18 years of age with cervical instability requiring instrumented or onlay bone graft fusion. Clinical data were analyzed for diagnosis, surgical fusion technique and number of revision surgeries related to fusion or hardware failure as well as other complications. Most recent radiographs or computer tomographic images were used to assess fusion quality via the following criteria: (a) stability in dynamic x-rays, (b) visible Halo sign at the screw insertion sites, (c) radiographic confirmation of continuous bone fusion mass extending the instrumented area and (d) signs of hardware failure. **Results:** Twenty-one patients had a minimum follow-up of at least 2 years for clinical and radiographic data (mean follow-up 4.65 yr, range 2.0–10.68 yr) including 14 boys and 7 girls. The mean age at the time of surgery was 8.4 years (median 8 yr, range 0.7–14 yr). Indications for surgical fusion were C1/2 instability (9 patients), postlaminectomy instability (2 patients), status postaneurysmal bone cyst removal with consecutive instability (3 patients), trauma (2 patients) and other etiologies (5 patients). Eighteen patients underwent rigid posterior instrumentation with application of autologous bone graft and 4 patients received onlay bone graft only. The surgery was performed by a mixed surgical team: approach and decompression were done by the neurosurgical team, and cervical instrumentation and bone grafting were done by the orthopedic team. Revision surgery was performed in 3 patients, 2 for nonunion and 1 for increasing junctional kyphosis. Solid bone fusion was confirmed in all of the patients, including 2 patients with asymptomatic hardware failure. Neurologic status remained unchanged postoperatively and at last follow-up. The overall complication rate was 14%, which compares favourably with the 26% postsurgical complications reported in a multicentre review. **Conclusion:** This series shows that diverse fusion techniques of the cervical spine were performed safely by a combined neurosurgical/orthopedic team and resulted in adequate fixation with high fusion rates and minimal complications.

Presentation B5
Abstract 102
Effects of 8 years of growth hormone treatment on the onset and progression of scoliosis in children with Prader–Willi syndrome. ***Lionne Grootjen, Stephany Donze, Léonie Damen, Joost Rutges, Anita Hokken-Koelega.* From the Erasmus Medical Centre, Rotterdam, the Netherlands (Grootjen, Donze, Damen, Rutges, Hokken-Koelega); and the Dutch Growth Research Foundation, Rotterdam, the Netherlands (Grootjen, Donze, Damen, Hokken-Koelega).**

Background: Most children with Prader–Willi syndrome (PWS) develop scoliosis. Our previous study found no difference in the onset of scoliosis and curve progression after 3 years of growth hormone (GH) treatment. However, long-term effects of GH treatment on scoliosis in children with PWS are currently unknown. The aim of this study is to investigate the effect of 8 years of GH treatment on the onset and progression of scoliosis in children with PWS. **Methods:** We conducted a prospective cohort study of 34 children (preliminary data) with PWS. All patients were naïve to GH treatment at the time of enrolment and received GH at a dose of 1 mg/m^2/day (approx. 0.035 mg/kg/d). Main outcome measures were onset of scoliosis (determined as a Cobb angle of > 10º) and the progression of the scoliotic curve during 8 years of GH. After 8 years of GH the outcomes were compared with those of a group of 15 children with PWS who did not receive GH. **Results:** GH treatment started at a mean age of 1.3 years. Twenty patients were boys and 14 were girls. Median age of onset of scoliosis (> 10º) was 3.7 years. After 8 years of GH treatment, mean age was 9.4 and 11.9 years in the control group ($p < 0.001$). In the GH group, 78% of the patients had a Cobb angle greater than 10º compared with 100% in the control group. The mean Cobb angle in the GH group was 15º compared with 35º in the control group ($p < 0.001$). The GH group was significantly taller and had a higher trunk lean body mass than the control group, while weight and body mass index were significantly lower. **Conclusion:** Preliminary data show reassuring results: there was no increase in severity of scoliosis after 8 years of GH treatment compared with untreated children with PWS. On the contrary, these preliminary data suggest that GH treatment might even limit the progression of scoliosis in children with PWS.

Presentation B6
Abstract 144
Klippel–Feil syndrome: clinical phenotypes associated with surgical treatment. ***Laureen Hachem, Francois Mathieu, Maria Lamberti-Pasculi, Brian Hanak, Reinhard Zeller, Abhaya Kulkarni, James Drake, George Ibrahim.* From the Division of Neurosurgery, University of Toronto, Toronto, Ont. (Hachem, Mathieu); the Division of Neurosurgery, Hospital for Sick Children, Toronto, Ont. (Lamberti-Pasculi, Hanak, Kulkarni, Drake, Ibrahim); and the Division of Orthopedic Surgery, Hospital for Sick Children, Toronto, Ont. (Zeller).**

Background: Klippel-Feil syndrome (KFS) is characterized by the congenital fusion of cervical vertebrae; however, patients often present with a variety of other spinal and extraspinal anomalies, suggesting this syndrome encompasses a heterogeneous patient population. Moreover, it remains unclear how the abnormalities seen in KFS correlate to neurologic outcomes and the need for surgical intervention. This study aimed to define distinct KFS patient phenotypes that are associated with the need for surgical intervention. **Methods:** Principal component (PC) analysis was performed on 132 KFS patients treated at a large pediatric hospital between 1981 and 2018. Thirty-five variables pertaining to patient- and disease-related factors were examined. Significant PCs were included as independent variables in multivariable logistic regression models designed to test associations with 3 primary outcomes: cervical spine surgery, thoracolumbar/sacral spine surgery and cranial surgery. **Results:** Fourteen significant PCs accounting for 70% of the variance were identified. Five components, representing 4 distinct phenotypes, were significantly associated with surgical intervention. The first group consisted of predominantly subaxial cervical spine fusions and thoracic spine abnormalities and was associated with thoracolumbar/sacral spine surgery. The second group was largely represented by axial cervical spine anomalies and had high association with cervical subluxation and cervical spine surgery. A third group, heavily represented by Chiari malformation, was associated with cranial surgery. Lastly, a fourth group was defined by thoracic vertebral anomalies and associations with sacral agenesis and scoliosis. This phenotype was associated with thoracolumbar/sacral spine surgery. **Conclusion:** This is the first data-driven analysis designed to relate KFS patient phenotypes to surgical intervention and provides important insights that may inform targeted follow-up regimens and surgical decision-making.

Presentation B7
Abstract 123
Anterior release for idiopathic scoliosis: Is it necessary for curve correction? ***Sultan Aldebeyan, Paul Rushton, Ravi Ghag, Firoz Miyanji.* From the B.C. Children's Hospital, Vancouver, B.C.**

Background: The role of anterior release (AR) in adolescent idiopathic scoliosis (AIS) has been increasingly challenged. To date, literature on the effect of AR with posterior spinal instrumented fusion (PSIF) has compared hybrid constructs to all pedicle screw constructs. AR in the setting of all pedicle screw constructs remains a point of debate. The aim of this study was to compare AR with PSIF to PSIF alone in AIS patients treated with all pedicle screw constructs. **Methods:** This was a retrospective review of a prospectively collected database. AIS patients treated with all pedicle screw PSIF with or without AR with a minimum 2-year follow-up were identified. Using propensity score matching, patients were matched on age, sex, major coronal Cobb, Ponte osteotomies and Lenke classification. Forty-seven matched pairs were identified and divided into 2 groups: PSIF alone and PSIF + AR. **Results:** The mean age was comparable between the groups (14.5 ± 2 yr PSIF; 14.2 ± 1.7 yr PSIF + AR). The majority of the patients were girls (74.5%) in both groups with a mean follow-up of 2 years. Mean major preoperative Cobb was similar between the groups (70.3 ± 17 PSIF; 70.7 ± 16.8 PSIF + AR). The mean Ponte osteotomies were not statistically different between the groups

(p = 0.772). There was no difference in coronal Cobb correction (23.9 ± 9.9 PSIF; 22.3 ± 9.9 PSIF + AR), thoracic kyphosis correction (23.15 ± 8.2 PSIF; 21.85 ± 11 PSIF + AR) and rib hump correction (46.9% PSIF; 48.6% PSIF + AR) at 2 years between the groups. The percentage of lumbar prominence correction, however, was significantly better in the PSIF + AR group (70.5%) compared with the PSIF group (41.1%) (p = 0.047). No statistically significant difference in operative time, estimated blood loss, complication rates, as well as Scoliosis Research Society outcome scores was noted between the groups. **Conclusion:** This study demonstrated the limited value of AR for AIS in patients treated with all pedicle screw constructs, specifically for coronal and sagittal plane correction. AR can significantly enhance the axial plane correction of the lumbar spine, however, without increasing perioperative morbidity or postoperative complications.

Presentation B8
Abstract 62
Severe scoliosis: Do we know a better way? A retrospective comparative study. ***Masayoshi Machida, Reinhard Zeller, Stephen Lewis, David Lebel.* From the Hospital for Sick Children, Toronto, Ont.**

Background: The objective of this study was to compare the results and safety of severe scoliosis treated with intraoperative skull-femoral traction and 3-rod constructs (3R) versus 2-rod (2R) constructs with posterior column osteotomies (PCOs). **Methods:** Fifty-nine consecutive patients with severe scoliosis (Cobb angle > 90°) who underwent posterior spine fusion were identified in our institutional records. Inclusion criteria were minimum Cobb angle of 90°, age less than 18 years at the time of surgery and a minimum 2 years of follow-up. The charts and radiographs were evaluated immediately before surgery, following surgery and at last follow-up. Radiographic parameters, operative time, surgical blood loss, neuromonitoring events, intensive care unit and hospital length of stay, and postoperative short- and long-term complications were recorded and compared between the 2 groups. **Results:** There were 28 patients in the 3R group and 31 in the 2R group. The groups were similar in their baseline characteristics with regard to etiology, age, sex, Risser sign and both coronal and sagittal deformity parameters. The preoperative major Cobb angle averaged 104° ± 12° and 101° ± 10° in the 3R and 2R groups, respectively (p = 0.4). The average major curve correction was 53% and 61% in the 3R and 2R groups, respectively (p = 0.03). The postoperative thoracic kyphosis was 29° ± 11° and 21° ± 12° in the 3R and 2R groups, respectively (p = 0.009). The surgical time was 516 ± 92 minutes and 420 ± 117 minutes in the 3R and 2R groups, respectively (p = 0.002). Blood loss estimation was 875 ± 284 mL and 1368 ± 907 mL in the 3R and 2R groups, respectively (p = 0.03). Neuromonitoring recorded events were similar in the 2 groups. One patient had some permanent sensory deficit following surgery in the 2R group. There were 2 revisions in the 2R group. **Conclusion:** Similar corrections and complications were noted in the 3-rod plus traction and the 2-rod plus PCOs methods used to correct large coronal deformities. Patient safety is a major concern; therefore, surgeons should choose the method safest in their hands in dealing with these challenging cases.

Presentation B9
Abstract 21
Intraoperative skull femoral traction in adolescent idiopathic scoliosis: the correlation of traction with side-bending radiographs. ***Kedar Padhye, Alejandro Peiro-Garcia, Brent Benavides, David Parsons, Fabio Ferri-de-Barros.* From the Alberta Children's Hospital, Calgary, Alta. (Padhye, Benavides, Parsons, Ferri-de-Barros); and the Hospital Sant Joan de Déu, Barcelona, Spain (Peiro-Garcia).**

Background: Numerous radiologic methods have been used to determine the flexibility of the scoliosis curve preoperatively. The majority of the methods have operative-dependent or patient-dependent variables. We believe that 1 intraoperative skull femoral traction radiograph (IOSFTR) would replace the need to do the current standard side-bending radiograph (SBR) to assess curve flexibility and hence reduce the radiation and overall health care costs. The aim of this study was to verify whether the IOSFTR is a comparable method to SBR in terms of measuring scoliosis curves and to predict flexibility of the curves in adolescent idiopathic scoliosis (AIS). **Methods:** This prospective cohort study was conducted by reviewing the radiographs of 37 cases (8 males and 29 females) of AIS who underwent posterior instrumented stabilization and fusion (PSIF) with a hybrid construct. We measured mean Cobb angles (CA) on upright posteroanterior radiographs, SBR and IOSFTR. Mean CA and Flexibility Index (FI) in proximal thoracic, main thoracic and thoracolumbar region were compared with paired t tests of significance. **Results:** Mean CA based on SBR and IOSFTR in either the proximal thoracic (PT), main thoracic (MT) and thoracolumbar/lumbar (TL/L) curves. The mean CA in the PT, MT and TL/L curves on SBR was 15.1°, 28.6° and 12.8°, while the mean CA in the PT, MT and TL/L curves on IOSFTR was 16.1°, 30.6° and 16.3°, respectively. The FI in the PT, MT and TL/L curves based on SBR was 24.76%, 52.46% and 36.54%, respectively, while the FI based on IOSFTR was 24.77%, 52.41% and 36.41%, respectively, showing no statistically significant difference (p > 0.05). **Conclusion:** Scoliosis curve flexibility with IOSFTR is comparable to the measurements on the gold standard SBR. This study is the first study in the literature where radiography has been performed under a standardized traction weight and in a safe manner without any additional pullies, devices or belts.

Presentation B10
Abstract 147
What is the effect of intraoperative halo-femoral traction on correction of adolescent idiopathic scoliosis? ***Paul Rushton, Sultan Aldebeyan, Ravi Ghag, Firoz Miyanji.* From the B.C. Children's Hospital, Vancouver, B.C.**

Background: The role of intraoperative halo-femoral traction (HFT) in adolescent idiopathic scoliosis (AIS) remains poorly defined. This aim of this study was to determine the efficacy of HFT on curve correction in AIS. **Methods:** A prospective, multicentre, longitudinal database identified patients with major thoracic AIS (Lenke 1–4) treated with single-stage posterior-only surgery with intraoperative HFT and minimum 2 year follow-up. These cases were matched by Lenke curve type, age (within 6 mo) and major coronal Cobb angle (within 5°) with cases treated similarly but without HFT (non-HFT). Perioperative,

radiographic and clinical outcome data at 2 years after surgery were compared between the 2 groups. **Results:** A total of 104 cases treated with HFT were matched to 104 cases treated without HFT. Mean age at surgery was 15.2 years and the major coronal Cobb angle was 61° in both groups. Number of levels fused was 11.9 versus 11.7 (p = 0.6) and estimated blood loss was 11.7 versus 13.9 mL/kg (p = 0.9) for the HFT and non-HFT groups, respectively. HFT was associated with significantly greater operative time (339 v. 306 min, p < 0.001). HFT did result in significantly improved major coronal Cobb correction (71.0% v. 66.7%, p = 0.006) and rib hump improvement (66.6% v. 56.2%, p = 0.01) compared with non-HFT at 2 years after surgery. More frequent neuromonitoring alerts were noted in the HFT group (0.35 v. 0.05 per case, p < 0.001). No postoperative neurologic deficit occurred in either group. A significant loss of T5–T12 kyphosis was seen in the HFT group (–6.5° v. +0.5°, p < 0.001); however, loss of thoracic kyphosis did not correlate with either major coronal curve correction rate (r = 0.04) or rib hump correction rate (r = –0.13). Change in Scoliosis Research Society outcome scores were similar between the groups. **Conclusion:** HFT can significantly improve coronal and axial plane deformity correction in AIS; however, an increased rate of neuromonitoring alerts was noted with HFT. Surgeons should also pay careful attention to the sagittal plane when using intraoperative HFT as it may result in decreased postoperative thoracic kyphosis.

Presentation B11
Abstract 174
Extreme long-term outcome of surgically versus nonsurgically treated patients with adolescent idiopathic scoliosis. ***Thorsten Jentzsch, Lucas Kutschke, Christoph Laux, Method Kabelitz, Regula Schüpbach, Thomas Böni, Mazda Farshad.*** **From Balgrist University Hospital, University of Zurich, Zurich, Switzerland.**

Background: Reports of extreme long-term outcomes of adolescent idiopathic scoliosis (AIS) patients in relation to the chosen treatment are rare. We report on outcomes of surgically versus nonsurgically treated patients with moderate AIS after a minimum of 29 years. **Methods:** AIS patients with a follow-up of at least 41 years in the surgical group and at least 29 years in the nonsurgical group were included. Patients were treated surgically for primary curves of at least 45° versus nonsurgically for curves less than 45° or refusal of surgery. Groups were matched for age, sex, comorbidities and primary curve severity. Oswestry Disability Index (ODI) was used to measure clinical outcomes, and standard radiography was used to quantify curve severity at final follow-up. **Results:** Sixteen patients (8 in each group, 75% female) with a median age of 14 (interquartile range [IQR] 2) years could be included and followed up after 46 (IQR 12) years. All matched variables were similar for both groups, including the primary curve Cobb angles of 48° (IQR 16°) (surgical) versus 40° (IQR 19°) (nonsurgical) (p = 0.17). At final follow-up, the ODI was similar for both groups (15 [IQR 13] points v. 7 [IQR 15] points; p = 017) with however a primary curve magnitude lower in the surgical compared with the nonsurgical group (38° [IQR 3°] v. 61° [IQR 33°]; p = 0.01), respectively. **Conclusion:** After more than 40 years, surgical and nonsurgical treatment of moderate AIS showed similar subjective outcomes, but with a relevant smaller curve magnitude with surgical treatment.

Presentation B12
Abstract 172
The influence of multilevel spinal deformity surgery on the clinical outcome in the elderly: a prospective, observational, multicentre study. ***Thorsten Jentzsch, Christopher Nielsen, Stephen Lewis, AO Spine Knowledge Forum Deformity.*** **From the Toronto Western Hospital, University of Toronto, Toronto, Ont. (Jentzsch, Nielsen, Lewis); and AO Spine, Davos, Switzerland.**

Background: This study investigated the clinical outcome after multilevel spinal deformity surgery in the elderly. **Methods:** Twelve different international centres prospectively enrolled 255 patients (219 met inclusion criteria) 60 years of age and older with spinal deformity undergoing primary instrumented fusion surgery of 5 or more segments. Different clinical outcome scores were compared between baseline preoperatively and postoperatively at 24 months. The scores were grouped into improvement from baseline (substantial [≥ 20%] and marginal [≥ 10 to < 20%]), similarity to baseline (within 10%), and decrease from baseline (marginal [≥ 10 to < 20%] and substantial [≥ 20%]). **Results:** The mean age of patients was 68 years, 176 (80%) patients were female, and the mean number of fused segments was 10. The numeric rating scale (NRS) of the back improved substantially in 123 (70%) patients, improved marginally in 21 (12%), remained similar in 22 (12%), decreased marginally in 3 (2%) and decreased substantially in 7 (4%) (n = 176). The NRS of the leg improved substantially in 93 (54%) patients, improved marginally in 13 (8%), remained similar in 40 (23%), decreased marginally in 9 (5%) and decreased substantially in 17 (10%) (n = 172). The EuroQol 5 dimensions (EQ-5D) score improved substantially in 80 (47%) patients, improved marginally in 22 (13%), remained similar in 53 (31%), decreased marginally in 9 (5%) and decreased substantially in 6 (4%) (n = 170). The Scoliosis Research Society-22r Questionnaire (SRS-22r) score improved substantially in 88 (61%) patients, improved marginally in 23 (16%), remained similar in 31 (21%), decreased marginally in 2 (1%) and decreased substantially in 1 (1%) (n = 145). All SRS-22r subgroups (function, pain, self-image, mental health and satisfaction) showed similar improvements. **Conclusion:** In this prospective multicentre, international study, multiple patient-reported outcome measures showed significant improvement in overall outcome scores, including pain and function, at 2-year follow-up in patients 60 years of age and older undergoing multi-level spinal deformity surgery.

Presentation B13
Abstract 49
Demographics of a prospective evaluation of elderly deformity surgery: a prospective international observational multicentre study. ***Stephen Lewis, Lawrence Lenke, Christopher Shaffrey, Kenneth Cheung, Sigurd Berven, Yong Qiu, Yukihiro Matsuyama, Ferran Pellisé-Urquiza, David Polly, Jr., Jonathan Sembrano, Benny Dahl, Michael Kelly, Marinus de Kleuver, Maarten Spruit, Ahmet Alanay.*** **From the Department of Surgery and Spine Program, University of Toronto, Toronto, Ont. (Lewis); the Department of Orthopedic Surgery, Spine Hospital, New York, N.Y., (Lenke); the Department of Orthopedic Surgery, Duke**

University, Durham, N.C. (Shaffrey); the Department of Orthopaedics and Traumatology, University of Hong Kong, China (Cheung); the Department of Neurosurgery and Orthopaedic Surgery, University of California, San Francisco, Calif. (Berven); the Drum Tower Hospital of Nanjing University Medical School, Nanjing, China (Qiu); the Department of Orthopedic Surgery, Hamamatsu University School of Medicine, Hamamatsu, Shizuoka, Japan (Matsuyama); Hospital Universitari de la Vall d'Hebron, Barcelona, Spain (Pellisé-Urquiza); the Department of Orthopaedic Surgery, University of Minnesota, Minneapolis, Minn. (Polly, Sembrano); the Division of Orthopedic Surgery, Texas Children's Hospital, Houston, Tex. (Dahl); the National University of Denmark, Copenhagen, Denmark (Dahl); the Washington University School of Medicine, St. Louis, Mo. (Kelly); the Radboud University Medical Centre, Nijmegen, the Netherlands (De Kleuver); the Sint Maartenskliniek, Nijmegen, the Netherlands (Spruit); and the Department of Orthopedics and Traumatology, Acibadem University, Istanbul, Turkey, Turkey (Alanay).

Background: The purpose of this review was to determine the demographics of the patients deemed candidates for surgery. **Methods:** The demographics of the patients enrolled in a multicentre international prospective study of patients over 60 years of age who were undergoing primary fusions of 5 or more levels for spinal deformity were reviewed. The preoperative demographic data were assessed to determine criteria for candidates deemed suitable for adult deformity spinal surgery. **Results:** A total of 219 of the 255 patients enrolled from 12 centres met the criteria for inclusion in the study. There were 176 females and 43 males with a mean age of 67.5 (range 60–83) years. Thiry-four (15.5%) patients were employed or self-employed at the time of surgery and 132 (60.3%) were retired. There were 124 (56.6%) Caucasians and 87 (39.7%) Asians. The mean body mass index was 26.1 (range 15.7–49.3). A total of 127 (59.1%) had depression/anxiety, 10 (4.6%) were smokers, 41 (18.7%) were ex-smokers and 22 (10.0%) drank alcohol daily. The Charlson Comorbidity Index score for the cohort was 0.5 (median 0.0, range 0.0 to 4.0). The mean bone density in 131 patients who had the test preoperatively was a mean T score (total hip) of –1.1 (range –3.3 to –2.5), and for 149 patients at the spine it was 0.1 (range –4.1 to –5.9). Preoperative patient-reported scores showed a mean Scoliosis Research Society-22r Questionnaire (SRS-22r) total score of 2.8, a mean Oswestry Disability Index (ODI) score of 46.3, a mean EQ-5D Index score of 0.53, a mean back pain numeric rating scale (NRS) score of 6.1, a mean NRS leg score of 4.9 and a median animal fluency test score of 20 words. **Conclusion:** Patients older than 60 years of age in good health, with good bone density and moderate to severe patient-reported disability as analyzed by the SRS-22r, the ODI, the NRS back and leg, and the EQ-5D were deemed candidates for spinal deformity surgery.

Presentation B14
Abstract 119

Timing of conversion to cervical malalignment and proximal junctional kyphosis following surgical correction of adult spinal deformity. ***Peter Passias; Haddy Alas, Han Jo Kim, Renaud Lafage, Alex Soroceanu, Aaron Hockley, Christopher Ames, Eric Klineberg, Douglas Burton, Bassel Diebo, Shay Bess, Breton Line, Christopher Shaffrey, Justin Smith, Frank Schwab, Virginie Lafage, International Spine Study Group.*** **From NYU Langone Health, New York, N.Y. (Passias, Alas); the Hospital of Special Surgery, New York, N.Y. (Kim, R. Lafage, Schwab, V. Lafage); the University of Calgary, Calgary, Alta. (Soroceanu, Hockley); the University of California, San Francisco, Calif. (Ames); the University of California, Davis, Calif. (Klineberg); the University of Kansas Medical Center, Kansas City, Ks. (Burton); SUNY Downstate, New York, N.Y. (Diebo); the Denver International Spine Clinic, Presbyterian St. Luke's/Rocky Mountain Hospital for Children, Denver, Colo. (Line, International Spine Study Group); the Duke University School of Medicine, Durham, N.C. (Shaffrey); and the University of Virginia Medical Center, Charlottesville, Va. (Smith).**

Background: The objective of this study was to assess conversion rate from baseline (BL) cervical alignment to postoperative cervical deformity (CD) and corresponding proximal junctional kyphosis (PJK) rate in patients undergoing thoracolumbar adult spinal deformity (ASD) surgery. **Methods:** Operative patients who met ASD criteria (aged > 18 yr, scoliosis 320°, sagittal vertical axis (SVA) 35 cm, pelvic tilt 325° and/or thoracic kyphosis (TK) > 60°) with baseline and up to 3 years of radiographs were included. Patients with no BL CD were postoperatively stratified by Ames CD criteria (T1 slope minus cervical lordosis [TS-CL] > 20°, cSVA > 40 mm) if they fulfilled more than 1 criterion. Severe CD was defined as TS-CL greater than 30° or cSVA greater than 60 mm. Follow-up intervals for post-ASD surgery were as follows: 6 weeks after surgery (early), 6 weeks to 1 year after surgery (intermediate), 1–2 years after surgery (late) and 2–3 years after surgery (long). Descriptive and McNemar tests identified CD conversion rate, PJK rate (< –10° change upper instrumented vertebra [UIV] and UIV+2) and specific alignment parameters. **Results:** A total of 266 surgical ASD patients (59.7 yr, 77.4% female) with complete 3-year radiographic data were included (CD early: 38 patients; intermediate: 26 patients; late: 29 patients, long: 10 patients). At conversion, patients in the early group had the highest mean TS-CL and cSVA (25.4° ± 8.5°; 33.6 mm). Patients in the long group had the highest mean C2-T3 angle, C2-T3 SVA and PJK rate. TS-CL and cSVA conversion (> 20°; > 40 mm) were the most common types of CD. Patients in the early group had the highest rate of conversion to severe CD: 9 patients had severe TS-CL. Seven patients progressed from having only malaligned TS-CL at BL (with normal cSVA) to CD with both malaligned TS-CL and cSVA by 6 weeks, and 26 patients progressed by 1 year. Conversely, 2 patients progressed from malaligned cSVA to both malaligned cSVA and TS-CL, while 20 patients progressed by 1 year. Greater thoracic kyphosis at baseline predicted later conversion, while higher pelvic incidence – lumbar lordosis, lower TK and higher TK apex immediately after surgery were significant predictors of earlier conversion compared with later (all $p < 0.05$). **Conclusion:** While the highest number of patients converted within 6 weeks after surgery, patients who converted in the late or long follow-up intervals trended toward higher rates of concurrent PJK and greater radiographic progression.

Presentation B15
Abstract 44

Prioritization of realignment associated with superior clinical outcomes for surgical cervical deformity patients. ***Katherine Pierce, Peter Passias, Renaud Lafage, Alex Soroceanu, Aaron Hockley, Breton Line, Eric Klineberg, Shay Bess, Themistocles Protopsaltis, Christopher Shaffrey, Frank Schwab, Justin Scheer, Justin Smith, Virginie Lafage, Christopher Ames, ISSG International Spine Study Group*. From NYU Langone Health, New York, N.Y. (Pierce, Passias, Protopsaltis); the Hospital for Special Surgery, New York, N.Y., (R. Lafage, Schwab, V. Lafage); the University of Calgary, Calgary, Alta. (Soroceanu, Hockley); the Denver International Spine Clinic, Denver, Colo. (Line, ISSG International Spine Study Group); University of California, Davis, Calif. (Klineberg); the University of Virginia Medical Center, Charlottesville, Va. (Shaffrey, Smith); and the University of California, San Francisco, Calif. (Scheer, Ames).**

Background: The objective of this study was to prioritize the cervical parameter targets for alignment. **Methods:** The study included cervical deformity (CD) patients with full baseline (BL) and 1-year parameters and health-related quality of life (HRQL) scores (Neck Disability Index; NDI) and patients with cervical or cervicothoracic primary driver Ames type. Excluded were patients with both low CD cSVA (< 4 cm) and T1 slope minus cervical lordosis (TS-CL) (< 15°). We assessed whether patients met the minimal clinically important difference (MCID) for NDI of greater than 15 points. Ratios of correction found for regional parameters (cSVA, CL, T1 slope, TS-CL, chin-brow vertical angle [CBVA], McGregor slope [MGS], C2–T3 sagittal vertical axis [SVA], C2–T3 angle, C2 slope) were categorized by primary Ames driver (cervical [C] or cervicothoracic [CT]). Decision tree analysis assessed cut-offs for differences associated with meeting NDI MCID at 1 year. **Results:** Seventy-seven CD patients were included (62.1 yr, 64% female, 28.8 kg/m^2); 41.6% met the MCID for NDI. A backward linear regression model including radiographic differences as predictors from BL-1-year for meeting MCID for NDI demonstrated an R^2 of 0.820 (p = 0.032) and included TS-CL, cSVA, MGS, C2SS, C2–T3 angle, C2–T3 SVA and CL. By primary Ames driver, 67.5% were categorized as C and 32.5% as CT. Ratios of change in predictors for MCID NDI patients (BL at 1 year) for C driver patients were as follows: 260.8% MGS, 140.3% CL, 121.2% C2–T3 angle, 49.6% C2 slope, 41.1% cSVA, 20.5% TS-CL and 3.1% C2–T3 SVA. Correction in CT driver patients included the following: 168.7% CL, 93% MGS, 70.8% C2–T3 angle, 31.1% cSVA, 27.5% C2 slope, 24.9% TS–CL and 13.7% C2–T3 SVA. The ratios were not significantly different between the 2 groups (p > 0.050). Decision tree analysis determined cut-offs for radiographic change, prioritizing in the following order (based on ordinal regression): a correction less than or equal to 42.5° C2–T3 angle (odds ratio [OR] 5.667, 95% confidence interval [CI] 1.074–29.891, p = 0.041), less than 35.4° CL (OR 4.636, 95% CI 0.857–25.071, p = 0.075), greater than –31.76° C2 slope (OR 3.2, 95% CI 0.852–12.026, p = 0.085), greater than –11.57 mm cSVA (OR 3.185, 95% CI 1.137–8.917, p = 0.027), greater than –2.16° MGS (OR 2.724, 95% CI 0.971–7.636, p = 0.057). **Conclusion:** Certain ratios of correction of cervical parameters contribute to improving neck disability. Specific cut-offs of radiographic differences from baseline to 1 year were found prioritizing C2–T3 angle, CL, C2 slope, cSVA and MGS, all strongly associated with meeting the MCID for NDI. Prioritizing these radiographic parameters will optimize patient-reported outcomes for patients undergoing CD surgery.

Presentation B16
Abstract 50

Outcome of multilevel spinal deformity surgery in patients over 60 years of age: a multicentre international prospective study. ***Stephen Lewis, Lawrence Lenke, Christopher Shaffrey, Kenneth Cheung, Sigurd Berven, Yong Qiu, Yukihiro Matsuyama, Ferran Pellisé-Urquiza, David Polly, Jr., Jonathan Sembrano, Benny Dahl, Michael Kelly, Marinus de Kleuver, Maarten Spruit, Ahmet Alanay*. From the Department of Surgery and Spine Program, University of Toronto, Toronto, Ont. (Lewis); the Department of Orthopedic Surgery, Spine Hospital, New York, N.Y. (Lenke); the Department of Orthopaedic Surgery, Duke University, Durham, N.C. (Shaffrey); the Department of Orthopaedics and Traumatology, University of Hong Kong, Hong Kong, China (Cheung); the Department of Neurosurgery and Orthopaedic Surgery, University of California, San Francisco, Calif. (Berven); Spine Surgery, the Drum Tower Hospital of Nanjing University Medical School, Nanjing, China (Qiu); the Department of Orthopedic Surgery, Hamamatsu University School of Medicine, Hamamatsu, Japan (Matsuyama); the Hospital Universitari de la Vall d'Hebron, Barcelona, Spain (Pellisé-Urquiza); the Department of Orthopaedic Surgery, University of Minnesota, Minneapolis, Minn. (Polly, Sembrano); the Division of Orthopedic Surgery, Texas Children's Hospital, Houston, Tex. (Dahl); the National University of Denmark, Copenhagen, Denmark (Dahl); the Department of Orthopaedic Surgery, Washington University School of Medicine, St. Louis, Mo. (Kelly); the Department of Orthopedics, Radboud University Medical Center, Nijmegen, the Netherlands (De Kleuver); the Sint Maartenskliniek, Nijmegen, Gelderland, the Netherlands (Spruit); and the Department of Orthopedics and Traumatology, Acibadem University, Istanbul, Turkey (Alanay).**

Background: The objective of this study was to determine the outcome of multilevel spinal fusions on patients greater than 60 years of age. **Methods:** In this multicentre international prospective study, data for patients over 60 years of age undergoing primary fusions of 5 or more levels for spinal deformity were reviewed. The decision to operate and the choice of procedure were at the discretion of the treating surgeon. A central organization oversaw the study to ensure each centre complied with the study protocols and collected the data at the appropriate time intervals. Multiple outcome measures were used and collected at 10 weeks (± 6 weeks), 1 year (± 2 months) and 2 years (± 2 months) follow-up. Mixed effect models were applied to evaluate the outcome scores over time. **Results:**

Two hundred and nineteen of the 255 patients enrolled from 12 centres met the criteria for inclusion in the study. There were 176 women and 43 men with a mean age of 67.5 (range 60–83) years. A total of 210 patients completed the 10-week, 188 completed the 1-year, and 179 completed the 2-year follow-up visits. Significant improvements were seen in the Scoliosis Research Society (SRS-22r) patient questionnaire total score and the subdomains of function, pain, self-image and satisfaction, EQ-5D, Oswestry Disability Index, and numeric rating back and leg scales at 1- and 2-year follow-ups. Some improvement was seen at 10-week follow-up with maximal improvement at 1 year that was maintained at 2-year follow-up. No difference in outcome scores was noted between age groups when comparing patients between the ages of 60–64, 65–69, 70–74 years and those older than 75 years of age. **Conclusion:** Despite the magnitude of the procedures, significant improvements in patient-reported outcomes were observed in 4 different outcome measures at 1- and 2-year follow-up. Carefully selected healthy patients older than 60 years of age can benefit from multilevel spinal deformity surgery.

Presentation B17
Abstract 122

A simpler, modified frailty index weighted by complication occurrence correlates to pain and disability for adult spinal deformity patients. ***Peter Passias, Cole Bortz, Katherine Pierce, Haddy Alas, Avery Brown, Alex Soroceanu, Aaron Hockley, Shaleen Vira, Waleed Ahmad, Sara Naessig, Bassel Diebo, Tina Raman, Themistocles Protopsaltis, Aaron Buckland, Michael Gerling, Renaud Lafage, Virginie Lafage*****. From NYU Langone Health, New York, N.Y. (Passias, Bortz, Pierce, Alas, Brown, Ahmad, Naessig, Raman, Protopsaltis, Buckland, Gerling); the University of Calgary, Calgary, Alta. (Soroceanu, Hockley); the UT Southwestern Medical Center, Dallas, Tex. (Vira); SUNY Downstate, New York, N.Y. (Diebo); and the Hospital of Special Surgery, New York, N.Y. (R. Lafage, V. Lafage).**

Background: The objective of this study was to develop a simplified, weighted frailty index for patients with adult spinal deformity (ASD). **Methods:** Component ASD-FI parameters contributing to overall ASD frailty index (ASD-FI) score were assessed via Pearson correlation. Clinically relevant factors were regressed against ASD-FI score to generate the modified ASD-FI (mASD-FI). Component mASD-FI factors were regressed against incidence of medical complications and factor weights were calculated from regression these coefficients via the Beta/Sullivan method. Total mASD-FI score ranged from 0 to 21 and was calculated by summing the weights of expressed parameters. Linear regression and published ASD-FI cutoffs generated corresponding mASD-FI frailty cutoffs: not frail (NF, < 7), frail (7–12), severely frail (SF, > 12). **Results:** Fifty ASD patients were included (52 ± 20 yr). All of the following preoperative factors correlated with ASD-FI score (all $p < 0.039$), and, combined, accounted for 85.0% ($p < 0.001$) of the variation in ASD-FI score: body mass index less than 18.5 kg/m^2 or greater than 30 kg/m^2 (weight: 5), depression (weight: 5), difficulty climbing stairs (3), presence of more than 3 medical comorbidities (2), leg weakness (2), difficulty getting dressed (1), bladder incontinence (1) and patient-reported deterioration in health within the past year (1). These factors were used to calculate the overall population's mean mASD-FI score (5.7 ± 5.2). Combined, these factors comprising the mASD-FI showed a trend of predicting the incidence of medical complications (Nagelkerke $R^2 = 0.558$, Cox and Snell $R^2 = 0.399$, $p = 0.065$). Overall patient breakdown by mASD-FI frailty category was not frail (70%), frail (12%) and severely frail (18%). Increasing frailty category was associated with significant impairments in validated measures of disability, including Oswestry Disability Index score (not frail: 23.4, frail: 45.0, severely frail: 49.3, $p < 0.001$), Scoliosis Research Society-22R instrument score (not frail: 3.5, frail: 2.6, severely frail: 2.4, $p = 0.001$), Pain Catastrophizing Scale score (not frail: 41.9, frail: 32.4, severely frail: 27.6, $p < 0.001$) and Numerical Rating Scale Leg Pain (not frail: 2.3, frail: 7.2, severely frail: 5.6, $p = 0.001$). **Conclusion:** This study modifies an existing ASD frailty index and proposes a weighted, shorter mASD-FI. As increasing mASD-FI score is associated with inferior clinical measures of pain and disability, the mASD-FI may serve as a valuable tool for preoperative risk assessment.

Presentation B18
Abstract 75

Change in Oswestry Disability Index at 24 months following multilevel spinal deformity surgery in patients over 60 years of age: a multicentre international prospective study. ***Christopher Nielsen, Stephen Lewis, Lawrence Lenke, Christopher Shaffrey, Kenneth Cheung, Sigurd Berven, Yong Qiu, Yukihiro Matsuyama, Ferran Pellisé-Urquiza, David Polly, Jr., Jonathan Sembrano, Benny Dahl, Michael Kelly, Marinus de Kleuver, Maarten Spruit, Ahmet Alanay*****. From the Faculty of Medicine, University of Toronto, Toronto, Ont. (Nielsen); the Department of Surgery and Spine Program, University of Toronto, Toronto, Ont. (Lewis); the University Health Network, Toronto, Ont. (Lewis); the Department of Orthopedic Spine Surgery, Spine Hospital, Columbia University Medical Center, New York, N.Y. (Lenke); the Department of Orthopaedic Surgery, Duke University, Durham, N.C. (Shaffrey); the Department of Orthopaedics and Traumatology, University of Hong Kong, Hong Kong, China (Cheung); the Department of Neurosurgery and Orthopaedic Surgery, University of California, San Francisco, Calif. (Berven); the Department of Spine Surgery, Drum Tower Hospital of Nanjing University Medical School, Nanjing, China (Qiu); the Department of Orthopedic Surgery, Hamamatsu University School of Medicine, Hamamatsu, Japan (Matsuyama); the Hospital Universitari de la Vall d'Hebron, Barcelona, Spain (Pellisé-Urquiza); the Department of Orthopaedic Surgery, University of Minnesota, Minneapolis, Minn. (Polly, Sembrano); the Division of Orthopedic Surgery, Texas Children's Hospital, Houston, Tex. (Dahl); the National University of Denmark, Copenhagen, Denmark, (Dahl); the Department of Orthopaedic Surgery, Washington University School of Medicine, St. Louis, Mo. (Kelly); the Department of Orthopedics, Radboud University Medical Center, Nijmegen, the Netherlands (De Kleuver); the Sint Maartenskliniek, Nijmegen, the Netherlands (Spruit); and the Department of Orthopedics, Acibadem University, Istanbul, Turkey (Alanau).**

Background: The objective of this study was to determine the outcome as measured by the Oswestry Disability Index (ODI) of elderly patients (> 60 yr of age) undergoing multilevel spinal surgery. **Methods:** This was a prospective multicentre international study in which data for patients over 60 years of age undergoing primary fusions of 5 or more levels were reviewed. The decision to operate and the choice of procedure were at the discretion of the treating surgeon. The ODI score was measured preoperatively and at 24 months. Patients were divided into quintiles on the basis of their preoperative ODI score (i.e., score 0–20, 21–40, 41–60, 61–80, 81–100). **Results:** A total of 219 of the 255 patients enrolled from 12 centres met the criteria for inclusion in the study. There were 176 women and 43 men with a mean age of 67.5 (range 60–83) years. The mean number of levels fused was 10.4 (range 5–24). When we stratified and compared preoperative and 24-month follow-up ODI scores into quintiles, 64.1% patients had improvement in their ODI score. A total of 30.1% of patients remained in their original quintile ODI score at 24 months, while 5.8% of patients reported worsening of their ODI score. Preoperatively, 58.3% patients had ODI scores greater than 40% compared with only 21.1% at 24 months. Preoperatively, 6.4% patients had ODI scores between 0% and 20%, and 35.3% had scores between 21% and 40%. At 24 months, 41.0% had ODI scores between 0% and 20%, and 37.8% scored between 21% and 40%. Similarly, 44.2% had preoperative ODI scores of 41%–60%, and 14.1% had ODI of 61%–80%; in comparison, at 24 months this was significantly decreased to 17.9% patients with ODI scores of 41%–60% and only 3.2% with ODI scores between 61% and 80%. **Conclusion:** Despite undergoing multilevel spinal deformity surgeries, in this prospective international multicentre study, only 6% of patients showed worsening of their ODI scores, while 64.1% of patients improved their ODI scores at 24-month follow-up. Two-thirds of carefully selected healthy patients older than 60 years of age can expect to see improvement in ODI score after multilevel spinal deformity surgery.

Presentation C19
Abstract 19

A prospective cohort study evaluating trends in the surgical treatment of degenerative spondylolisthesis in Canada and the utility of a novel surgical decision aid. ***Andrew Glennie*, *Chris Bailey*, *Raj Rampersaud*, *Charles Fisher*. From Dalhousie University, Halifax, N.S. (Glennie); Western University, London, Ont. (Bailey); the University of Toronto, Toronto, Ont.(Rampersaud); and the University of British Columbia, Vancouver, B.C. (Fisher).**

Background: A standardized clinical assessment and management plan (SCAMP) was created as a decision aid for surgeons based on the radiographic stability and clinical presentation of patients. The purpose of this study was to compare outcomes of patients who followed the decision aid with respect to fusion/no fusion with outcomes of those who did not. **Methods:** Patients were prospectively enrolled from 11 different Canadian institutions and followed from 2015 to 2019. A degenerative spondylolisthesis instability classification system (DSIC) was created using the best available evidence stratifying patients into 3 different subtypes (type 1, stable degenerative spondylolisthesis; type 2, potentially unstable spondylolisthesis; and type 3, unstable spondylolisthesis). One-year changes in health-related quality of life, length of hospital stay (LOS), medication use and surgical time were compared among the groups and in the context of whether the treatment fell within the decision aid recommendation (simple decompression [type 1], posterolateral fusion [type 2] or interbody fusion [type3]). **Results:** There were 394 patients initially enrolled and 334 (84.8%) with full 1-year data available for comparison. There were 95 type 1, 224 type 2 and 75 type 3 patients initially classified. Baseline Oswestry Disability Index (ODI), EQ-5D, and SF-12 mental component summary (MCS) scores were significantly worse for type 3 patients than for type 1 patients. One hundred and eight patients were treated within the recommendations of the DSIC system (108/334, 32.3%). Surgeons performed interbody fusions in 141 patients (42%) rather than following DSIC recommending a less invasive approach. There were no significant differences in EQ-5D, SF-12 PCS/MCS, PHQ-9 or ODI scores at 1 year between patient groups. There was a trend toward shorter operating times for patients following the DSIC system (195 min for nonfollowers v. 180 min for followers, p = 0.078) and reduced hospital stay (4.46 d for nonfollowers v. 3.98 d for followers, p = 0.065). **Conclusion:** There were no differences in clinical outcome at 1 year. Surgeons were more likely to perform rigid surgical constructs with stable spondylolisthesis leading to less judicious/responsible uses of hospital resources.

Presentation C20
Abstract 154

Decompression compared with decompression and fusion for degenerative lumbar spondylolisthesis: a Canadian Spine Outcomes and Research Network (CSORN) study. ***Eric Crawford*, *Tan Chen*, *Greg McIntosh*, *Raja Rampersaud*. From the Division of Orthopaedic Surgery, University of Toronto, Toronto, Ont. (Crawford, Chen); the Canadian Spine Outcomes and Research Network, Markdale, Ont. (McIntosh); and the Division of Orthopaedic and Neurosurgery, Toronto Western Hospital, Toronto, Ont. (Rampersaud).**

Background: Controversy remains regarding the optimal surgical procedure (decompression alone or decompression and instrumented fusion) for patients with degenerative lumbar spondylolisthesis (DLS). The objective of this study is to compare patient characteristics and outcomes for patients with DLS undergoing decompression versus decompression and fusion procedures across the national setting. **Methods:** We conducted a multicentre review of prospectively collected data for consecutive patients with DLS enrolled by the Canadian Spine Outcomes and Research Network (CSORN) from 2015 to 2018, who underwent 1- or 2-level decompression alone or decompression and fusion procedures. Baseline patient demographic, pain and disability measures were compared between the 2 groups. Patient-reported outcomes measures (PROMs) were compared at 3 months and 1 year postoperatively. A logistic regression was used to adjust for baseline differences. **Results:** A total of 799 patients with DLS met inclusion criteria, with 234 patients (29.3%) undergoing decompression alone and 565 (70.7%) undergoing decompression and fusion. For patients undergoing fusion procedures, 75.9% (429/565) had interbody fusions. Patients undergoing fusion procedures were younger

(mean age 64.9 v. 68.4 yr; $p < 0.001$) had increased back pain (mean numerical rating scale: 7.0 v. 6.5; $p = 0.022$), but no difference in leg pain, and were more likely to report symptoms for more than 2 years (75.8% v. 64.3%; $p = 0.001$), preoperatively. Additionally, patients undergoing fusion procedures had increased disability (mean Oswestry Disability Index [ODI] scores 42.25 v. 41.65; $p = 0.002$), decreased physical function (mean SF-12 physical component score 32.35 v. 34.67; $p = 0.001$) and health-related quality of life (mean EQ-5D 0.52 v. 0.56; $p < 0.036$) at baseline. After adjusting for baseline differences, patients undergoing decompression procedures reported less disability at 3 months postoperatively (mean change in ODI score –18.3 v. –15.8; $p = 0.020$). At 1 year after surgery, there were no differences in patient-reported outcomes. **Conclusion:** Our findings suggest that patients undergoing fusion procedures for DLS have a more advanced disease state at baseline, with slightly greater pain and disability. Additionally, patients undergoing decompression-alone procedures may report improved short-term functional outcomes. Future research should include a cost-utility analysis of these surgical techniques.

Presentation C21
Abstract ID 77
Lumbar degenerative spondylolisthesis: factors impacting decision to fuse. ***Nicole Schneider, Mohammed Karim, Jennifer Urquhart, Charles Fisher, John Street, Marcel Dvorak, Scott Paquette, Raphaele Charest-Morin, Tamir Ailon, Andrew Glennie, Neil Manson, Raja Rampersaud, Ken Thomas, Parham Rasoulinejad, Chris Bailey.*** **From Western University, London, Ont. (Schneider, Rasoulinejad, Bailey); the University of British Columbia, Vancouver, B.C. (Karim, Fisher, Street, Dvorak, Paquette, Charest-Morin, Ailon); the Lawson Health Research Institute, London, Ont. (Urquhart); Dalhousie University, Halifax, N.S. (Glennie); the Canada East Spine Centre, Saint John, N.B. (Manson); the University of Toronto, Toronto, Ont. (Rampersaud); and the University of Calgary, Calgary, Alta. (Thomas).**

Background: The aim of this study is to assess which factors influence the decision of a Canadian spine surgeon to perform a fusion for lumbar degenerative spondylolisthesis (LDS). **Methods:** This study used data for 241 consecutive patients prospectively enrolled in a multicentre study designed to evaluate the assessment and management of LDS. Inclusion criteria were radiographic evidence of LDS and neurogenic claudication or radicular pain, undergoing posterior decompression or decompression and fusion between 2015 and 2018. Patient demographics, patient-rated outcome measures and imaging parameters were recorded in the Canadian Spine Outcomes and Research Network (CSORN) database. Surgeon factors were retrieved by survey. Multivariate backward logistic regression was used to identify the factors associated with the decision to perform a fusion. **Results:** Patients who had a fusion were younger (65.3 ± 8.3 yr v. 68.6 ± 9.7 yr), had worse Oswestry Disability Index (ODI) scores (45.9 ± 14.7 v. 40.2 ± 13.5), had a smaller average disc height (6.1 ± 2.7 mm v. 8.0 ± 7.3 mm), had grade II spondylolisthesis (31% v. 14%) and had a nonlordotic disc angle (26% v. 17%). The rate of fusion varied by individual surgeon and academic centre ($p < 0.001$). Surgeons who were fellowship trained in Canada more frequently fused than those who did their fellowship training outside of Canada (76% v. 57%). Surgeons on salary fused more frequently than surgeons remunerated by fee-for-service (80% v. 64%). Multivariate analysis revealed that for each 5-year decrease in age, 1-mm decrease in disc height and 10-point increase in ODI the odds of fusion increased by 20%, 8% and 23%, respectively. Grade II spondylolisthesis, nonlordotic disc angle, fellowship training in Canada and salaried remuneration had 3.2, 2.0, 2.1 and 2.9 times the odds of having a fusion. **Conclusion:** The decision to perform a fusion for LDS is multifactorial. Although patient and radiographic parameters are important in the decision-making process, multiple surgeon factors appear to influence the decision to perform a fusion for LDS. This demonstrates the need for further implementation of evidence-based decision-making.

Presentation C22
Abstract 27
Patient-reported outcomes following surgery for lumbar disc herniation: comparison of a universal and multitier health care system. ***Oliver Ayling, Tamir Ailon, Charles Fisher.*** **From the University of British Columbia, Vancouver, B.C.**

Background: Canada has a government-funded universal health care system, and access to spinal surgeons requires a referral. In contrast, the United States utilizes a combined public and private payer system where patients may directly access specialists. The purpose of this study is to investigate whether there are differences in clinical outcomes between patients surgically treated for lumbar disc herniation in Canada as compared with the United States. **Methods:** Surgical lumbar disc herniation patients enrolled in the Canadian Spine Outcomes and Research Network prospective multicentre registry were compared with the surgical cohort enrolled in the Spine Patient Outcomes Research Trial (SPORT) study. Patient-reported outcomes were compared at 3 months and 1 year postoperatively. **Results:** The CSORN cohort consisted of 443 patients and the SPORT cohort was made up of 573 patients. The rate of females in each cohort was similar (47.2% v. 46.4%, $p = 0.78$). Patients in the CSORN cohort were older (46.2 ± 13.2 yr v. 41.6 ± 10.9 yr, $p < 0.001$), had a higher rate of smoking (32.0% v. 22.8%, $p < 0.001$) and were more likely to be employed (66.9% v. 61.3%, $p = 0.034$). The CSORN cohort had a slightly lower Owestry Disability Index score at baseline (50.5 ± 15.1 v. 55.7± 19.6, $p < 0.01$) but had a higher proportion of patients with a symptom duration greater than 6 months (44.5% v. 21.1%, $p < 0.0001$). The CSORN cohort demonstrated significantly greater rates of satisfaction after surgery at 3 months (74.8% v. 65.3%, $p = 0.003$) and 1 year (81.4% v. 68.7%, $p < 0.001$). Improvements in back and leg pain followed similar trajectories between the 2 cohorts. Membership in the CSORN cohort was a significant independent predictor of patient satisfaction at 1 year on multivariable logistic regression (odds ratio 1.3, 95% confidence interval 1.29–1.49, $p < 0.001$). **Conclusion:** Patients undergoing surgical treatment for lumbar disc herniation in Canada (CSORN) reported higher rates of satisfaction at 3 months and 1 year postoperatively than the United States cohort (SPORT) despite having longer durations of symptoms.

Presentation C23
Abstract 151
Do patients with recurrent lumbar disc herniations fair worse with discectomy than primary operations? A retrospective analysis from the Canadian Spine Outcomes and Research Network. ***Sean Christie*, *Ryan Greene*, *Andrew Glennie*. From Dalhousie University, Halifax, N.S.**

Background: The objective of this study was to determine if functional, self-reported outcomes differ between patients undergoing primary lumbar disc surgery and those undergoing revision discectomy for radiculopathy. **Methods:** We retrospectively analyzed data from a national database (Canadian Spine Outcomes and Research Network). Revision surgeries involving fusions were excluded. Cohorts were examined to investigate the differences between those who underwent surgery for the first time and those having a revision discectomy. Variables included demographics (age, body mass index [BMI], smoking and sex) and outcome questionnaires (EQ-5D, numerical rating scale back/leg, Oswestry Disability Index [ODI], health scale and SF-12). These questionnaires were administered at baseline, 3 months and 1 year after surgery. Categorical data were analyzed with χ^2 tests, whereas continuous variables were compared with one-way analysis of variance or the Mann–Whitney *U* test. Significance was taken at p less than or equal to 0.05. **Results:** There were 935 patients included in this analysis: 888 were first operations and 47 were revisions. There were 517 men and 418 women, with there being no statistical difference between men and women having had previous surgery (p = 0.131). There were also no significant differences regarding age (p = 0.378), smoking (p = 0.149) or BMI (p = 0.443). For patient-reported outcome measures, the 1-year ODI score differed between primary and revision surgery. Those who had not undergone previous surgery had an average ODI score of 20.65, and those who had had prior surgery had an average ODI score of 29 (p = 0.036). The mean absolute change in ODI score was 28.13 for first-time surgery and 19.14 for revision surgery (p = 0.043). The EQ-5D at 1 year was also significantly different, with an index of 0.80 for those who had not undergone previous surgery, and an index of 0.71 for those who had (p = 0.02). **Conclusion:** Demographic characteristics were not different between those who had had previous surgery and those who had not. However, functional outcomes were inferior in patients undergoing revision lumbar disc surgery at 1 year after surgery.

Presentation C24
Abstract 136
A province-wide assessment of the appropriateness of lumbar spine MRI. ***Ryan Greene*, *Dakota Duquette*, *Dylan LeBlanc*, *Brian Martell*, *Matthias Schmidt*, *Sean Christie*. From Dalhousie University, Halifax, N.S.**

Background: The objective of this study was to determine the province-wide appropriateness of ordering lumbar spine magnetic resonance imaging (MRI), on the basis of geographic and demographic differences, as well as physician specialty. **Methods:** An algorithm was developed on the basis of Choosing Wisely Canada and best practice guidelines to determine the appropriateness of ordering lumbar spine MRIs. Using the provincial picture archiving and communications system (PACS), 2 reviewers retrospectively examined the requisitions for all patients who underwent a lumbar spine MRI between Jan. 1, 2018, and Dec. 31, 2018. χ^2 test was used to determine the impact of all outcome variables on the appropriateness of ordering a lumbar spine MRI. **Results:** Family doctors accounted for (66%) of all MRIs ordered. Just over half (54.6%) of requisitions reviewed were deemed appropriate. Age was a significant factor when determining if ordering the MRI was appropriate or not (p < 0.001), whereas sex was not a significant factor (p = 0.498). Neither physician specialty nor location of imaging were predictive of appropriateness (p = 0.125 and 0.224, respectively). **Conclusion:** Almost half of all lumbar spine MRIs ordered throughout the province were considered inappropriate. Age was significantly different when it came to determining appropriateness, with older individuals having a higher proportion of appropriately ordered MRIs than their younger counterparts. Appropriateness was not influenced by physician specialty or by hospital location. There was no observed difference in appropriateness of MRI requisitions before or after the publication of the Choosing Wisely statements. This study illustrates the opportunity for further education to improve resource utilization.

Presentation D25
Abstract 32
Surgical site infection reduction — a 10-year quality improvement journey. ***Supriya Singh*, *Dan Banaszek Titus Wong*, *Christian Di Paola*, *Tamir Ailon*, *Raphaele Charest-Morin*, *Nicolas Dea*, *Dr Marcel Dvorak*, *Charles Fisher*, *Brian Kwon*, *Scott Paquette*, *John Street*. From the Vancouver Spine Surgery Institute, Vancouver, B.C. (Singh, Banaszek, Ailon, Charest-Morin, Dea, Dvorak, Fisher, Kwon, Paquette, Street); and the University of British Columbia, Vancouver, B.C. (Singh, Banaszek, Wong, Di Paola, Ailon, Charest-Morin, Dea, Dvorak, Fisher, Kwon, Paquette, Street).**

Background: In 2007, the spine surgical site infection (sSSI) rate at our Canadian quaternary referral centre was 8.1%. As a result, a multidisciplinary team was created to identify and initiate quality improvement (QI) strategies to reduce this unacceptably high sSSI rate. This abstract outlines the institutional and divisional QI strategies that have been central to our ongoing efforts to reduce the incidence of sSSI. **Methods:** A framework for evaluating surgical safety, based on that proposed by Mirza, was adopted to identify risk factors for sSSI at our institution. Surgical (midline lumbar approach, odds ratio [OR] 4.2), microbiological (urinary tract infection, OR 5.8), patient (diabetes mellitus OR 4.2) and process (ICU OR 1.75) factors were explored. A predictive model for sSSI was developed with an area under the receiver operative characteristic curve of 0.88. Numerous QI initiatives were introduced and their effect on sSSI was monitored by the institutional infection prevention and control group. **Results:** From 2008, the Wiltse approach was used, in favour of midline, for 1- and 2-level decompression and fusion of the lumbar spine. The total sSSI rate fell from 8.1% to 7.2%. Routine use of intraoperative navigation from 2009 did not adversely effect the sSSI rate. From 2011 to 2014, photodynamic nasal decolonization and chlorhexidine skin

decontamination (PDT/CHG) were applied to all elective and emergency spine cases, with the sSSI rate falling from 7.2% to 2%. With routine use of intrawound vancomycin powder in posterior instrumented cases from 2016, total sSSI rates further decreased from 2% to 1.6%. With the routine use of silver-coated indwelling urinary catheters in patients with acute traumatic spinal cord injuries, sSSI rates were reduced to 0.8% by early 2019 and have remained below 1% since. **Conclusion:** We present our experience in addressing sSSI through risk identification and prophylactic QI initiatives. We highlight the importance of a multidisciplinary team approach, the value of a safety framework model and the importance of continued use of the plan-do-study-act cycle model.

Presentation D26
Abstract 34
The impact of frailty on patient-reported outcome measures following elective thoraco-lumbar spine surgery. ***Philippe Beauchamp-Chalifour, John Street, Alana Flexman, Raphaele Charest-Morin*. From Laval University, Quebec, Que. (Beauchamp-Chalifour); and the University of British Columbia, Vancouver, B.C. (Street, Flexman, Charest-Morin).**

Background: Frailty has been shown to be a risk predictor for perioperative adverse events (AEs) in patients undergoing various types of spine surgery. However, its relationship with patient-reported outcome measures (PROMs) remains unknown. The primary objective of this study was to determine the impact of frailty on PROMs in patients undergoing surgery for thoraco-lumbar degenerative conditions. The secondary objective was to determine the association between frailty and baseline PROMs. **Methods:** This is a retrospective study of a prospective cohort of patients older than 55 years of age who underwent surgery between 2012 and 2018. Patient data and PROMs (EQ-5D, SF-12, Oswestry Disability Index [ODI], back and leg pain numerical rating scale [NRS]) were extracted from the Canadian Spine Outcomes and Research Network registry for a single academic centre. Frailty was retrospectively calculated using the modified frailty index (mFI) and patient were classified as frail, prefrail and nonfrail. Patient characteristics and outcomes were analyzed using analysis of variance or the Kruskal–Wallis test for continuous variables and χ^2 or Fisher's exact test for proportions. A generalized estimating equations (GEEs) regression model was used to assess the association between patients' baseline frailty status and PROM measures at 3 and 12 months. **Results:** A total of 293 patients were included (mean age of 67 ± 7 yr). Twenty-two percent of the patients (n = 65) were frail, 59% (n = 172) were prefrail and 19% (n = 56) were nonfrail. At baseline, the 3 groups had similar PROMs, except for the physical component score of the SF-12, which was worse in the frail group (mean difference, –4.9, 95% confidence interval –8.6 to –1.1, p = 0.0083). The improvement in the EQ-5D score, physical and mental component scores of the SF-12, ODI score and back and leg pain NRS scores was not significantly different between the 3 groups ($p > 0.05$). There was no difference in the evolution of the PROMs at 3 and 12 months between the 3 groups ($p > 0.05$). **Conclusion:** Although frailty is a known predictor of adverse events, it does not predict worse PROMs after spine surgery in that population.

Presentation D27
Abstract 8
Moving toward better health: exercise practice is associated with improved outcomes after spine surgery. ***Phumeena Balasuberamaniam, Abeer Wasim, Carolyn Schwartz, Roland Stark, Mopina Shrikumar, Joel Finkelstein*. From the Division of Orthopedic Surgery, Sunnybrook Health Sciences Centre, Toronto, Ont. (Balasuberamaniam, Wasim, Shrikumar, Finkelstein); the DeltaQuest Foundation, Inc., Concord, Mass. (Schwartz, Stark); and the Departments of Medicine and Orthopaedic Surgery, Tufts University School of Medicine, Boston, Mass. (Schwartz).**

Background: Degenerative lumbar conditions are more common as one ages. When conservative treatment is ineffective, spine surgery is commonly performed. Recovery and rehabilitation following surgery can take many months, and understanding what patients can do to facilitate recovery is beneficial. The present work examines the role of exercise in recovery trajectories after elective spine surgery. **Methods:** This prospective longitudinal cohort study included adult patients who were diagnosed with a lumbar degenerative spinal condition and underwent spinal decompression and/or fusion surgery. Participants completed the following patient-reported outcome (PRO) measures: Rand-36 (to generate physical and mental component scores; PCS and MCS); Oswestry Disability Index (ODI); Numeric Rating Scale for pain (NRS); and the PROMIS Pain Interference (PROMIS) short-form. Exercise practice was determined on the basis of patient response to questions at baseline and over the course of follow-up about the frequency of muscle-strength exercises, nonstop aerobic activity, and yoga or Pilates. Random effects models investigated the relationship of exercise, follow-up time, and their interaction in predicting each PRO over time, with and without sociodemographic covariates. **Results:** The study sample included 168 people (mean age 61 yr, 50% female) with data before surgery and up to 12 months after surgery. Analysis revealed modest, statistically significant main effects of exercise on the PCS, MCS, ODI and PROMIS Pain Interference and main effects of time on all outcomes. The exercise-by-time interaction was significant in predicting the ODI and MCS trajectories. When full models were adjusted for education and employment status, interaction effects were no longer significant but exercise main effects remained significant for the ODI. **Conclusion:** Patients who engage in exercise before and after spine surgery have slightly better recovery trajectories than those who do not. Exercise maintained long-term was associated with slightly better spine-specific disability scores, even after covariate adjustment. These findings support encouraging patients to exercise within their preoperative limitations and as soon as they are able after surgery, and maintain exercise long-term.

Presentation D28
Abstract 33
Preoperative decolonization does not adversely affect the microbiologic spectrum of spine surgical site infection. ***Supriya Singh, Alexandra Gara, Dan Banaszek, Titus Wong, Tamir Ailon, Elizabeth Bryce, Raphaele Charest-Morin, Nicolas Dea, Marcel Dvorak, Charles Fisher, Brian Kwon, Scott Paquette, John Street*. From the Vancouver Spine**

Surgery Institute, Vancouver, B.C. (Singh, Banaszek, Ailon, Charest-Morin, Dea, Dvorak, Fisher, Kwon, Paquette, Street); the University of British Columbia, Vancouver, B.C. (Singh, Banaszek, Wong, Ailon, Charest-Morin, Dea, Dvorak, Fisher, Kwon, Paquette, Street); and Infection Control Vancouver Coastal Health, Vancouver, B.C. (Gara, Bryce).

Background: In 2011, a preoperative decolonization program was introduced for all spine patients, using intranasal photodisinfection therapy, in addition to chlorhexidine-impregnated body wipes (PDT/CHG). This intervention resulted in an absolute risk reduction of 5.2% (spine surgical site infection [SSI] reduction from 7.2% to 2% from 2011 to 2014). It is unknown whether such decolonization affects the microbiologic spectrum of subsequent SSIs, as this could have profound treatment implications. The purpose of this study was to investigate the effect of PDT/CHG on the microbiology of subsequent SSIs. **Methods:** Data were prospectively collected by our institutional SSI surveillance program and our Spine SAVES2 system. We examined SSI organism types for a period before PDT/CHG (2010 to Aug. 31, 2011) and a period after PDT/CHG (2015 to 2018). Cultures from infected sites within a week of symptom onset, as well as within a week before and after a source control procedure, if applicable, were examined for the implicated organism(s). **Results:** Of 37 SSIs before implementation, 54% of patients had monomicrobial infections with gram-positive organisms (85% were staphylococci), 13% had monomicrobial gram-negative infections (all were Enterobacteriaceae), 16% had polymicrobial infections and the remaining 17% had no growth or no specimens available for analysis. Among 34 SSIs after implementation, 59% (n = 20) had Gram-positive organisms (90% were staphylococci), 20% (n = 7) had Gram-negative organisms, 15% (n = 5) had polymicrobial infections and 6% (n = 2) had no cultures collected. **Conclusion:** In this small cohort of spine surgery patients, the microbiologic spectrum of SSIs was similar before and after implementation of PDT/CHG. Contrary to other methods, including nasal mupirocin and intrawound antibiotics, PDT/CHG does not adversely affect the microbiologic spectrum of subsquent infections, while resulting in significant reduction in SSI rates.

Presentation D29
Abstract 61
Feedback: reducing after-hours spine cases using an encrypted messaging system. ***Rosalie Mercure-Cyr, Amit Persad, Michael Spiess, Adam Wu, Allan Woo, Luke Hnenny, Daryl Fourney*****. From the Royal University Hospital, University of Saskatchewan, Saskatoon, Sask.**

Background: After-hours bookings for urgent/emergent spine surgery are controversial because surgery performed outside of regular hours is associated with increased morbidity and mortality. We implemented routine use of a cross-platform messaging system (CPMS, WhatsApp Inc.) for spine surgeons to critically examine indications for after-hours cases before booking. The purpose of this study is to determine if real-time, interdisciplinary quality care discussion affects the number or type of after-hours spine surgeries. **Methods:** We retrospectively compared the number, type and length of after-hour spine surgeries over 3 time periods: (A) June 1, 2016, to May 31, 2017 (baseline control); (B) June 1, 2017, to May 31, 2018 (implementation of quality care spine rounds); and (C) June 1, 2018, to May 31, 2019 (implementation of CPMS). Data were analyzed and compared using analysis of variance and the Student t test. A secondary outcome was an analysis of discussions from CPMS, including rates of differences in opinion with respect to timing or type of surgery. **Results:** The mean number of after-hour spine cases/month over the 3 study periods (A, B, C) was 10.83, 9.75, and 7.58 (p = 0.014); the length of surgery was 41.82, 33.14, and 25.37 hours/month (p = 0.001). The largest area of controversy was booking E3 cases, defined as those that should be done within 24 hours. Over the 3 study periods, E3 cases decreased by a mean of 6.75, 4.92 and 3.83 cases/month (p = 0.005). The timing of surgery agreement with the on-call spine surgeon booking was 87.1% overall and was highest for the most urgent types of indications. The type of procedure was disputed in 23.6% of cases. **Conclusion:** Prospective (rather than retrospective) quality care discussion of after-hours spine surgery via CPMS reduces both the number and extent of cases.

Presentation D30
Abstract 177
Complex spine surgery is safe and effective in the extremely elderly age group: results from an ambispective study of 722 patients over 75 years old from a single institution. ***Jamie Wilson, Hetshree Joshi, Omar Khan, Jetan Badhiwala, Raja Rampersaud, Stephen Lewis, Eric Massicotte, Michael Fehlings*****. From the University of Toronto Spine Program, Toronto, Ont.**

Background: The aim of this study was to investigate the variance in outcomes and complications of complex spine surgery in the extremely elderly age group (over age 75 yr). **Methods:** Prospectively collected database records from a single tertiary spine care centre were retrospectively interrogated from Jan. 1, 2005, until July 31, 2018, to identify all patients over the age of 75 years. Descriptive demographics were collected, including type of surgery, region of surgery, operated levels, perioperative complications and patient-reported outcome measures, among others. Multivariate regression analysis was performed to compare increasing age with the change of complications by region, number of levels, rate of revision surgery and outcomes at 1 month and 1 year. **Results:** A total of 722 patients were included, with an age range of 75–92 years (mean 78.36 yr). A total of 57% underwent lumbar region surgery, 27% cervical and 16% thoracic/occipital. In total, 412 cases (57%) underwent instrumented fusion surgery, with the most common indication being degenerative stenosis. A total of 43% of all cases were 1- or 2-level surgery, with 57% including 3 or more levels. Perioperative complications (total) occurred in 16% of cases, with 93 (13%) revision cases performed in the follow-up period. Multivariate analysis demonstrated an increasing likelihood of fewer levels of surgery as age increased (p = 0.009). The rate of complications at 1 year did not vary with region of surgery (p = 0.773) and did not increase with increased number of levels (p = 0.265); however, increasing age was associated with increased risk of revision surgery (adjusted for region and

number of levels; $p = 0.009$). **Conclusion:** Complex spine surgery at any anatomic region, including instrumented fusion surgery, can be effectively administered in the extremely elderly patient population. However, increasing age is associated with an increased risk of revision surgery and this should be considered during preoperative decision-making.

Presentation E31
Abstract 38

Clinical predictors of achieving minimal clinically important difference after surgery for cervical spondylotic myelopathy: an external validation study from the Canadian Spine Outcomes and Research Network. ***Nathan Evaniew*, *David Cadotte*, *Christopher Bailey*, *Sean Christie*, *Nicolas Dea*, *Charles Fisher*, *Jerome Paquet*, *Alexandra Soroceanu*, *Kenneth C. Thomas*, *Y. Raja Rampersaud*, *Jefferson Wilson*, *Neil Manson*, *Michael Johnson*, *Hamilton Hall*, *Greg McIntosh*, *Bradley Jacobs*. From the University of Calgary, Calgary, Alta. (Evanview, Cadotte, Soroceanu, Thomas, Jacobs); Western University, London, Ont. (Bailey); Dalhousie University, Halifax, N.S. (Christie); the University of British Columbia, Vancouver, B.C. (Dea, Fisher); Université Laval, Québec, Que. (Paquet); the University of Toronto, Toronto, Ont. (Rampersaud, Wilson); the Canada East Spine Centre, Saint John, N.B. (Manson); the University of Manitoba, Winnipeg, Man. (Johnson); and the Canadian Spine Society, Toronto, Ont. (Hall, McIntosh).**

Background: Recently identified prognostic variables among patients undergoing surgery for cervical spondylotic myelopathy (CSM) are limited to 2 large international data sets. We evaluated which preoperative clinical factors are significantly associated with improvement on the modified Japanese Orthopaedic Association (mJOA) scale by at least the minimum clinically important difference (MCID) 12 months after surgery among patients from the Canadian Spine Outcomes and Research Network (CSORN). **Methods:** We performed an observational cohort study with data that were prospectively collected by participating surgeons between 2015 and 2017. We tested candidate variables using univariate and multivariate binomial logistic regression and performed multiple sensitivity analyses to test assumptions about the nature of our statistical models. We implemented validated mJOA MCIDs that varied according to baseline CSM severity. **Results:** Among 205 CSM patients, there were 64 (31%) classified as mild, 86 (41%) as moderate and 55 (26%) as severe. Overall, 52% of patients achieved MCID and the mean change in mJOA at 12 months after surgery was 1.7 points (standard deviation [SD] 2.6, $p < 0.01$), but the subgroup of patients with mild CSM did not significantly improve (mean change 0.1, SD 1.9, $p = 0.8$). Univariate analyses failed to identify significant associations between achieving MCID and sex, body mass index, living status, education, smoking, disability claims or number of comorbidities. After adjustment for potential confounders, the odds of achieving MCID was significantly reduced with each of older age (odds ratio [OR] 0.7 per decade, 95% confidence interval [CI] 0.5–0.9, $p < 0.01$) and higher baseline mJOA (OR 0.8 per point, 95% CI 0.7–0.9, $p < 0.01$). The effects of symptom duration (OR 1.0 per additional month, 95% CI 0.9–1.0, $p = 0.3$) and smoking (OR 0.4, 95% CI 0.2–1.0, $p = 0.06$) were not statistically significant. **Conclusion:** Surgery is effective at halting the progression of functional decline with CSM, and approximately half of all patients achieve the MCID. Data from CSORN confirmed that older age is independently associated with poorer outcomes, but novel findings include the finding that patients with milder CSM did not experience meaningful improvement and the finding that symptom duration and smoking were not important.

Presentation E32
Abstract 66

The natural history of degenerative cervical myelopathy: an ambispective longitudinal cohort study. ***Allan Martin*, *Sukhvinder Kalsi-Ryan*, *Muhammad Ali Akbar*, *Jetan Badhiwala*, *Jefferson Wilson*, *Lindsay Tetreault*, *Aria Nouri*, *Anna Rienmuller*, *Eric Massicotte*, *Michael Fehlings*. From the University of Toronto, Toronto, Ont. (Martin, Kalsi-Ryan, Akbar, Badhiwala, Wilson, Rienmuller, Massicotte, Fehlings); University College Cork, Cork, Ireland (Tetreault); and Hôpitaux Universitaires de Genève, Geneva, Switzerland (Nouri).**

Background: Degenerative cervical myelopathy (DCM) is the most common pathology affecting the spinal cord, but its natural history is poorly characterized. Mild DCM is often managed nonoperatively, but surgical treatment is recommended if neurologic deterioration occurs. This study investigates the natural history of DCM patients who are managed nonoperatively and the utility of quantitative clinical measures to detect myelopathic progression. **Methods:** Patients with (a) a new diagnosis of DCM or (b) recurrent myelopathy after previous surgery were enrolled prospectively and retrospective chart reviews were also performed. Patients who did not undergo surgery or had multiple clinic visits before surgery were included. Standard clinical assessments by the treating surgeons were used as the clinical case definition of neurologic deterioration. A battery of quantitative neurologic assessments were performed at 1 or more visits, including modified Japanese Orthopaedic Association (mJOA) scale, QuickDASH, GRASSP-myelopathy (motor, sensory,and dexterity), grip dynamometer, Berg balance, gait stability ratio, and gait variability index; a deterioration of 10% in any of these measures was considered significant (e.g., a 2-point decrease in mJOA). Anatomic magnetic resonance imaging (MRI) scans were assessed for evidence of worsening compression or spinal cord signal change. **Results:** A total of 116 DCM patients were included (94 newly diagnosed, 22 with recurrent myelopathy). Over a mean follow-up of 2.2 years, 57% (95% confidence interval [CI] 47%–67%) of newly diagnosed and 73% (95% CI 52%–87%) of recurrent DCM patients deteriorated neurologically. The most sensitive quantitative measures to detect deterioration were grip strength (60%), GRASSP dexterity (60%) and gait stability ratio (50%). mJOA and anatomic MRI had relatively low sensitivity (33% and 28%, respectively). A composite score of clinical measures had a sensitivity of 81% and a specificity of 82%. **Conclusion**: DCM has a poor natural history with a high rate of neurologic deterioration. Longitudinal monitoring of patients should include grip strength, dexterity and gait analysis. A lack of worsening on anatomic MRI or mJOA should not be considered evidence of clinical stability.

Presentation E33
Abstract 159
Quantitative assessment of gait characteristics in degenerative cervical myelopathy (DCM): a prospective study. ***Anna Rienmueller, Sukhvinder Kalsi-Ryan, Lauren Riehm, Allan Martin, Jetan Badhiwala, Muhammad Akbar, Eric Massicotte, Michael Fehlings.*** **From the Department of Orthopaedics, Toronto, Ont. (Rienmueller); the Department of Physical Therapy, University of Toronto, Toronto, Ont. (Kalsi-Ryan); KITE University, Toronto, Ont. (Kalsi-Ryan); the University of Toronto, Toronto, Ont. (Riehm); and the Department of Neurosurgery, University of Toronto, Toronto, Ont. (Martin, Badhiwala, Akbar, Massicotte, Fehlings).**

Background: There are challenges in discriminating the early presentation of degenerative cervical myelopathy (DCM) as well as sensitively and accurately distinguishing between mild, moderate and severe levels of impairment. Gait dysfunction is 1 of the cardinal symptoms of DCM, but it requires detailed assessment to sensitively detect changes in function. Accurate assessment of gait dysfunction is a potentially useful clinical evaluation tool in the DCM population. The objective of our study was to characterize gait in the DCM population through the use of spatiotemporal parameters, assessed on a gait pressure surface, and to determine the discriminative and evaluative properties of this form of gait assessment in DCM. **Methods:** In a cross-sectional observational study, 140 study participants presenting with 1 or more signs of DCM were prospectively recruited along with 37 nonmyelopathic subjects. Study participants were stratified on the basis of DCM severity, as measured using the modified Japanese Orthopaedic Association (mJOA) scale. Demographic information and the neurologic status of each participant were also collected. GAITRite and the ProtoKinetics Zeno Walkway (Haverton) were used to conduct all gait assessments. SPSS version 21.0 was used to perform the statistical analysis. **Results:** Significant differences ($p \leq 0.05$) were observed between healthy normative data and the mild DCM study participants for multiple spatio-temporal parameters. Several parameters were also noted to be discriminative ($p \leq 0.05$) between at least 2 DCM severity groups. Step length, stride velocity, single stance ratio and the enhanced gait variability index (eGVI) demonstrated the greatest discrimination between DCM severities. Parameters collected during fast-paced walking demonstrated similar discrimination as compared with self-selected pace. **Conclusion:** The single stance ratio and eGVI were the most discriminative and evaluative out of all the spatiotemporal parameters, and they differentiated between normative ranges and the DCM study participants (all severities).

Presentation E34
Abstract 130
Prognostic factors in degenerative cervical myelopathy (DCM) for patients managed operatively and non-operatively. ***Allan Martin, Sukhvinder Kalsi-Ryan, Muhammad Ali Akbar, Jetan Badhiwala, Jefferson Wilson, Lindsay Tetreault, Aria Nouri, Anna Rienmuller, Eric Massicotte, Michael Fehlings.*** **From the University of Toronto, Toronto, Ont.**

Background: Degenerative cervical myelopathy (DCM) is the most common pathology affecting the spinal cord, but few factors have been identified that predict outcomes with or without surgery. This study investigates baseline clinical and magnetic resonance imaging (MRI) data for (a) prediction of deterioration in DCM patients managed nonoperatively and (b) prediction of postoperative recovery. **Methods:** Patients with a diagnosis of DCM were enrolled prospectively. In patients managed nonoperatively, a binary outcome variable of neurologic deterioration was defined on the basis of comprehensive assessment by the surgeon, including modified Japanese Orthopedic Association (mJOA), physical examination and subjective factors. For postoperative recovery, the mJOA recovery ratio was used as the outcome variable. Baseline data were analyzed for univariate associations with the outcome variables using χ^2, t and Pearson correlation tests. Logistic and linear regression models with backward stepwise elimination were used for multivariate analysis. **Results:** In 117 patients, deterioration was more common with lower baseline GRASSP dexterity (nondominant hand, $p = 0.001$; dominant, $p = 0.006$), lower mJOA ($p = 0.003$), clumsy hands ($p = 0.008$), numb hands ($p = 0.01$), unsteady gait ($p = 0.01$), longer follow-up ($p = 0.02$), smoking ($p = 0.03$), depression ($p = 0.03$) and decreased grip strength (dominant, $p = 0.04$); trends were also seen with higher QuickDASH score ($p = 0.06$), Hoffman sign ($p = 0.07$), obesity ($p = 0.09$) and increased age ($p = 0.10$). In 71 patients, postoperative recovery was improved with stronger baseline grip strength ($p = 0.01$, nondominant), cord compression at C4–5 ($p = 0.01$) and no cord compression at C2–3 ($p = 0.02$); trends were observed with the presence of diabetes ($p = 0.07$), no cardiac dysfunction ($p = 0.08$), younger age ($p = 0.10$) and no previous myelopathy ($p = 0.10$). Multivariate analysis found independent predictors of mJOA ($p = 0.02$), follow-up duration ($p = 0.02$) and smoking ($p = 0.04$) for nonoperative deterioration, and grip strength (nondominant, $p = 0.02$) and C4–5 cord compression ($p = 0.03$) for postoperative recovery. **Conclusion:** Patients with more severe baseline neurologic dysfunction, smoking, depression and longer follow-up appear more likely to deteriorate without surgery, whereas those with preserved grip strength and C4–5 cord compression have better postoperative recovery potential. These variables may be useful to inform surgical decision-making and improve outcomes.

Presentation E35
Abstract 175
Efficacy of surgical decompression in patients with cervical spondylotic myelopathy: results of a Canadian prospective multicentre study. ***Mohammed Karim, Bradley Jacobs, Michael Johnson, Christopher Bailey, Sean Christie, Jérôme Paquet, Andrew Nataraj, David Cadotte, Jeffrey Wilson, Neil Manson, Hamilton Hall, Ken Thomas, Raja Rampersaud, Greg McIntosh, Charles Fisher, Nicolas Dea.*** **From the Combined Neurosurgery and Orthopaedic Spine Program, University of British Columbia, Vancouver, B.C. (Karim, Fisher, Dea); the Department of Clinical Neurosciences, Division of Neurosurgery, Department of Radiology, Hotchkiss Brain Institute, University of Calgary, Calgary, Alta. (Jacobs, Cadotte, Thomas); the Department of Surgery, Section of Orthopaedics and Neurosurgery, University of Manitoba, Winnipeg, Man. (Johnson); the Department of Surgery, Western University, London, Ont. (Bailey); the Division of**

Neurosurgery, Dalhousie University, Halifax, N.S. (Christie); the Department of Orthopaedics, Centre hospitalier universitaire de Québec, Québec, Que. (Paquet); the Division of Neurosurgery, Faculty of Medicine and Dentistry, University of Alberta, Edmonton, Alta. (Nataraj); the Division of Neurosurgery, Department of Surgery, University of Toronto, Toronto, Ont. (Wilson); the Canada East Spine Centre, Saint John Regional Hospital, Saint John, N.B. (Manson); the Department of Surgery, University of Toronto, Toronto, Ont. (Hall); the Division of Orthopaedic Surgery and Neurosurgery, Department of Surgery, University of Toronto, Toronto, Ont. (Rampersaud); and the Canadian Spine Society, Toronto, Ont. (McIntosh).

Background: Recent evidence suggests that patients with cervical spondylotic myelopathy (CSM) benefit from surgical intervention regardless of preoperative disease severity. The goals of this study are (a) to validate previous results and (b) to assess the impact of surgery on outcome measures at 12 months after surgery. **Methods:** In this multicentre, prospective cohort study, patients were recruited by 35 surgeons from 7 Canadian centres from 2015 to 2018. Outcome measures include modified Japanese Orthopedic Association (mJOA) score, Neck Disability Index (NDI), EQ-5D and SF-12. These were assessed at baseline and at 12 months after surgery. Outcome measures at 12 months were compared with baseline for the whole cohort and were further analyzed on the basis of preoperative disease severity: mild (mJOA ≥ 15), moderate (mJOA 12–14) and severe (mJOA < 12). **Results:** A total of 378 patients have been enrolled in the study and undergone surgery with 1-year follow-up data on mJOA scores available for 224 patients (59%). Mean age is 60 years, and males comprise 62% of the cohort. One hundred and four patients (28%) had mild myelopathy, 153 (40%) moderate and 107 (28%) severe; data were missing for 14 patients (4%). At baseline, patients with severe myelopathy were older and more disabled with lower health-related quality of life scores. For the whole cohort, there was significant improvement in all outcome measures at 12 months ($p < 0.001$), with mean mJOA scores improving from 13.1 to 14.9 ($p < 0.001$). Patients with severe myelopathy saw a mean mJOA improvement of 3.8 ($p < 0.0001$), and patients with moderate myelopathy improved by 1.9 ($p < 0.0001$). Patients with mild myelopathy demonstrated no meaningful or statistically significant improvement (0.12) in mJOA score. **Conclusion:** This study validates the results of previous studies that demonstrated improved outcomes with surgical decompression in CSM. Patients with mild myelopathy, however, did not improve significantly compared with patients with moderate and severe disease. These findings highlight the controversy in management of patients with mild cervical myelopathy and support a more conservative approach with close follow-up in neurologically stable patients.

Presentation E36
Abstract 67
Interobserver reliability of the modified Japanese Orthopedic Association (mJOA) score in degenerative cervical myelopathy. ***Allan Martin*, *Jamie Wilson*, *Thorsten Jentzsch*, *Fan Jiang*, *Jetan Badhiwala*, *Ali Moghaddamjou*, *Muhammad Ali Akbar*, *Anick Nater*, *Anna Rienmuller*, *Mario Ganau*, *Eric Massicotte*, *Michael Fehlings*. From the University of Toronto, Toronto, Ont.**

Background: The modified Japanese Orthopedic Association (mJOA) score has become widely accepted as the most important assessment in degenerative cervical myelopathy (DCM); this score has been used in clinical practice guidelines to directly influence treatment recommendations, but its reliability has not been established. This study aims to determine the interobserver reliability of the mJOA in a large cohort of DCM patients. **Methods:** This prospective cross-sectional study involved administration of a refined version of the mJOA to DCM patients by 2 or more experienced clinicians who were blinded. The reliabilities of subscores and total score were analyzed using intraclass correlation (ICC) and concordance. Subgroup analyses were performed by mJOA severity (mild: 15–17; moderate: 12–14; severe: < 12). Data were also analyzed using analysis of variance for differences by assessor, assessment order, previous surgery, age and sex. **Results:** A total of 115 DCM patients underwent 245 assessments. ICC was 0.66 for upper extremity motor, 0.70 for lower extremity motor, 0.57 for upper extremity sensation, 0.65 for sphincter function and 0.71 for total mJOA. The average difference in mJOA was 0.90 points between assessors. Identical scores (across all 4 subscores) were observed in 21%, differences of 2 or more points occurred in 19% and disagreement between mild and moderate severity occurred in 14% of patients. Lower extremity motor score was lower during second assessments ($p = 0.02$). Other variables that were analyzed did not demonstrate significant relationships with mJOA scores. **Conclusion:** The interobserver reliability of the mJOA is moderate, and disagreement occurs in the vast majority of patients. These findings suggest that the mJOA should be interpreted with caution and considered in conjunction with additional measures, particularly when the total score falls near the threshold between severity categories or when a patient is monitored longitudinally for deterioration, as small differences can alter management. Further efforts to standardize the mJOA are needed to improve its reliability and help deliver optimal management of DCM.

Presentation F37
Abstract 128
Continuous optical monitoring of spinal cord hemodynamics during the first 7 days after injury in a porcine model of acute spinal cord injury. ***Amanda Cheung*, *Lorna Tu*, *Neda Manouchehri*, *Kyoung-Tae Kim*, *Kitty So*, *Megan Webster*, *Shera Fisk*, *Seth Tigchelaar*, *Sara Dalkilic*, *Eric Sayre*, *Femke Streijger*, *Andrew Macnab*, *Brian Kwon*, *Babak Shadgan*. From the International Collaboration on Repair Discoveries (ICORD), University of British Columbia, Vancouver, B.C. (Cheung, Tu, Manouchehri, Kim, So, Webster, Fisk, Tigchelaar, Dalkilic, Sayre, Streijger, Kwon, Shadgan); the Department of Neurosurgery, Kyungpook National University, Kyungpook National University Hospital, Daegu, South Korea (Kim); the Department of Pediatrics, University of British Columbia, Vancouver, B.C. (Macnab); and the Department of Orthopaedics, University of British Columbia, Vancouver, B.C. (Kwon, Shadgan).**

Background: Current clinical guidelines recommend augmenting the mean arterial pressure (MAP) in acute spinal cord injury (SCI) patients to increase spinal cord perfusion and potentially improve neurologic function. However, it is difficult for clinicians to hemodynamically manage acute SCI patients without real-time

physiologic information about the effect of MAP augmentation within the injured cord. In this study, we investigated the feasibility and validity of using a customized optical sensor, based on near-infrared spectroscopy (NIRS), to noninvasively monitor spinal cord tissue oxygenation and hemodynamics during the first 7 days after injury in a porcine model of acute SCI. **Methods:** Six Yucatan minipigs received a weight-drop T10 contusion–compression injury. A multiwavelength NIRS system with a custom-made optical sensor was placed directly onto the dura at T9. Using NIRS, the spinal cord tissue oxygenation (Hbdiff) and concentrations of oxygenated (O_2Hb), deoxygenated and total hemoglobin (THb) were monitored before and after SCI. To validate the NIRS measures, an invasive intraparenchymal (IP) combined PO_2/blood flow (SCBF) sensor was inserted into the spinal cord adjacent to the NIRS sensor at T11. Episodes of MAP alterations and hypoxia were performed acutely after injury, 2 days, and 7 days after injury to simulate the hemodynamic changes SCI patients experience after injury. **Results:** Noninvasive NIRS monitoring identified changes in spinal cord hemodynamics and oxygenation levels during the MAP alterations and hypoxia. Changes of THb followed similar patterns of perfusion changes measured by the IP SCBF sensor, and changes of Hbdiff and O_2Hb showed significant correlations with oxygenation changes measured by IP PO_2 ($p < 0.0001$). **Conclusion:** Our novel NIRS sensor is feasible as a noninvasive technique to monitor real-time changes in spinal cord oxygenation and hemodynamics 7 days after injury. Further development of this method would allow a clinically applicable device spine surgeons could place on the dura at the time of surgical decompression to monitor spinal cord tissue hemodynamics after injury.

Presentation F38
Abstract 106
Development of a prediction model for central cord syndrome: an evaluation of motor recovery and the effectiveness of early surgery in a prospective, multicentre cohort. ***Jetan Badhiwala, Jefferson Wilson, Michael Fehlings*. From the University of Toronto, Toronto, Ont.**

Background: There is a paucity of data on the outcomes of central cord syndrome (CCS) and their predictors in the modern era. Further, the efficacy of early surgical decompression in this setting remains unclear. In patients with CCS, we therefore sought to (a) develop a clinical prediction model for neurologic outcome and (b) evaluate the effect of time to decompressive surgery on neurologic recovery. **Methods:** Patients with CCS (lower and upper extremity motor scores of 35) were identified from 4 prospective, multicentre spinal cord injury data sets (NACTN, STASCIS, Sygen, NASCIS III). A clinical prediction model was developed by multiple linear regression; the outcome was American Spinal Cord Injury Association (ASIA) motor score (AMS) at 1 year. Covariates were chosen a priori on the basis of literature support and hypothesis: (a) age (continuous, yr), (b) baseline AMS (continuous), (c) baseline ASIA Impairment Scale (AIS) grade (dichotomous, C v. D), (d) time to surgery (continuous, h) and (e) time to surgery AIS grade. Time to surgery was log transformed given skewness in distribution. Effect sizes were summarized by β coefficients. Internal validation was performed by bootstrapping. **Results:** A total of 264 patients were eligible. β coefficients were significant for all variables in the model: age (–0.21, $p < 0.01$), baseline AMS (0.28, $p < 0.01$), baseline AIS grade D (–11.68, $p = 0.04$), log time to surgery (–3.40, $p < 0.01$), baseline AIS grade D log time to surgery (4.22, $p < 0.01$). The mean R^2 value across bootstraps was 0.40. In patients with AIS grade C injury, shorter time to surgical decompression was significantly associated with superior motor recovery; by contrast, time to surgery did not observably affect motor outcome in patients with AIS grade D injury. **Conclusion:** Motor recovery after CCS may be predicted by age, AMS, AIS grade and time to surgery. These data support expeditious surgical decompression in patients with AIS grade C acute traumatic central cord syndrome.

Presentation F39
Abstract 135
Spinal cord dynamics under different clinical configurations of thoracolumbar burst fractures through numerical simulations. ***Lucien Diotalevi, Nicolas Bailly, Eric Wagnac, Jean-Marc Mac-Thiong, Julien Goulet, Yvan Petit*. From the Centre de recherche de l'Hôpital du Sacré-Coeur de Montréal, Montreal, Que. (Diotalevi), the International Laboratory — Spine Imaging and Biomechanics (iLab-Spine), Montreal, Que. (Diotalevi, Bailly, Wagnac, Petit); the École de technologie supérieure, Montreal, Que. (Bailly, Wagnac, Petit); and Université de Montréal, Montreal, Que. (Thiong).**

Background: The primary injury of traumatic spinal cord injury (tSCI) involves a direct transfer of energy from vertebral fragments to the spinal cord. Unfortunately, imaging performed after the accident only depicts the residual pattern of thoracolumbar burst fracture and spinal cord compression, providing little insight into its dynamics. Knowledge of underlying mechanisms could be helpful in determining the severity of the primary injury and hence the extent of spinal cord damage and associated potential for recovery. Numerical modelling is often used to study dynamic processes but it has never been used to specifically simulate different configurations of thoracolumbar burst fractures. **Methods:** A comprehensive finite-element model of a T11–L1 burst fracture, including 2 typical fragments, was developed and validated. Sixteen clinical cases of T12 burst fracture were simulated in a full factorial design under the following conditions: presence/absence of comminution of the superior fragment (delta fragment consisting of the posterosuperior border of the vertebral body), upward rotational displacement of the upper fragment, presence/absence of a retropulsed inferior fragment (posteroinferior portion of the vertebral body), and low or high retropulsion velocity of fragments. The severity of the spinal cord damage was quantified by its sustained peak strain, stress and pressure. **Results:** Fragment velocity was the most significant ($p < 0.05$) and influential factor (+26.7% strain, +82.4 kPa stress and +127.7 kPa pressure). Fragment upward rotation and presence of an inferior fragment significantly increased pressure (+55.2 and +18.3 kPa, respectively), but rotation decreased strain (–10.1%). Although significant for the peak strain, comminution of the superior fragment negligibly affected the severity of damage sustained by the spinal cord (–2.7%). **Conclusion:** This study is the first to dynamically simulate spinal cord compression for varying configurations of thoracolumbar burst fractures. Our results suggest that higher fragment velocity highly affects the stress, strain and pressure sustained by the spinal cord. The presence of an inferior fragment and fragment upward rotation should raise the suspicion of a severe primary injury.

Presentation F40
Abstract 60
Predicting the heterogeneity of outcome following sensorimotor complete cervical spinal cord injury: trajectory-based analysis of 655 prospectively enrolled patients. ***Blessing Jaja, Jetan Badhiwala, Robert Grossman, Fred Geisler, Michael Fehlings, Jefferson Wilson*. From St. Michael's Hospital, Toronto, Ont. (Jaja, Badhiwala, Wilson); the Methodist Hospital, Houston, Tex. (Grossman); the University of Saskatchewan, Saskatoon, Sask. (Geisler); and Toronto Western Hospital, Toronto, Ont. (Fehlings).**

Background: While the prognosis for recovery following sensorimotor complete cervical spinal cord injury (SCI) remains poor, there is individual heterogeneity in outcomes. Using a novel approach, we aimed to characterize unique temporal patterns of neurologic recovery after injury and to identify patient, injury and treatment variables that predict such patterns. **Methods:** Subjects with cervical American Spinal Injury Association (ASIA) Impairment Scale (AIS) grade A SCI were pooled from 4 prospective multicentre cohort studies. Group-based trajectory modelling (GBTM) was applied to model trajectories of recovery over the initial 12 months after injury. Measures of neurologic function included Upper Extremity Motor Score, Total Motor Scores and AIS grade improvement. Within the GBTM framework, multinomial logit regression was applied to identify characteristics associated with recovery trajectories. **Results:** The GBTM categorized subjects (n = 655) into 3 distinct trajectories of recovery. These included (a) marginal recovery trajectory, characterized by minimal or no improvement in motor strength or change in AIS grade (remained grade A); (b) moderate recovery trajectory, characterized by low baseline motor scores that improved by approximately 10 points, or AIS conversion of 1 grade point; and (c) good recovery trajectory, characterized by motor scores in the upper quartile at baseline that improved to near maximum values within 3 months of injury. Subjects following this trajectory, on average, improved 2 AIS grades within 3 months of injury. Subjects following the moderate or good recovery trajectories were of younger age, had more caudally located injuries, had a higher degree of preserved motor/sensory function at baseline examination and exhibited a greater extent of motor and sensory function in the zone of partial preservation. **Conclusion:** Subjects with cervical complete SCI can be classified into 1 of 3 distinct trajectories for neurologic recovery. This analysis may serve as a starting point to define unique clinical phenotypes on the basis of potential for recovery, rather than baseline severity of injury alone.

Presentation F41
Abstract 167
Mortality in the year following discharge to the community from inpatient care for acute traumatic spinal cord injury: When and why? ***Nader Fallah, Carly Rivers, Brian Kwon, Zeina Waheed, Jerome Buenaventura, Suzanne Humphreys, Vanessa Noonan, Nathan Evaniew, Marcel Dvorak*. From the Praxis Spinal Reseach Institute, Vancouver, B.C. (Fallah, Rivers, Waheed, Buenaventura, Humphreys, Noonan); the University of British Columbia, Vancouver, B.C. (Kwon, Dvorak); and the University of Calgary, Calgary, Alta. (Evanview).**

Background: Individuals with traumatic spinal cord injury (tSCI) have an increased rate of death following injury secondary to the neurologic and functional sequelae of their injury. Our objectives were to investigate mortality within the first year of community living after discharge from inpatient care, to inform the optimization of health care delivery, self-management and education and to identify risk factors. **Methods:** The study cohort of 4625 acute SCI patients admitted to an acute care facility in British Columbia over a 23-year period from 1995 to 2017 was composed by scanning all Hospital Discharge Abstract Database (DAD) using *International Classification of Diseases, Ninth Revision* (ICD-9) and *International Statistical Classification of Diseases and Related Health Problems, 10th Revision* (ICD-10) codes. We examined time of death following discharge, the main cause of death, the place where death occurred, and readmission to hospital in the year following discharge from initial inpatient care. Demographics and details regarding time and cause of death, and readmissions to acute care, were obtained from the Consolidation File, Vital Statistics-Deaths and the Hospital DAD, respectively. **Results:** Of the 4352 individuals who survived and were discharged to community, 203 (4.7%) died within 1 year of discharge. Of those who died, mean age at injury was 70.7 years (standard deviation [SD] 17.3 yr), and 140 (69.0%) were male. Median time of death after discharge from inpatient care was 100 days (range 2–366 d). Over half of those who died (117/203, 57.6%) were readmitted to acute care at least once before death; 11.8% died at home. The most elderly (aged 75 yr or older, mean 83.4, SD 5.5) represented 14.4% of the entire cohort, and 51.2% (104/203) of those who died. Most common causes of death included falls, lung cancer, athlerosclerotic heart disease, myocardial infarction and stroke. **Conclusion:** There is a high risk of mortality within the year following initial discharge to the community following tSCI in the elderly, and most die in care. Falls and comorbid conditions are leading causes of death. This further understanding of mortality-related factors can help with prevention strategies and help clinicians with decision-making around goals of management and communication of prognosis to patients and families.

Presentation F42
Abstract 104
A novel method to classify patients with cervical incomplete spinal cord injury based on potential for recovery: a group-based trajectory analysis using prospective, multicentre data from over 800 patients. ***Jetan Badhiwala, Jefferson Wilson, Michael Fehlings*. From the University of Toronto, Toronto, Ont.**

Background: The outcomes of cervical incomplete spinal cord injury (SCI) are heterogeneous. Using a novel technique, this study sought to dissociate subgroups of cervical incomplete SCI patients with distinct longitudinal trajectories of upper limb motor recovery. **Methods:** Patients with cervical incomplete SCI (American Spinal Injury Association Impairment Scale [AIS] B-D; C1-C8) were identified from 4 prospective, multicentre SCI data sets (NACTN, STASCIS, Sygen, NASCIS III). A group-based trajectory model was fit to upper extremity motor scores out to 1-year follow-up. Multivariable multinomial logistic regression was performed to identify baseline features that characterize each trajectory group. **Results:** In total, 801 patients

were eligible. Four distinct trajectory groups were identified: (a) poor outcome (severe neurologic injury with very minimal, gradual recovery), (b) moderate recovery (moderate-to-severe neurologic injury with moderate recovery), (c) good recovery (moderate neurologic injury with good recovery) and (d) excellent outcome (mild neurologic injury with good recovery by 3 months). On adjusted analyses, older age was associated with lower likelihood of an excellent outcome ($p = 0.020$). Compared with AIS B injuries, AIS C injuries were associated with moderate recovery ($p < 0.001$), good recovery ($p < 0.001$) and excellent outcome ($p < 0.001$), and AIS D injuries were significantly associated with good recovery ($p < 0.001$) and excellent outcome ($p < 0.001$). Mid cervical injuries occurred more frequently in moderate recovery ($p < 0.001$), good recovery ($p < 0.001$) and excellent outcome ($p < 0.001$) groups, as compared with upper cervical injuries. The presence/absence of central cord syndrome did not predict temporal recovery profile. Early surgical decompression (< 24 h) was independently associated with an increased propensity for good recovery ($p = 0.039$) and excellent outcome ($p = 0.048$). **Conclusion:** Patients with cervical incomplete SCI demonstrate distinct trajectories of recovery in upper limb motor function. The trajectory a patient is likely to follow may be predicted by baseline characteristics. The presence of central cord syndrome does not affect prognosis, whereas early surgery may support conversion to a more favourable recovery trajectory.

Presentation G43
Abstract 7
Responsiveness of standard spine outcome tools: Do they measure up? ***Abeer Wasim*, *Mopina Shrikumar*, *Phumeena Balasuberamaniam*, *Bruce Rapkin*, *Carolyn Schwartz*, *Roland Stark*, *Joel Finkelstein*. From the Sunnybrook Health Sciences Centre, Toronto, Ont. (Wasim, Shrikumar, Balasuberamaniam, Finkelstein); the Albert Einstein College of Medicine, Bronx, N.Y. (Rapkin); the DeltaQuest Foundation, Concord, Mass. (Schwartz, Stark); and Tufts University Medical School, Boston, Mass. (Schwartz).**

Background: Given the challenges of maintaining high-quality data in clinical research studies, it would be important to evaluate the contribution of each patient-reported outcome (PRO) to confirm that they merit the respondent burden. This study aimed to examine the spine PROs' association with clinically important change, and relative responsiveness in explaining variance in patients' global assessment of change (GAC). **Methods:** This prospective longitudinal cohort study included adults recruited from 3 active spine surgery practices at a Toronto-based hospital. Patients were diagnosed with a degenerative spinal condition and underwent spinal decompression and/or fusion surgery. Participants completed the Rand-36 (to generate the physical and mental component scores; PCS, MCS), Oswestry Disability Index (ODI), numeric rating scale for pain (NRS), PROMIS Pain Interference (PROMIS) and a GAC item. Random effects models investigated the relationship of each PRO in predicting GAC over time, and responsiveness (i.e., PRO main effects and PRO-by-time interactions, respectively). Pearson correlations investigated the association between PRO trajectory scores derived from the random effects models to assess overlap in information gained. **Results:** The study sample included 209 people (mean age 60 yr, 48% female) with presurgery and up to 12 months postsurgery data. Random effects models revealed significant main effects for all the PROs. Significant time-by-PRO interactions were detected for the PCS, PROMIS, ODI and NRS ($p < 0.01$, 0.05, 0.001 and 0.05, respectively), but not for the MCS. There were large effect-size correlations among the trajectory scores for the ODI, PCS, NRS and PROMIS (r ranged from 0.57 to 0.69). **Conclusion:** All of the PROs currently included in the spine outcome core measures are associated with patients' subjective assessment of clinically important change, and all but the MCS are responsive to clinically important change. Four measures show substantial overlap in predicting clinically important change. On the basis of these findings, the core spine PROs could be reduced if the focus is on detecting patients' subjective assessment of clinically important change.

Presentation G44
Abstract 142
Patient outcomes: important psychological measures. ***Neil Manson*, *Erin Bigney*, *Mariah Darling*, *Eden Richardson*, *Dana El-Mughayyar*, *Edward Abraham*. From the Division of Orthopaedic Surgery, Zone 2, Horizon Health Network, Saint John, N.B. (Manson, Abraham); the Canada East Spine Centre, Saint John, N.B. (Manson, Bigney, Darling, Richardson, Mughayyar, Abraham); and the Department of Surgery, Dalhousie University, Saint John, N.B. (Manson, Abraham).**

Background: The aim of this study was to elucidate which baseline psychological measures add to the prediction of patient-reported outcomes 2 years after thoracolumbar surgery. **Methods:** We conducted a prospective observational study of elective thoracolumbar surgery patients ($n = 195$) who participate in the Canadian Spine Outcomes and Research Network (CSORN) registry. Patients were given additional baseline psychological measures: Pain Catastrophizing Scale (PCS), Tampa Scale for Kinesiophobia (TSK), Multidimensional Scale of Perceived Social Support (MSPSS) and the Chronic Pain Acceptance Questionnaire (CPAQ). Outcome variables of interest were the modified Oswestry Disability Index (ODI) and numeric rating scales for back and leg pain (NRS-B and NRS-L) 2 years after surgery. Outcome variables were collapsed based on achieving a minimum clinically important difference (MCID). A binary logistic regression was run. Independent variables included the psychological measures of interest as well as the CSORN variables: Mental Health Component Summary Score (MCS), comorbid depression, demographic variables and clinical/health history variables. Significance was set at α less than 0.05. **Results:** A total of 60.3% of the sample achieved a MCID for ODI 2 years after surgery. The final regression model for ODI included baseline MCS, ODI score and CPAQ Pain Willingness with the model correctly predicting 68.9% of cases ($\chi^2 = 29.482$, $p < 0.001$). A total of 68.2% of the sample achieved a MCID for NRS-B 2 years after surgery. The regression model for NRS-B included baseline MCS, NRS-B score and principal pathology with the model accurately predicting 77.7% of cases ($\chi^2 = 60.598$, $p < 0.001$). A total of 70.5% of the sample achieved a MCID for NRS-L 2 years after surgery. The regression model for NRS-L included baseline ODI, NRS-L score, CPAQ Pain Willingness, PCS Magnification, MSPSS

Category and comorbid depression with the model correctly predicting 82.7% of cases ($\chi^2 = 52.719$, $p < 0.001$). **Conclusion:** The addition of psychological measures increases a surgeon's ability to predict the likelihood of not meeting MCID on outcomes following surgery. In particular, the MCS, CPAQ Pain Willingness, PCS Magnification and MSPSS were found to contribute to the prediction and could provide value in making surgical decisions.

Presentation G45
Abstract 84
Accuracy of surveillance for surgical site infections after spine surgery: a Bayesian latent class analysis using 4 independent data sources. ***Oliver Lasry, John Street.*** **From the Vancouver Spine Surgery Institute, Vancouver, B.C.**

Background: Surgical site infections (SSIs) are morbid and costly complications of spine surgery. Understanding the impact that interventions have on reducing the risk of SSIs requires appropriate surveillance. Unfortunately, valid approaches to conducting SSI surveillance in the spine surgery population are lacking because of varying SSI case definitions and the lack of a gold-standard definition for SSIs. We aimed to assess the accuracy of 4 data sources that capture SSIs after spine surgery while estimating a measurement error-adjusted SSI incidence, without relying on a gold-standard definition. **Methods:** We assessed the accuracy of SSI surveillance algorithms across the following 4 data sources for patients undergoing spine surgery at the Vancouver General Hospital in 2017: (a) the discharge abstract database (DAD), (b) the National Surgical Quality Improvement Program (NSQIP) database, (c) the Infection Prevention and Control Canada (IPAC) database and (d) our local Spine Adverse Events Severity (SAVES) database. A Bayesian latent class model was used to assess the sensitivity/specificity of each data source to identify SSI and to estimate a measurement-error adjusted incidence, without relying on a gold-standard SSI definition. **Results:** A total of 976 patients underwent spine surgery during the study period. The most sensitive data source was the DAD (0.77, 95% credible interval [CrI] 0.54–0.95), while the least sensitive was the NSQIP database (0.51, 95% CrI 0.32–0.71). The most specific data source was the IPAC database (0.997, 95% CrI 0.993–1.000), while the least specific was the DAD (0.970, 95% CrI 0.957–0.981). The measurement error-adjusted SSI incidence was 0.034 (95% CrI 0.021–0.051). **Conclusion:** Adjustment for the measurement error of various spine surgery SSI surveillance data sources is achievable using the accuracy measures provided in this study. Thus, high-quality spine surgery SSI surveillance and research can now be feasibly conducted in a timely fashion using the most readily available data sources to stakeholders.

Presentation G46
Abstract 169
Econometric modelling: development of a surgical cost calculator for degenerative conditions of the lumbar spine. ***Eric Crawford, Lenny Radomski, Raja Rampersaud.*** **From the Division of Orthopaedic Surgery, University of Toronto, Toronto, Ont. (Crawford, Radomski); and the Division of Orthopaedic and Neurosurgery, Toronto Western Hospital, Toronto, Ont. (Rampersaud).**

Background: Finite resources require accurate prediction models of surgical costs rather than the common practice of applying mean cost to heterogenous patients. We aimed to develop a patient-level spine surgical cost calculator. **Methods:** A retrospective review of patients undergoing surgery for degenerative lumbar spine conditions over a 2-year period at a tertiary care centre (Toronto Western Hospital) was undertaken to create a predictive model of surgical costs. The economic perspective was that of the hospital. Total costs were based on individual patient level micro-case costed data. Prospectively collected, preoperative patient and planned surgery variables were scrutinized, as potential predictors of total episode of care costs. Alternative prediction models were compared on the basis of residual values, corresponding graphical plots and where appropriate R^2 or Akaike information criterion values. **Results:** Two hundred and eighty-four patients met inclusion criteria. The average per procedure total cost was $Can10 420 (standard deviation [SD] 10 684). A log-transformed linear regression model was found to best fit the data. This model identified 7 independent predictors of total cost out of 8 factors entered in the model. Preoperatively, patients with American Society of Anesthesiologists physical status classification scores of 4 had significantly higher costs than those with a score of 1 ($p < 0.001$). Increased patient age ($p = 0.014$) and body mass index ($p = 0.002$) were also predictive of higher total costs. Day surgery ($p < 0.001$) and minimally invasive procedures ($p = 0.003$) were associated with lower costs, whereas fusion ($p < 0.001$) and multilevel (> 1 level) procedures ($p < 0.001$) were associated with significantly higher costs. This model accounted for a large proportion of the variance of total costs, with an R^2 value of 0.82. **Conclusion:** This 7-factor model may help to predict individual patient hospital incurred costs for patients undergoing surgery for degenerative lumbar spine conditions and be beneficial for budgetary planning and resource allocation. Validation of the model in larger and different patient samples is required to hone its precision and determine its generalizability, respectively.

Presentation G47
Abstract 124
The economic impact of nonreimbursable events in open, minimally invasive and robot-assisted lumbar fusion surgery. ***Avery Brown, Katherine Pierce, Cole Bortz, Haddy Alas, Sara Naessig, Waleed Ahmad, Shaleen Vira, Bassel Diebo, Daniel Sciubba, Hamid Hassanzadeh, Aaron Hockley, Alex Soroceanu, Themistocles Protopsaltis, Aaron Buckland, Peter Passias.*** **From the Department of Orthopedic Surgery, NYU Langone Orthopedic Hospital, New York, N.Y. (Brown, Pierce, Bortz, Alas, Naessig, Ahmad, Vira, Diebo, Protopsaltis, Buckland, Passias); the Department of Neurosurgery, Johns Hopkins University School of Medicine, Maryland, Md. (Sciubba); the Department of Orthopedics, University of Virginia Charlottesville, Va. (Hassanzadeh); and the Department of Orthopaedic Surgery, University of Calgary, Calgary, Alta. (Hockley, Soroceanu).**

Background: The aim of this study was to investigate the rates of economic impact of nonreimbursable events in lumbar spine fusion surgery. **Methods:** Patients 18 years of age and older undergoing lumbar fusion surgery were included. Patients were categorized into 3 groups on the basis of procedure type: open, miniminally invasive surgery (MIS) and robotic. The open group

included posterior spinal fusion. The MIS group included transforaminal lumbar interbody fusion (TLIF) or lateral lumbar interbody fusion (LLIF) with percutaneous screws. The robotic group included robot-assisted interbody fusion. We conducted propensity score matching (PSM) between all groups for number of levels fused. Rates of postoperative complications and nonreimbursable events were assessed for each group. Nonreimbursable events were surgical site infection (SSI), urinary tract infection (UTI), pulmonary embolism or deep venous thromboembolism (PE/DVT). Costs of nonreimbursable events were calculated using the PearlDiver database. For robotic cases, costs were reflective of operational fees and initial purchase costs. Complications and comorbidities (CC) and major CC (MCC) were assessed according to CMS.gov manual definitions. **Results:** A total of 360 propensity matched patients (120 open, 120 MIS, 120 robotic) were included. Descriptive statistics for the cohort were as follows: age 58.8 ± 13.5 years, 50% women, body mass index 29.4 ± 6.3, operative time 294.4 ± 119.0 minutes, length of stay 4.56 ± 3.31 days, estimated blood loss 515.9 ± 670.0 mL, and 2.3 ± 2.2 average levels fused. Overall, rates of postoperative complications were significantly higher in robotic cases than in open and MIS cases (43% v. 21% and 22% for open and MIS, $p < 0.05$). When compared with open and MIS cases, robotic cases had higher rates of nonreimbursable events (12.0% robotic v. 8.0% open, and 7.0% MIS, both $p < 0.001$), as well as baseline surgery costs (($60 047.01 v. $42 538.98 open and $41 471.21 MIS). On average, nonreimbursable events cost $20 299.07. The overall costs of care for patients who experienced nonreimbursable events were significantly higher for robotic patients than for open and MIS patients ($79 094.35 robotic v. $63 902.18 open and $61 957.87 MIS, both $p < 0.05$). **Conclusion:** Matching for levels fused, robot-assisted patients had 30% higher costs of surgery and rates of never-events compared with MIS and open spine surgery patients. Further longitudinal research is needed to fully assess the impact of nonreimbursable events in lumbar spine surgery.

Presentation G48
Abstract 164
Are there sex differences in preoperative health status and health care delivery for patients undergoing scheduled lumbar surgery? An analysis from the Canadian Spine Outcomes and Research Network. ***Mark A. MacLean, Ryan Greene, Sean D. Christie, on behalf of the CSORN Investigators.*** **From the Dalhousie University, Halifax, N.S. (MacLean, Greene, Christie); and the Canadian Spine Society, Toronto, Ont. (CSORN Investigators).**

Background: Sex differences in pre- and post-operative clinical assessment scores have been described for patients undergoing scheduled lumbar spine surgery for degenerative disease. Given this, our objective was to identify sex differences in preoperative health status, lifestyle, expectations of surgery and utilization of health care resources using a national spine database. **Methods:** Data were derived from the Canadian Spine Outcomes and Research Network (CSORN) prospective, multicentre registry for patients undergoing lumbar surgery for degenerative disease. Demographic variables, patient visits to health care professionals, use of diagnostic testing, physical activity level, analgesia use and other surrogate markers of health status were analyzed. Analysis of variance and χ^2 tests were used for continuous and categorical variables, respectively. **Results:** Data were analyzed for 5039 patients (2642 males and 2397 females). No preoperative sex differences were identified for age, body mass index, smoking status, use of diagnostic imaging or time with condition. Females were more likely to take over-the-counter drugs ($p < 0.001$), antiinflammatories ($p = 0.03$), antidepressants ($p < 0.001$) and neuroleptics ($p = 0.002$). Females were more likely to be on medication for more than a year ($p = 0.041$) and visit their family doctor ($p < 0.001$), emergency department ($p = 0.035$), a naturopath ($p = 0.019$) or a massage therapist ($p < 0.001$). A great proportion of males reported not taking medications for their back pain ($p < 0.001$) and had a worker's compensation claim ($p < 0.001$). Females were more likely to be widowed and males more likely to be married ($p < 0.001$). Females were more likely to live alone and males more likely to live with a partner ($p < 0.001$). A greater proportion of females were homemakers and males employed ($p < 0.001$), particularly in jobs requiring heavy lifting ($p < 0.001$). **Conclusion:** Females were more likely to utilize preoperative allied health care professionals and analgesia to treat their back pain. Sex differences in marital status, employment and living arrangements were identified. This study identifies differences in care between sexes and further study is required to better understand the reasoning behind these observations.

Presentation H49
Abstract 41
Patient phenotypes associated with functional outcomes after spinal cord injury: a principal component analysis in 1119 patients. ***Omar Khan, Jetan Badhiwala, Michael Fehlings.*** **From the Division of Neurosurgery, University of Toronto, Toronto, Ont.**

Background: Spinal cord injury (SCI) patients frequently experience significant disability and loss of functional capacity. However, the variables that best predict functional impairment after SCI are incompletely understood. Here, we use principal component analysis (PCA) to determine patient phenotypes that predict functional outcomes after SCI in a large prospective series of SCI patients. **Methods:** This is an ambispective analysis of 1119 patients from the North American Clinical Trials Network (NACTN) registry and the NASCIS-3 and STASCIS trials. The data set comprised 158 baseline predictor variables. The primary outcomes were complete independence in 14 functional domains from the functional independence measure (FIM) 1 year after SCI. PCA was performed on the data set by computation of a covariance matrix among the predictor variables, followed by eigen decomposition. The significant principal components (eigenvalues > 1) were used for multivariate logistic regression analyses for each outcome. Odds ratios were evaluated for each principal component (PC) to determine which PCs were strongly associated with each outcome. **Results:** We identified 9 significant PCs accounting for 87% of variance in the data. The first PC (PC1), dominated by the overall light touch and pinprick scores, had a significant positive correlation with all outcomes. PC4 was mainly derived from the overall motor scores and also showed a significant positive

correlation with all outcomes. Thus, patients with better neurologic function at baseline are most likely to achieve functional independence at 1 year. PC2 contained positive contributions from lower extremity neurologic scores and negative contributions from upper extremity neurologic scores. It was positively associated with independence in lower extremity functions and negatively associated with upper extremity functions. PC2 may represent the central cord syndrome phenotype, where patients have worse upper extremity function than lower extremity function. **Conclusion:** Data-driven techniques such as PCA have the ability to distinguish the effects of demographic and neurologic factors and accurately compile them into meaningful phenotypes that guide clinical management and inform patient selection in research trials.

Presentation H50
Abstract 103
Early versus late surgical decompression for acute traumatic spinal cord injury: a pooled analysis of prospective, multicentre data in 1548 patients. ***Jetan Badhiwala, Christopher Witiw, Jefferson Wilson, Michael Fehlings.* From the University of Toronto, Toronto, Ont.**

Background: The effect of time to decompression on neurologic recovery following acute traumatic spinal cord injury (SCI) remains unclear. This study leverages high-quality prospective data from over 1500 acute SCI patients to compare sensorimotor recovery with early (< 24 h) versus late (≥ 24 h) surgical decompression. **Methods:** Patients with acute SCI who underwent surgical decompression were identified from 4 prospective, multicentre SCI data sets (NACTN, STASCIS, Sygen, NASCIS III). Patients were dichotomized into early (< 24 h) and late (≥ 24 h) surgery groups. The primary end point was change in American Spinal Injury Association (ASIA) motor score (AMS) at 1 year. Secondary outcomes included ASIA Impairment Scale (AIS) grade and change in ASIA light-touch and pinprick scores at 1 year. One-stage meta-analyses comparing outcomes for early versus late surgery were performed by hierarchical mixed-effects regression using a stratified intercept to account for clustering of patients within individual studies. Fixed-effect covariates were specified for baseline score, age, injury mechanism, AIS grade, neurologic level and steroids. **Results:** A total of 1548 patients were eligible. Patients who underwent early surgery had greater improvements than the late surgery group at 1 year for AMS (mean difference [MD] 4.0, 95% confidence interval [CI] 1.7–6.2, $p = 0.001$), light-touch score (MD 4.6, 95% CI 1.9–7.2, $p = 0.001$) and pinprick score (MD 4.2, 95% CI 1.5–6.9, $p = 0.003$). Further, on "shift analysis," the early surgery group achieved a more favourable distribution of AIS grades at 1 year (crude odds ratio 1.46, 95% CI 1.14–1.87, $p = 0.003$). The effect of early surgery was strongest for cervical SCI ($p = 0.003$); however, there was a trend toward improved recovery with early versus late surgery for thoracic SCI as well ($p = 0.088$). **Conclusion:** In an individual patient data meta-analysis adjusting for confounders, we found early surgery, within 24 hours of injury, to be associated with superior sensorimotor recovery at 1 year following acute SCI, as compared with late surgery. These findings will inform clinical practice guidelines for acute SCI.

Presentation H51
Abstract 79
Clinical outcome correlation of diffusion tensor imaging and magnetic resonance imaging values: a systematic review. ***Kaelan Gobeil Odai, Hamid Nessek, Eugene Wai, Philippe Phan.* From the University of Ottawa and the Ottawa Hospital Research Institute, Ottawa, Ont.**

Background: Standard imaging for spinal cord injury (SCI), conventional magnetic resonance imaging (MRI), can only evaluate macroscopic spinal cord changes. Comparatively, microstructural changes can be addressed by diffusion tensor imaging (DTI). We aim to determine if DTI is a valid biomarker in SCI patients and if it correlates better than MRI with clinical outcomes (CO). **Methods:** A literature search was performed in PubMed, Medline and Web of Science. Eligibility criteria were traumatic or acute SCI evaluated by MRI, DTI and CO with imaging values correlated with CO. Exclusion criteria were postmortem patients, patient death upon arrival, nontraumatic SCI, lumbar SCI, chronic or degenerative myelopathy, autoimmune disorders, infection, case reports, narrative reviews, stem cell trials, animal studies, lack of CO evaluation, MRI quantitation or MRI/DTI correlation with CO. Levels of evidence were determined on the basis of predefined criteria. **Results:** The literature search yielded 3444 studies (1317 duplicates); 2027 were screened, 341 were assessed and 7 were selected. Four high-quality studies (HQS) identified conflicting associations between measures of DTI and various CO. However, multiple consistent studies presented strong evidence that DTI fractional anisotropy (FA) measures (subgroup) are correlated with various CO. Limited evidence from 1 low-quality study (LQS) demonstrated DTI measures do not correlate better with American Spinal Injury Association (ASIA) score than MRI. Moderate evidence from 1 HQS and 1 LQS supports that DTI does not have a greater correlation with International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) sensory scores than MRI. Moderate evidence from 1 HQS demonstrated that lateral funicle FA had greater correlation with Functional Independence Measure mobility scores than MRI. This should be interpreted with caution as it is the only relationship of many for which we identified DTI being significantly greater than MRI. Additionally, most studies involve small numbers, therefore posing the risk of type II error. **Conclusion:** Strong evidence supports DTI FA as a valid biomarker for CO, yet no consistent evidence indicates better correlation than MRI. Further study, with larger numbers, is required to determine if specific types of DTI in addition to MRI improve prognostic classification.

Presentation H52
Abstract 137
A numerical study on the pathogenesis of central cord syndrome. ***Nicolas Bailly, Lucien Diotalevi, Marie-Hélène Beauséjour, Eric Wagnac, Jean-Marc Mac-Thiong, Yvan Petit.* From École de Technologie Supérieure, Montreal, Que. (Bailly, Beauséjour, Wagnac, Petit); the International Laboratory — Spine Imaging and Biomechanics (iLab-Spine), Montreal, Que. (Bailly, Diotalevi, Beauséjour, Wagnac, Petit); the Centre de recherche de l'Hôpital du Sacré-Coeur de Montréal, Montreal, Que. (Diotalevi); and Université de Montréal, Montreal, Que. (Mac-Thiong).**

Background: The pathogenesis of the central cord syndrome is still unclear. There is a consensus that hyperextension is the main traumatic mechanism leading to this condition; however, the underlying mechanism of spinal cord injury is still debated. The aim of this study is to assesses the impact of intervertebral disc bulging and ligamentum flavum hypertrophy on the pathogenesis of central cord syndrome using numerical simulations. **Methods:** A detailed finite element model of the cervical spine and spinal cord was used to simulate high-speed hyperextension. Four typical case scenarios of preexisting spondylotic cervical stenosis were modelled to study the impact of hypertrophic ligamentum flavum and intervertebral disc bulging on the von Mises stress and strain in the cord. **Results:** During hyperextension, the downward displacement of the ligamentum flavum and associated reduction in spinal canal diameter (up to 17%) led to dynamic compression of the spinal cord. Ligamentum flavum hypertrophy was associated with stress and strain (peak of 0.17 MPa and 0.26 mPA, respectively) in the lateral corticospinal tracts, which is consistent with the histologic pattern seen with a central cord syndrome. Intervertebral disc bulging alone led to a higher stress in the anterior and posterior funiculi (peak 0.22 MPa). Combined with hypertrophic ligament flavum, it increased the stress and strain in the corticospinal tracts and in the posterior horn (peak of 0.3 MPa and 0.3 mPa, respectively). **Conclusion:** Preexisting stenotic features (location and geometry) greatly influence the stress and strain distribution resulting from hyperextension. According to the results of this study, ligamentum flavum hypertrophy is a main feature contributing to central cord syndrome.

Presentation H53
Abstract 42
Feasibility and utility of machine learning in prediction of bladder outcomes after spinal cord injury: analysis of 1250 patients from the European Multicenter Study about Spinal Cord Injury (EMSCI) registry. ***Omar Khan*, *Jetan Badhiwala*, *Michael Fehlings*. From the Division of Neurosurgery, University of Toronto, Toronto, Ont.**

Background: Neurogenic bladder dysfunction is a common and devastating consequence of spinal cord injury (SCI), making the early prediction of bladder function important in facilitating timely urologic management. The goal of this work is to demonstrate the feasibility and utility of machine learning (ML) as a superior tool in the prediction of independence in bladder function after SCI. **Methods:** Data from 1250 patients enrolled in the European Multicenter Study about Spinal Cord Injury (EMSCI) registry were analyzed. Important predictors included baseline demographic features and neurologic scores. The primary outcome measure was independence in bladder function 1 year after injury, determined using item 6 of the Spinal Cord Independence Measure. Multiple ML models were trained and optimized on the data set using 10-fold cross-validation. A previous logistic regression model was compared with the ML models using a separate 111-patient validation data set from the EMSCI registry. The calibration and area under the receiver operating characteristic curves (AUC) were used to compare model performance. **Results:** The extreme gradient-boosted decision tree exhibited excellent discrimination on the training set, with an AUC of 0.948. This exceeded the AUC of 0.932 that the logistic regression model showed on the same data set. Additionally, when evaluated on the testing set, the ML model had an AUC of 0.981 (sensitivity 89%, specificity 98%), compared with an AUC of 0.965 of the logistic regression model. The calibration curves for the ML model also showed good concordance between the actual and predicted probabilities. Our ML models showed that an increased baseline lower extremity motor score, intact anal contraction, and pinprick sensation at S3 were the most important predictors of independence in bladder function 1 year after SCI. **Conclusion:** We demonstrated that ML models provide excellent prediction of independence in bladder function after SCI. As a result, ML can serve as a valuable and practical tool for clinicians managing SCI.

Presentation H54
Abstract 18
Interventions to optimize spinal cord perfusion in patients with acute traumatic spinal cord injuries: a systematic review. ***Nathan Evaniew*, *Shahriar Mazlouman*, *Emilie Belley-Côté*, *Bradley Jacobs*, *Brian Kwon*. From the University of British Columbia, Vancouver, B.C. (Evanview, Kwon); the University of Calgary, Calgary, Alta. (Evanview, Jacobs); the International Collaboration on Repair Discoveries (ICORD), Vancouver, B.C. (Mazlouman, Kwon); and McMaster University, Hamilton, Ont. (Belley-Côté).**

Background: Interventions to optimize spinal cord perfusion via support of mean arterial pressure (MAP) or spinal cord perfusion pressure (SCPP) are thought to play a critical role in the management of patients with acute traumatic spinal cord injuries, but there is ongoing controversy about efficacy and safety. We aimed to determine the effects of optimizing spinal cord perfusion on neurologic recovery and risks for adverse events. **Methods:** We searched multiple databases for published and unpublished reports. Two reviewers independently screened articles, extracted data and evaluated risk of bias. We synthesized data and evaluated confidence in anticipated treatment effects according to the grades of the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) approach. **Results:** We identified 20 eligible observational studies and 1 eligible randomized controlled trial. According to low or very low quality evidence, the effect of MAP support on neurologic recovery after acute traumatic spinal cord injury is uncertain, and the use of vasopressors to support MAP may be associated with increased rates of predominantly cardiac adverse events. Increased SCPP might be associated with improved neurologic recovery, but SCPP monitoring via intradural catheters at the anatomic site of injury may involve increased risks of cerebrospinal fluid leakage requiring revision surgery or pseudomeningocele. No study directly compared the effects of specific MAP targets, SCPP targets, SCPP monitoring techniques or durations of treatment. Very low quality evidence suggests that norepinephrine may have less risk of adverse events than dopamine. **Conclusion:** The current literature is insufficient to make strong recommendations about interventions to support spinal cord perfusion via MAP or SCPP goals in patients with acute traumatic spinal cord injuries. Data are compatible with a variety of treatment decisions, and a nuanced approach may be optimal. Further investigation to clarify the risks, benefits and alternatives to MAP or SCPP support in this population is warranted.

Presentation i55
Abstract 55

The effect of posterior lumbar spinal surgery on passive stiffness of rat paraspinal muscles 13 weeks post-surgery. ***Shun Yamamoto, Masoud Malakoutian, Marine Theret, John Street, Stephen Brown, Fabio Rossi, Thomas Oxland.*** **From the Orthopaedic and Injury Biomechanics Group, Departments of Mechanical Engineering and Orthopaedics, University of British Columbia, Vancouver, B.C. (Yamamoto, Malakoutian, Street, Oxland); the International Collaboration on Repair Discoveries (ICORD),University of British Columbia, Vancouver, B.C. (Yamamoto, Malakoutian, Oxland); the Department of Medical Genetics, University of British Columbia, Vancouver, B.C. (Theret, Rossi); the Department of Orthopaedics, University of British Columbia, Vancouver, B.C. (Street); and the Department of Human Health and Nutritional Sciences, University of Guelph, Guelph, Ont. (Brown).**

Background: The paraspinal muscles are key spine stabilizers and iatrogenic muscle damage may lead to postoperative functional disability. The influence of surgery on paraspinal muscles is important, but few biomechanical studies have been done. The purpose of this study is to evaluate the passive mechanical properties of paraspinal muscles after posterior spinal surgery in an animal model. **Methods:** Twelve Sprague–Dawley rats were divided equally into 2 groups, sham and surgical injury. For the surgical injury group, the paraspinal muscles were detached from the vertebrae, per normal surgical procedures. After 13 weeks, multifidus and longissimus were biopsied at the L1, L3 and L5 levels. The passive stiffness of 4 fibre bundles and 3 fibres of each muscle was tested biomechanically. **Results:** A total of 220 fibres and 279 fibre bundles were tested. The passive stiffnesses of the multifidus and longissimus muscle fibres, as well as the longissimus fibre bundles, were not statistically different between the surgery and sham groups ($p > 0.01$). However, the stiffness of the multifidus muscle fibre bundles was significantly greater in the surgical injury group ($p < 0.01$) **Conclusion:** Posterior spine surgery changes the passive mechanical properties of multifidus fibre bundles. Fibrotic changes that result in stiffer muscle are probably important in the postoperative compensation of the spine. Future work will address the changes in muscle properties in people with spinal deformity.

Presentation i56
Abstract 43

A computed tomographic based morphometric analysis of the axis in adult population. ***Manmohan Singh, Pankaj Singh, Sarat Chandra.*** **From the All India Institute of Medical Sciences, New Delhi, India.**

Background: Fractures of the odontoid process of the axis have been a matter of extensive research as they constitute 10% of all cervical spine injuries. Odontoid screw placement, although technically challenging, is the ideal treatment in indicated cases. Thorough knowledge of the dimensions of the odontoid process is necessary before surgical endeavours, more so when planning double odontoid screws. **Methods:** A prospective morphometric analysis of retrospective data of 250 patients was conducted using a Somatom Definition Edge 128-slice 64-row detector Seimens computed tomography (CT) scanner. The dimensions of the odontoid process were measured at the waist (narrowest portion), at the widest diameter and just 2 mm below the tip in both the anteroposterior and transverse diameters. The dimensions of the C2 vertebra were also measured at the level of the superior and inferior end plates both in the coronal and in the sagittal plane. **Results:** A total of 250 patients were evaluated, with age ranging from 18 to 80 years. Men constituted 174 (69.6%) while 76 (30.4%) were women. Mean transverse diameter (TD) at the odontoid waist (narrowest diameter) was 8.84 mm and 8.47 mm in men and women, respectively ($p = 0.016$). Mean TD at the widest point of the odontoid was 9.93 mm in men and 9.42 mm in women ($p = 0.002$). Mean TD at the C2 base was 15.07 mm in men and 13.64 mm in women ($p < 0.001$). Mean anteroposterior (AP) diameter 2.5 mm away from the midline at the left side at the level of the waist was 9.87 mm in men and 9.15 mm in women ($p < 0.001$). Mean AP diameter at the C2 base was 15.82 mm in men and 14.83 mm in women ($p < 0.001$). Mean AP diameter at the C2 body superior surface was 11.82 mm in men and 11.199 mm in women ($p < 0.001$). C**onclusion:** Double odontoid screw insertion is feasible in only 36% of the population in the transverse plane while 98.4% of the odontoids can accommodate double screws in the sagittal plane if the orientation of the screws is changed.

Presentation i57
Abstract 92

Is there value to flexion–extension x-rays for degenerative spondylolisthesis? A multicentre retrospective study. ***Aidin Kashigar, Joseph Laratta, Leah Carreon, Erica Bisson, Zoher Ghogawala, Andrew Yew, Tino Mkorombindo, Praveen Mummaneni, Steven Glassman.*** **From the Norton Leatherman Spine Center, Louisville, Ky. (Kashigar, Laratta, Carreon, Mkorombindo, Glassman); the University of Utah, Salt Lake City, Utah, (Bisson); the Tufts University School of Medicine, Burlington, Mass. (Ghogawala); Beth Israel Lahey Health, Burlington, Mass. (Yew); and the University of California, San Francisco, Calif. (Mummaneni).**

Background: Flexion–extension views are frequently used to assess motion in patients with degenerative spondylolisthesis. However, they expose patients to additional radiation and potentially to increased cost. The aim of this study is to determine if flexion–extension x-rays provide additional information not seen on upright lateral x-rays and supine magnetic resonance imaging (MRI) that may guide surgical decision-making. **Methods:** From the Quality Outcomes Database, patients who had surgery for grade 1 degenerative spondylolisthesis were identified. Magnitude of slip on preopoperative supine MRI, upright neutral, flexion and extension x-rays were measured. Additional motion was defined as more than 3-mm slip difference between films. For the purpose of this analysis, patients with a slip of more than 7 mm on upright neutral were assumed to require a fusion. **Results:** One hundred and ninety-one patients were identified. Mean age was 61.6 years (114 females, 60%). Only 12 patients (6%) had additional motion on flexion–extension views but not on upright x-rays versus supine MRI. Of these 12 patients, 8 had slips of less than 7 mm on upright x-ray, generating equipoise for fusion. **Conclusion:** Flexion–extension x-rays may play a limited role in the management of degenerative spondylolisthesis. In over 94%

of spondylolisthesis cases, information used for surgical planning may be ascertained by comparing motion between supine MRI and upright lateral x-rays. The subset of patients for which flexion–extension views were most likely to provide value were patients with smaller slips (< 7 mm) with no evidence of motion on standing x-rays versus MRI.

Presentation i58
Abstract 98
The novel "7/20 EMG protocol" in combination with O-arm image-guided navigation for accurate lumbar pedicle placement while minimizing diagnostic radiation exposure. ***Amit Persad, Michael Kindrachuk, Luke Hnenny, Adam Wu, Jonathan Norton, Daryl Fourney.*** **From the University of Saskatchewan, Saskatoon, Sask.**

Background: Three-dimensional image navigation (e.g., O-arm, Stealth) has largely supplanted freehand methods and plain x-rays for accurate placement of lumbar pedicle screws. The current imaging is of such high quality that the role of electromyography (EMG) as an adjunct for safety has been questioned. Many surgeons perform "final check" O-arm imaging of screws, but this repeat patient radiation exposure may be unnecessary. The objective of this study was to validate a standardized intraoperative EMG protocol as an adjunct to O-arm image-guided navigation to reduce diagnostic radiation exposure. **Methods:** We are conducting a prospective cohort analysis of all patients undergoing elective lumbar instrumentation. Inclusion criteria include age older than 18 years, elective procedure and degenerative spinal etiology. All screws were placed using a standard "7/20 EMG protocol," O-arm image-guided navigation, and "final check" O-arm assessment of screw placement. The primary outcome is prediction of any potentially clinically relevant pedicle breach at any stage of the procedure. **Results:** Information on 45 patients and 282 pedicle screws has been collected so far. Eight screws were revised intraoperatively: 4 because of abnormal 7-mA stimulation, 1 because of screw depth on fluoro, 2 because of palpable defect and 1 because of 20-mA stimulation. Sensitivity of 7-mA stimulation is 0.8, with specificity of 0.96 and a false positive rate of 64%. Mann–Whitney *U* test found a *p* value of 0.03 for 7-mA stimulation in prediction of screw breakthrough. **Conclusion:** In this study, 7-mA stimulation was the most common reason for intraoperative screw revision. O-arm imaging and 20-mA stimulation had equal results in the setting of false-positive 7-mA stimulation. These findings suggest that O-arm guided navigation supplemented with EMG may render "final check" O-arm imaging of screws unnecessary.

Presentation i59
Abstract 148
Comparative biomechanical study of 2 types of transdiscal fixation implants for high-grade L5/S1 spine spondylolisthesis in a porcine model. ***Renan Jose Rodrigues Fernandes, Aaron Gee, Hui-Ling Kerr, Andrew Kanawati, Radovan Zdero, Kevin Gurr, Christopher Bailey, Parham Rasoulinejad.*** **From Western University, London, Ont.**

Background: High-grade lytic spondylolisthesis is fused through a variety of surgical techniques, but there is little biomechanical comparison between techniques in the literature. This biomechanical study compares 2 transdiscal fixation techniques for high-grade spine spondylolisthesis in an in-vitro porcine lumbar spine model. **Methods:** Twelve lumbar–sacral porcine spines were divided into 2 groups. Soft tissues were removed while preserving the ligaments and discs. Segments were potted in cement at L3 and S1. Baseline range of motion (ROM) and stiffness testing was performed on intact specimens using a pure moment protocol for 3 cycles. Afterward, a high-grade isthmic spondylolisthesis was created and surgically stabilized according to the proposed technique. The transdiscal screw (Screw) technique connected L4 pedicle screws to transdiscal screws starting in S1 and crossing into the L5 vertebral body. The transdiscal fibula (Fibula) graft technique joined L4 to S1 pedicle screws associated with a transdiscal fibula strut graft. The same stiffness and ROM protocol were performed. Analysis used unpaired 2-tailed Student *t* test; significance was determined as *p* less than 0.05. **Results:** Compared with intact specimens, both techniques had significantly less flexion–extension (FE) ($p < 0.001$) and lateral bending (LB) ($p < 0.02$) but no significant difference in axial rotation (AR). The Screw technique had significantly less motion in FE compared with Fibula, but not in LB and AR. There was no difference in stiffness between the Screw technique and intact specimens. The Fibula technique had significantly higher LB ($p < 0.001$) stiffness, lower AR stiffness ($p = 0.017$) and no difference in FE stiffness compared with intact specimens. The Screw technique was significantly stiffer than the Fibula technique in AR ($p = 0.004$), but not different in FE or LB stiffness. **Conclusion:** Both fixation techniques limit motion and increase stiffness compared with intact specimens. Screw is stiffer and has reduced ROM compared with Fibula.

Presentation i60
Abstract 85
The effects of fibre bundle size and vertebral level on passive stiffness of the lumbar paraspinal muscles in a rat model. ***Masoud Malakoutian, Shun Yamamoto, Sandeep Sadaram, Jason Speidel, Jie Liu, John Street, Stephen Brown, Thomas Oxland.*** **From the Department of Mechanical Engineering, University of British Columbia, Vancouver, B.C. (Malakoutian, Sadaram, Speidel, Oxland); the International Collaboration on Repair Discoveries (ICORD), University of British Columbia, Vancouver, B.C. (Malakoutian, Yamamoto, Liu, Street, Oxland); the Department of Orthopaedics, University of British Columbia, Vancouver, B.C. (Street, Oxland); and the Department of Human Health and Nutritional Sciences, University of Guelph, Guelph, Ont. (Brown).**

Background: Passive mechanical properties of the paraspinal muscles are important to the biomechanical functioning of the spine. In most computational models, the same mechanical properties are assumed for all paraspinal muscles, which may be untrue. Further, most studies assume that the fibre bundle stiffness is proportional to cross-sectional area, but this assumption may not completely address the effect of bundle size. The objectives of this study are (a) to explore whether passive stiffness of a fibre or a fibre bundle in paraspinal muscles depends on the spinal level and (b) to explore if the size of a fibre bundle has an influence on its passive stiffness. **Methods:** The left paraspinal muscles of 13 Sprague–Dawley rats were exposed under

anesthesia. Six muscle biopsies were collected from each rat: 3 from multifidus (1 per each of the L1, L3 and L5 levels) and similarly 3 from longissimus. From each biopsy, 2 to 3 fibres and 2 to 6 fibre bundles were mechanically tested in passive state. **Results:** A total of 182 fibres and 246 fibre bundles were tested. In both muscle groups, neither the fibres nor the fibre bundles showed a significant difference in passive stiffness among the 3 spinal levels (for fibres: $p = 0.9$ multifidus, $p = 0.08$ longissimus; and for fibre bundles: $p = 0.13$ multifidus, $p = 0.49$ longissimus). There was a significant effect of fibre bundle size on its passive stiffness, with lower stiffness associated with larger bundles ($p < 0.001$). **Conclusion:** This study highlighted that the passive stiffness of the lumbar paraspinal muscles is independent of spinal level in a rat model. This finding provides the basis for the assumption of similar mechanical properties along a paraspinal muscle group. We found that the size of a fibre bundle influences its passive stiffness, even after normalizing for cross-sectional area. This finding emphasizes that fibre bundle sizes should be consistent when compared between different groups.

Presentation J61
Abstract 157

A self-assembling peptide biomaterial to enhance human neural stem cell-based regeneration of the injured spinal cord. ***Christopher Ahuja, Mohamed Khazaei, Inaara Walji, Maryam Dadabhoy, Nitya Gulati, Niharikaa Aiyar, Sophie Ostmeier, Ali Hasan, Vjura Senthilnathan, Nayaab Punjani, Yao Yao, Suyue Yue, Gokce Ozdemir, Zijian Lou, William Luong, Alex Post, Amirali Tootsi, Priscilla Chan, Michael Fehlings.*** **From the University of Toronto, Toronto, Ont. (Ahuja, Walji, Dadabhoy, Gulati, Aiyar, Hasan, Senthilnathan, Punjani, Ozdemir, Lou, Luong, Post, Fehlings); the University Health Network, Toronto, Ont. (Ahuja, Khazaei, Ostmeier, Yao, Yue, Ozdemir, Lou, Luong, Post, Tootsi, Fehlings); and the University of British Columbia, Vancouver, B.C. (Chan).**

Background: Human induced pluripotent stem cell-derived neural stem cells (hiPS-NSCs) are a promising therapeutic approach for regeneration after traumatic spinal cord injury (SCI). Unfortunately, most patients are in the chronic phase of injury where ex vacuo microcystic cavitation forms a formidable barrier to regenerative cell migration and neurite outgrowth. QL6 (K2(QL)6K2; Medtronic) is a novel, biodegradable, peptide biomaterial that self-assembles into an extracellular matrix (ECM)-like lattice in vivo. It has previously been shown to reduce inflammation and support endogenous and exogenous mouse cell survival. However, its ability to support translationally relevant hiPS-NSCs continues to be a critical knowledge gap. **Methods:** Nonvirally derived hiPS-NSCs were cultured on QL6 biomaterial versus a Geltrex ECM control. The mechanism of adhesion was assessed by ethylenediaminetetraacetic acid (EDTA) assay and quantitative polymerase chain reaction (qPCR). hiPS-NSC survival, proliferation and neurosphere formation were extensively characterized in vitro through immunohistochemistry and scanning electron microscopy techniques. T cell deficient RNU rats ($n = 60$) capable of supporting a human graft were given a clinically relevant C6–7 clip-contusion injury or sham surgery. In the chronic injury phase, animals were randomly assigned to (a) vehicle, (b) hiPS-NSCs, (c) QL6 or (d) QL6+hiPS-NSCs. All rats received delayed daily treadmill rehabilitation. A subset of animal cords underwent high-throughput single-cell RNA sequencing (scRNAseq). **Results:** hiPS-NSCs proliferated robustly on self-assembled QL6 versus control as demonstrated by Ki67+/DAPI+ immunocytochemistry (29% v. 6%, $p < 0.01$). EDTA adhesion assay demonstrated that human NSC binding to QL6 is largely driven by calcium-independent mechanisms. Importantly for NSCs, QL6 enhanced the formation of adherent neurospheres, the native conformation of NSCs. Scanning electron microscope imaging demonstrated an interwoven human NSC–biomaterial interaction in vitro. Blinded sensorimotor assessments of transplanted rats are ongoing with a 22-week postinjury end point. Early scRNAseq differential gene expression analyses demonstrate enhanced mature oligodendrocyte marker expression (MBP, MAG) by the graft when cotransplanted with QL6. **Conclusion:** This work provides key proof-of-concept data that QL6 self-assembling peptide can support translationally relevant human iPS-NSCs for use in traumatic SCI.

Presentation J62
Abstract 162

Measuring demyelination, axonal loss and inflammation after human spinal cord injury with quantitative magnetic resonance imaging and histopathology. ***Sarah Morris, Andrew Yung, Shana George, Valentin Prevost, Andrew Bauman, Piotr Kozlowski, Farah Samadi, Caron Fournier, Lisa Parker, Kevin Dong, Femke Streijger, Wayne Moore, Cornelia Laule, Brian Kwon.*** **From the International Collaboration on Repair Discoveries (ICORD), University of British Columbia, Vancouver, B.C. (Morris, Yung, George, Prevost, Bauman, Kozlowski, Samadi, Fournier, Dong, Streijger, Moore, Laule, Kwon); the Department of Physics and Astronomy, University of British Columbia, Vancouver, B.C. (Morris, Kozlowski, Laule); the Department of Radiology, University of British Columbia, Vancouver, B.C. (Morris, Yung, Provost, Bauman, Kozlowski, Laule); the UBC MRI Research Centre, University of British Columbia, Vancouver, B.C. (Yung, Prevost, Bauman, Kozlowski); Carson Graham Secondary School, North Vancouver, B.C. (George); the Department of Pathology and Laboratory Medicine, University of British Columbia, Vancouver, B.C. (Samadi, Fournier, Moore, Laule); Vancouver General Hospital, Vancouver, B.C. (Parker, Moore); the Department of Medicine, University of British Columbia, Vancouver, B.C. (Moore); and the Vancouver Spine Surgery Institute, University of British Columbia, Vancouver, B.C. (Kwon).**

Background: Magnetic resonance imaging (MRI) is commonly used to characterize spinal cord damage after acute traumatic injury. Objective MRI biomarkers could help define injury severity and prognosticate outcome after spinal cord injury (SCI). While MRI features have been correlated to injury severity and used to predict outcome, it is typically not possible to relate MRI features with the actual histopathology within the injured spinal cord. Here, we took advantage of postmortem spinal cords obtained from acute SCI patients to relate specific quantitative MRI features with the actual histology of the injured spinal cord. **Methods:** Eleven whole formalin-fixed spinal cords from the International SCI Biobank had high-field 7-Tesla MRI to assess myelin (inhomogeneous magnetization transfer, ihMT) as well

as axons, intracellular water, extracellular water and free water (diffusion basis spectrum imaging, DBSI). Time from SCI to death was 1–60 days. After MRI, the cord was sectioned and stained with hematoxylin and eosin (H&E) (nuclei/cytoplasm), Luxol fast blue (myelin phospholipids), phosphorylated neurofilament (axons) and fibrinogen (blood–spinal cord barrier breakdown). Ascending sensory and descending motor tracts were examined. **Results:** Histology showed axonal spheroids in H&E and phosphorylated neurofilament stains, and blood–spinal cord barrier breakdown through fibrinogen leakage. ihMT was significantly correlated with myelin staining ($R^2 = 0.731$, $p < 0.001$). ihMT and DBSI-measured axon fibre fractions were 20%–30% lower in downstream areas, consistent with demyelination and axonal loss due to Wallerian degeneration. In the same areas intracellular water increased by 20%, possibly because of greater density of inflammatory cells. Extracellular and free water increased up to 50% near the injury epicentre, consistent with edema and tissue structure breakdown. **Conclusion:** ihMT was established as a biomarker for myelin in human spinal cord tissue. DBSI and ihMT MRI techniques detected microstructural changes in downstream areas consistent with Wallerian degeneration in acute and subacute lesions in SCI. This is the first study to correlate these quantitative MRI measures with actual histopathologic findings in acute human SCI.

Presentation J63
Abstract 179

Characterization of ubiquitin C-terminal hydrolase L1 (UCH-L1) as a fluid biomarker of human traumatic spinal cord injury. ***Sophie Stukas*, *Jasmine Gill*, *Jennifer Cooper*, *Kevin Dong*, *Femke Streijger*, *John Street*, *Scott Paquette*, *Tamir Ailon*, *Raphaele Charest-Morin*, *Charles Fisher*, *Marcel Dvorak; Sanjay Dhall*, *Jean-Marc Mac-Thiong*, *Stefan Parent*, *Christopher Bailey*, *Sean Christie*, *Cheryl Wellington*, *Brian Kwon*. From the Department of Pathology and Laboratory Medicine, University of British Columbia, Vancouver, B.C. (Stukas, Gill, Cooper, Wellington); the Djavad Mowafaghian Centre for Brain Health, University of British Columbia, Vancouver, B.C. (Stukas, Gill, Cooper, Wellington); the International Collaboration on Repair Discoveries (ICORD), University of British Columbia, Vancouver, B.C. (Dong, Streijger, Kwon); the Department of Orthopedics, Division of Spine, University of British Columbia, Vancouver, B.C. (Street, Charest-Morin, Fisher, Dvorak, Kwon); the Division of Neurosurgery, University of British Columbia, Vancouver, B.C. (Paquette, Ailon); the Department of Neurosurgery, University of California, San Francisco, Calif. (Dhall); Hôpital du Sacré-Coeur de Montréal, Montreal, Que. (Mac-Thiong); the Department of Surgery, Centre hospitalier universitaire Sainte-Justine, Montreal, Que. (Parent); the Division of Orthopaedic Surgery, Schulich School of Medicine and Dentistry, Victoria Hospital, London, Ont. (Bailey); and the Division of Neurosurgery, Halifax Infirmary, Dalhousie University, Halifax, N.S. (Christie).**

Background: A major obstacle for translational research in acute spinal cord injury (SCI) is the lack of biomarkers that can be used to objectively stratify injury severity and predict outcome. Given the pathophysiologic similarities of neurotrauma in the brain and spinal cord, we hypothesize that traumatic brain injury (TBI) biomarkers will also be useful as diagnostic and prognostic biomarkers of SCI. Ubiquitin C-terminal hydrolase L1 (UCH-L1) is a neuron-specific enzyme that has been proposed as a diagnostic biomarker in TBI, with US Food and Drug Administration (FDA) approval granted in 2018 for its use as a screening tool in mild TBI. **Methods:** Cerobrospinal fluid (CSF) and serum samples were collected as part of an ongoing multicentre clinical initiative in acute SCI patients with prospectively collected neurologic outcomes at 6 months after injury (ClinicalTrials.gov NCT01279811). UCH-L1 concentration was measured using the Quanterix Simoa platform in 10 laminectomy controls and 32 SCI patients and correlated to injury severity, time and neurologic recovery. **Results:** CSF UCH-L1 was significantly elevated 10- to 100-fold over laminectomy controls in an injury-severity-dependent manner following SCI, with sustained elevations observed in the most severely injured patients up to 5 days. While initial levels of CSF UCH-L1 were not significantly different between those SCI patients who improved an American Spinal Injury Association Impairment Scale (AIS) grade over 6 months versus those who did not improve, categorizing subjects on the basis of the trajectory of CSF UCHL-1 over the first 5 days after injury was 80% accurate in predicting AIS conversion in AIS A subjects. Further, 24-hour postinjury CSF UCH-L1 concentrations were negatively correlated with motor score change over 6 months. There was a weak to moderate correlation between serum and CSF UCH-L1; however, no change between acute SCI and control was observed. **Conclusion:** Our first evaluation of UCH-L1 in acute SCI shows promise as a biomarker in CSF to reflect injury severity and predict outcome in acute SCI. Further assay development to increase sensitivity is required to translate utility to serum analysis.

Presentation J64
Abstract 13

Utility and role of virtual reality based simulation models in spinal decompression training. ***Tan Chen*, *Eric Crawford*, *Yukun Zhang*, *Michael Hardisty*, *Joel Finkelstein*. From the Division of Spine Surgery, Sunnybrook Health Sciences Centre, Toronto, Ont. (Chen, Crawford, Finkelstein); and the Sunnybrook Research Institute, Sunnybrook Health Sciences Centre, Toronto, Ont. (Zhang, Hardisty).**

Background: Surgical simulation is a valuable educational tool for trainees to practise in a safe, standardized and controlled environment. Interactive feedback-based virtual reality (VR) has only recently moved to the forefront of spine surgery training, with the majority of commercial products focused on pedicle screw placement. There is a paucity of learning tools to understand anatomy, pathology and principles of treatment in spinal stenosis. The purpose of this study was to evaluate the efficacy of a VR simulation model and its educational role in decompression surgery. **Methods:** A VR simulation module was designed using the Samsung Odyssey user interface and incorporated patient-specific 3D-interactive models of lumbar spinal stenosis. A surgical toolkit allowed users to perform decompression procedures. Orthopedic and neurosurgical trainees were prospectively enrolled. Subjects underwent a pretest on anatomic knowledge and critical information on spinal stenosis,

after which they performed VR spinal decompression. A post-test and exit questionnaire was administered to assess module utility as a learning device. **Results:** A total of 15 trainees were enrolled (12 orthopedic, 3 neurosurgical). Pretest scores on spine anatomic knowledge progressively improved and showed strong positive correlation with year in training (Pearson r = 0.78). Following simulation, the average improvement in post-test scores was 11.7% in junior trainees (postgraduate year [PGY] 1 and 2) and 2.9% in senior trainees (PGY3 to fellows). A total of 93% of participants found the VR module useful in understanding the pathology of spinal stenosis, 80% found it useful in learning to perform a decompression and 100% believed it had utility in preoperative planning with patient-specific models. **Conclusion:** Simulations play a vital role in medical training and can be influential as surgical curricula become more competency based. Our original VR spinal decompression module has shown to be overwhelmingly positively received among trainees as a learning module of both pathoanatomy and patient-specific preoperative planning, with particular benefit for junior trainees. With further integration of haptic and acoustic feedback, VR-based training modules will be instrumental in the future of surgical education in a way that is interactive, safe and immersive.

Presentation J65
Abstract 160
Investigating the determinants for predicting surgical patient outcomes through the application of machine learning methods. ***Ege Babadagli, Nelofar Kureshi, Lisa Julien, Raza Abidi, Sean Christie*****. From Dalhousie University, Halifax, N.S. (Babadagli, Kureshi, Abidi, Christie); and the Nova Scotia Health Authority, Halifax, N.S. (Julien).**

Background: The Calgary Spine Assessment Score (CSAS) is a surgical spine referral scoring system, consisting of clinical, pathologic and radiologic criteria. Using machine learning methods, we sought to determine the subset of features from the CSAS and patient-reported scores that may predict surgical outcomes. **Methods:** A total of 145 retrospective, surgical patients with degenerative lumbar conditions were included. The initial data set contained demographic data, CSAS, pre- and postoperative SF-12 physical component score (PCS), Oswestry Disability Index (ODI) and Visual Analogue Scale scores. Waikato Environment for Knowledge Analysis (WEKA) was used. Feature selection was performed using information gain ratio. Classification models based on decision tree (C4.5), support vector machine with stochastic gradient descent (SVM-SGD) and logistic regression with stochastic gradient descent (Log-SGD) algorithms were trained on selected features to predict SF-12 PCS. Classification performance was evaluated with 10-fold cross-validation following 10 runs and statistically compared against a baseline classification model, based on the zero-rule (ZeroR) algorithm, using a corrected resampled paired t test (significance level = 0.05). **Results:** An information gain ratio of 0.005 was determined to be appropriate for feature selection in predicting SF-12 PCS related surgical outcomes, resulting in a reduction from 9 to 3 clinical, 7 to 4 pathologic, and 10 to 4 radiologic Assessment Score features, as well as a reduction from 73 to 43 total data set features. Assessment Score features with the highest information gain ratio, and therefore relevance, were indeterminate pathology (0.1918), radiologic instability (0.1677) and congenital pathology (0.1216). Baseline mean and maximum classification accuracies were 62.24% and 62.24%, respectively, for ZeroR. Mean and maximum classification accuracies were 80.70% and 82.56% for C4.5, 76.24% and 80.45% for Log-SGD, 77.64% and 81.22% for SVM-SGD. **Conclusion:** Information gain ratio resulted in an acceptable initial selection of a subset of features from the Assessment Score, SF-12 PCS, ODI and VAS most relevant to predicting SF-12 PCS and ODI related surgical outcomes. C4.5, Log-SGD and SVM-SGD models resulted in statistically significant improvements over the baseline model for predicting SF-12 PCS related surgical outcomes.

Presentation J66
Abstract 143
Comparison of screw design and technique on cervical lateral mass screw fixation. ***Mark Xu, Sara Parashin, Trevor Gascoyne, Michael Goytan*****. From the University of Manitoba, Winnipeg, Man. (Xu, Goytan); and the Orthopaedic Innovation Centre, Winnipeg, Man. (Parashin, Gascoyne).**

Background: The goal of this study is to determine the best screw type, insertion depth and trajectory for achieving optimal mechanical strength of the bone–screw interface for cervical lateral mass screws. **Methods:** Two lateral mass screw designs, 2 surgical techniques and 3 purchase depths are being tested and compared for lateral mass screw fixation. This includes (a) cortical versus cancellous thread-types, (b) Roy Camille versus Magerl trajectory and (c) depth of fixation: bicortical, backed-out bicortical and unicortical. Screws are being tested in laminated cortical-cancellous-cortical artificial bone blocks of similar material properties to cortical and cancellous bone found in the cervical spine. Static axial pull-out tests are being performed using a controlled load frame apparatus, where screw fixation is defined as maximum force to pull-out failure. Six replicates will be tested per sample group. Group means and standard deviations are to be reported and compared between sample groups to assess the variables of screw fixation strength in cervical spinal fusion. **Results:** Preliminary pull-out strength results demonstrate that regardless of insertion trajectory, bicortical purchase depth is stronger than both unicortical and backed-out bicortical purchase depths (Roy-Camille: 666 ± 50 N v. 522 ± 37 N v. 582 ± 19 N) (Magerl: 462 ± 55 N v. 338 ± 28 N v. 354 ± 31 N). Furthermore, no difference is seen between unicortical and backed-out bicortical purchase depths. Additionally, regardless of purchase depth, the Roy-Camille technique demonstrates stronger pull-out strengths than Magerl (bicortical: 666 ± 50 N v. 462 ± 5 N, backed-out bicortical: 522 ± 37 N v. 338 ± 28 N, unicortical: 582 ± 19N vs 354 ± 31N). No difference is seen between cancellous and cortical screw types. Expected date of completion for testing is December 2019. **Conclusion:** Preliminary results demonstrate stronger pull-out strength in bicortical compared with both unicortical and backed-out bicortical purchase depths, as well as Roy-Camille compared with Magerl insertion techniques. No difference is found between unicortical and backed-out bicortical purchase depths, or cancellous and cortical screws for cervical lateral mass fixation.

Presentation K67
Abstract 57

Development of clinical prognostic models for postoperative survival and quality of life in patients with surgically treated metastatic epidural spinal cord compression. ***Anick Nater, Junior Chuang, Kuan Liu, Nasir Quraishi, Dritan Pasku, Jefferson Wilson, Michael Fehlings.*** **From the Department of Neurosurgery, University of Toronto, Toronto, Ont. (Nater, Wilson, Fehlings); the Biostatistics Division, Dalla Lana School of Public Health, University of Toronto, Toronto, Ont. (Chuang, Liu); and the Centre for Spinal Studies and Surgery, Queen's Medical Centre, Nottingham University Hospital NHS Trust, Nottingham, United Kingdom (Quraishi, Pasku).**

Background: Surgery is generally considered for patients with metastatic epidural spinal cord compression (MESCC) with life expectancy longer than 3 months. No existing clinical prognostic models (CPMs) of survival are consistently used, and no CPMs exist that predict quality of life (QoL) following surgical treatment. These knowledge gaps are important given the challenges involved in managing MESCC. **Methods:** Using the Transparent Reporting of a Multivariable Prediction Model for Individual Prognosis or Diagnosis (TRIPOD) guidelines and data from 258 patients (AO Spine 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:** Higher SF-36 physical component score (PCS) (hazard ratio [HR] 0.96) was associated with longer survival 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 associated with shorter survival (c statistic 0.69, 95% confidence interval [CI] 0.64–0.73). Karnofsky performance status less than 70% (OR 2.50), living in North America (OR 4.06), SF-36 physical component score (OR 0.95) and SF-36 mental component score (OR 0.96) were associated with the likelihood of achieving a 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.

Presentation K68
Abstract 170

Sarcomas of the spine: a 20-year survey of disease and treatment strategy in Ontario, Canada. ***Colby Oitment, Anthony Bozzo, Anna Reinmuller, Allan Martin, Shear-Yashuv Hananel, Patrick Thornley, Aaron Gazendam, Ahmed Aoude, Chris Nielsen, Raja Rampersaud.*** **From Toronto Western Hospital, Toronto, Ont. (Oitment, Reinmuller, Martin, Hananel, Nielsen, Rampersaud); McMaster University, Hamilton, Ont. (Bozzo, Gazendam, Thornley); and McGill University, Montreal, Que. (Aoude).**

Background: Spinal sarcomas are a rare, heterogeneous group of mesenchymal tumours, and current literature reporting demographic variables and survival information is limited to small case series. We report on all spinal sarcomas diagnosed over a 20-year period in Ontario, Canada, with regard to 5- and 10-year survival, as well as treatment strategies over time. **Methods:** Using population-based data from ICES between 1993 and 2015, International Classification of Diseases (ICD) codes were searched and available data extracted for the purposes of reporting basic demographic information and calculation of Kaplan–Meyer survival curves. Databases used include the Ontario Cancer Registry, Discharge Abstract Database, Ontario Health Insurance Plan, National Ambulatory Care Reporting System, Registered Persons DataBase (death). **Results:** A total of 122 spinal sarcomas were diagnosed. The most common diagnosis was Ewing sarcoma (39.34% of spinal sarcomas), followed by chondrosarcoma (27.45% of diagnoses), followed by osteosarcoma (20.49% of diagnoses). The poorest survival was seen with spinal osteosarcoma, with 5- and 10-year survival rates of 36% and 30.9%, respectively. Ewing sarcoma had a 48.1% 5-year survival rate and a 44.9% 10-year survival rate. Chondrosarcoma had a 77.2% 5-year survival rate and a 64.2% 10-year survival rate. Four percent of patients encountered between 1993 and 2003 had surgery compared with 21.4% of patients between 2004 and 2015. **Conclusion:** The reported survival rate is within the published ranges for all tumours, except for spinal chondrosarcoma, for which the survival rate was well above the 55%–65% rate previously reported in all smaller case series. The reason for this is ultimately unknown, but it is attributed to advancements in surgical care over the last 20 years in spinal surgery, as well as the variability in treatment strategies that have developed over the last 20 years. This is the largest series of spinal sarcoma cases published to date and offers insight into treatment outcomes.

Presentation K69
Abstract 15

Metastatic spine disease: Should patients with short life expectancy be denied surgical care? An international retrospective cohort study. ***Mohammed Karim, Nicolas Dea, Anne Versteeg, Arjun Sahgal, Jorrit-Jan Verlaan, Raphaele Charest Morin, Laurence Rhines, Daniel Sciubba, James Schuster, Micheal Weber, Aron Lazary, Micheal Fehlings, Michelle Clarke, Paul Arnold, Stefano Boriani, Ilya Laufer, Ziya Gokaslan, Charles Fisher.*** **From Vancouver General Hospital, Vancouver, B.C. (Karim, Dea, Morin, Fisher); the University Medical Centre, Utrecht, the Netherlands (Versteeg, Verlaan); Sunnybrook Hospital, Toronto, Ont. (Sahgal); MD Anderson Cancer Center, Houston, Tex. (Rhines); John Hopkins, Baltimore, Md. (Sciubba); the University of Pennsylvania, Philadelphia, Pa. (Schuster); the McGill University Health Centre, Montreal, Que. (Weber); the National Center for Spinal Disorders, Budapest, Hungary (Lazary); the University of Toronto, Toronto, Ont. (Fehlings); the Mayo Clinic, Rochester, Minn. (Clarke); the University of Kansas, Kansas City, Kans. (Arnold); the IRCCS Istituto Ortopedico Galeazzi, Milan, Italy (Boriani); the Memorial Sloan Kettering Cancer Center, New York, N.Y. (Laufer); and the Warren Alpert Medical School, Providence, R.I. (Gokaslan).**

Background: Despite our inability to accurately predict survival in many cancer patients, a life expectancy of at least 3 months has historically been necessary to be considered for surgical treatment of spinal metastases. The primary objective of this study was to compare health-related quality of life (HRQoL) among patients surviving fewer than 3 months after surgical treatment with that of patients surviving more than 3 months to assess the validity of this inclusion criterion. **Methods:** Patients who underwent surgery for spinal metastases between August 2013 and May 2017 were retrospectively identified from an international cohort study. HRQoL was evaluated using generic and disease-specific outcome tools at baseline and at 6 and 12 weeks after surgery. The primary outcome was the HRQoL at 6 weeks after treatment measured by the Spine Oncology Study Group Outcomes Questionnaire (SOSGOQ). **Results:** A total of 253 patients were included; 40 patients died within the first 3 months after surgery and 213 patients survived more than 3 months. Patients surviving fewer than 3 months after surgery presented with lower baseline performance status. Adjusted analyses for baseline performance status did not reveal a significant difference in HRQoL between the 2 groups at 6 weeks after treatment. No significant difference in patient satisfaction at 6 weeks with regard to their treatment could be detected between the groups. **Conclusion:** When controlled for baseline performance status, quality of life 6 weeks after surgery for spinal metastasis is independent of survival. To optimize improvement in HRQoL for this patient population, baseline performance status should take priority over expected survival in the surgical decision-making process.

Presentation K70
Abstract 29
Nanoparticle-functionalized polymethyl methacrylate bone cement for sustained chemotherapeutic drug delivery.
***Mina Aziz*, *Derek Rosenzweig*, *Michael Weber*. From McGill University, Montreal, Que.**

Background: Studies have shown that drugs loaded onto polymethyl methacrylate (PMMA) cement are released in small bursts in the first 48–72 hours, and the remaining drug is trapped without any significant release over time. The objective of this study is to develop a nanoparticle-functionalized PMMA cement for use as a sustained doxorubicin delivery device. We hypothesize that PMMA containing mesoporous silica nanoparticles will release more doxorubicin than standard PMMA. **Methods:** High-viscosity SmartSet PMMA cement by DePuy Synthes was used. The experimental group consisted of 3 replicates each containing 0.24 g of mesoporous silica nanoparticles, 1.76 g of cement powder, 1 mL of liquid cement monomer and 1 mg of doxorubicin. The control group consisted of 3 replicates each containing 2.0 g of cement powder, 1 mL of liquid cement monomer and 1 mg of doxorubicin. The experimental group contained an average of 8.18 ± 0.008% (weight per weight) mesoporous silica nanoparticles. Each replicate was casted into a cylindrical block and incubated in a phosphate-buffered saline solution that was changed at predetermined intervals for 45 days. The concentration of eluted doxorubicin in each solution was measured using a fluorescent plate reader. The mechanical properties of cement were assessed by unconfined compression testing. The effect of the doxorubicin released from cement on prostate and breast tumour cell metabolic activity was assessed using the Alamar Blue test. **Results:** After 45 days the experimental group released 3.24 ± 0.25% of the initially loaded doxorubicin, which was more than the 2.12 ± 0.005% released by the control group ($p = 0.03$). There was no statistically significant difference in Young's modulus between groups ($p = 0.53$). Nanoparticle-functionalized PMMA suppressed the metabolic activity of prostate cancer by more than 50% but did not reach statistical significance. Nanoparticle-functionalized PMMA suppressed the metabolic activity of breast cancer cells by 69% ($p < 0.05$). **Conclusion:** Nanoparticle-functionalized PMMA cement can release up to 1.53 times more doxorubicin than the standard PMMA.

Presentation K71
Abstract 90
Development of the Spine Oncology Study Group Outcomes Questionnaire – 8 Domain (SOSGOQ-8D).
***Markian Pahuta*, *Felicity Fisk*, *Anne Versteeg*, *Charles Fisher*, *Arjun Sahgal*, *Ziya Gokaslan*, *Laurence Rhines*, *Stefano Boriani*, *Chetan Bettegowda*, *Nicolas Dea*, *The AOSpine Knowledge Forum Tumor*. From the Henry Ford Health System, Detroit, Mich. (Pahuta, Fisk); Utrecht University, Utrecht, the Netherlands (Versteeg); the University of British Columbia, Vancouver, B.C. (Fisher, Dea); the Sunnybrook Odette Cancer Centre and University of Toronto, Toronto, Ont. (Saghal); the Warren Alpert Medical School, Brown University, Providence, R.I. (Gokaslan); MD Anderson Cancer Center, Houston, Tex. (Rhines); the IRCCS Istituto Ortopedico Galeazzi, Milan, Italy (Boriani); the Johns Hopkins University School of Medicine, Baltimore, Md. (Bettegowda); and AO Spine, Davos, Switzerland (AOSpine Knowledge Forum Tumor).**

Background: AOSpine Knowledge Forum Tumor developed the spine oncology- specific outcome composite measurement scale known as the SOSGOQ2.0, which has been demonstrated to be a valid and reliable tool for measuring patient-reported health-related quality of life (HRQoL), but no mapping to utilities exists. The ability to calculate quality-adjusted life-years (QALYs) for metastatic spine disease would enhance treatment decision-making and facilitate economic analysis. **Methods:** SOSGOQ responses obtained from the Epidemiology, Process and Outcomes of Spine Oncology (EPOSO) and the Metastatic Tumor Research and Outcomes Network (MTRON) studies were used in a hybrid concept-retention and factorial analysis shortening approach. Confirmatory factor analysis was used to identify candidate items from the physical function, pain, mental health and social function domains. Poisson regression was used to identify the optimal combination of items. **Results:** All 4 neurologic function single questions (leg weakness, arm weakness, bladder dysfunction, bowel dysfunction) were retained to maintain content validity and clinical relevance. Confirmatory factor analysis demonstrated adequate model fit and confirmed the structure of nonneurologic SOSGOQ2.0 domains. All items were clinically relevant (factor loadings > 0.50). The highest loading items were limitations in activities of daily living and travelling from home (physical function), mobility limitation from pain and overwhelming pain (pain), and impaired concentration and relationships (social function). Poisson regression models for all combinations of candidate questions provided excellent fit. The regression model with the lowest rank sum consisted of

SOSGOQ2.0 items 3, 13, 16 and 19. **Conclusion:** We have developed an 8-item questionnaire by formally shortening SOSGOQ2.0, which can be used to facilitate mapping of utilities. Analysis indicates that in addition to the neurologic single items from the SOSGOQ2.0, the SOSGOQ-8D should include the following SOSGOQ2.0 items: "Does your spine limit your ability to care for yourself?" "How much has your pain limited your mobility (sitting, standing, walking)?" "Have you felt depressed?" "Do you feel that your spine condition affects your personal relationships?"

Presentation K72
Abstract 6
Treatment expectations of patients with spinal metastases: What do we tell our patients? ***Anne Versteeg, Roxanne Gal, Raphaele Charest-Morin, Jorrit-Jan Verlaan, Lenny Verkooijen, Charles Fisher.*** **From University Medical Center Utrecht, Utrecht, the Netherlands (Versteeg, Gal, Verlaan, Verkooijen); and the Vancouver General Hospital, Vancouver, B.C. (Charest-Morin, Fisher).**

Background: Recent research has demonstrated that patients with advanced lung and colon cancer are often overly optimistic regarding the outcomes of their cancer treatment. Realistic treatment expectations are important, as health-related quality of life (HRQoL) following treatment has been associated with meeting pretreatment expectations. Patients develop these expectations largely on the basis of information provided by their physician. The purpose of this study was to explore the information provided by physicians to patients with spinal metastases scheduled for surgery and/or radiotherapy. In addition, the goal was to explore how physicians verify treatment expectations with their patients. **Methods:** A qualitative study using semistructured interviews with spine surgeons, radiation and medical oncologists, and rehabilitation specialists was conducted. Physicians were asked about the content and extent of information they provide to patients with spinal metastases regarding treatment options, risks and treatment outcomes. In addition, physicians were asked whether they verify patient expectations and how they cope with unrealistic expectations and possible solutions to improve patient expectations. Interviews were transcribed and analyzed by 2 researchers to identify common themes. **Results:** Risks of treatment, disease status and the overall goal of treatment are generally discussed during the consult of patient with spinal metastases. Other topics including prognosis, pain, and physical and neurologic function are discussed, but to a limited extent. Interviewed physicians reported a lack of insight into the expectations of patients regarding treatment outcomes. Suggestions to improve treatment expectations included improving the multidisciplinary care approach for patients with spinal metastases and giving more detailed treatment information. **Conclusion:** Currently, physicians involved in the care of patients with spinal metastases generally do not verify treatment expectations with their patients. Information about goals of treatment, risks and disease status is provided. On the other hand, limited information regarding post-treatment pain and physical and neurologic function is given. Improving communication regarding treatment expectations, thereby establishing realistic expectations, is essential, as it may further improve patient self-perceived outcomes.

Presentation L73
Abstract 48
Factors related to risk of opioid abuse in primary care patients with low back pain. ***Kala Sundararajan, Anthony Perruccio, Raja Rampersaud.*** **From Krembil Research Institute, University Health Network, Toronto, Ont. (Sundararajan, Perruccio); the Dalla Lana School of Public Health, University of Toronto, Toronto, Ont. (Perruccio); the Division of Orthopaedics, Arthritis Program, University Health Network, Toronto, Ont. (Rampersaud); and the Division of Orthopaedic Surgery, Department of Surgery, University of Toronto, Toronto, Ont. (Rampersaid).**

Background: While patients with low back pain (LBP) are often prescribed opioids, the risk of opioid abuse has not been well characterized in the primary care LBP population. The objective of this study is to identify factors associated with increased risk of opioid abuse as measured by the Opioid Risk Tool (ORT) among primary care LBP patients. **Methods:** Patients referred from primary care to an interprofessional LBP program completed the ORT at intake. Patients at moderate or high risk of opioid abuse were compared with patients at low risk on a range of patient-reported factors. **Results:** The sample comprised 1908 patients (55% female, mean age 50.4 yr). Overall, 15% of patients were at increased (i.e., moderate/high) risk of opioid abuse, and 22% reported current opioid use. A total of 31% of the increased-risk group reported current opioid use versus 20% of the low-risk group ($p < 0.001$). Factors associated with increased risk of opioid abuse included Percocet use ($p < 0.001$), higher back pain severity ($p < 0.001$), worse Oswestry Disability Index score ($p < 0.001$), lower resilience (Connor-Davidson Resilience Scale-2, $p < 0.001$), lower self-efficacy (Self-Efficacy for Managing Chronic Disease, $p < 0.001$), increased back pain chronicity risk (STarT Back, $p = 0.001$), being unemployed or on disability benefit ($p < 0.001$), smoking ($p = 0.001$) and more comorbid health conditions ($p = 0.001$). Sex, body mass index, leg pain severity and anatomic LBP pattern were not associated with opioid abuse risk. **Conclusion:** Over 1 in 5 primary care LBP patients were current opioid users, and one-fifth of these patients were at increased risk of opioid abuse. Furthermore, 1 in 7 nonusers were at increased risk of abuse. Given the high prevalence of clinical LBP, these estimates suggest that careful consideration is warranted around use and abuse of opioids in LBP, including awareness that use may be associated with poorer LBP outcomes.

Presentation L74
Abstract 65
QI/QA of a transitional outpatient pain program for spine. ***Rob Tanguay, Denise Eckenswiller, Alvin Yu, Karin Klassen, Peter Lewkonia, Ken Thomas, Brad Jacobs, Nicole Miller, Ganesh Swamy, Michael Yang, Alex Soroceanu.*** **From the University of Calgary, Calgary, Alta.**

Background: Preoperative opioid use has been identified as a concern in surgical patients, with reported rates of 15%–30% in the spine population. Preoperative opioid use is one of the biggest risk factors for chronic postoperative use, and it has been linked to worse outcomes. Strategies to decrease opioid use have been mandated federally and provincially. We have implemented a novel Transitional Outpatient Pain Program for Spine

(TOPPS) at a single institution. This quality improvement study describes the TOPPS program and evaluates its success on tapering opioids and its impact on pain catastrophizing and disability for the first 22 patients. **Methods:** TOPPS was offered to elective spine surgery patients with a history of chronic nonmalignant pain and on chronic daily opioid therapy (> 3 mo). Patients underwent opioid tapering before surgery and after surgical intervention. They also had acceptance and commitment therapy (ACT) with the goal of reducing pain catastrophizing, and they participated in an individualized exercise program to reduce kinesiophobia. Opioid use was measured as morphine equivalents daily (MED). Catastrophizing was measured using the Pain Catastrophizing Scale (PCS). Disability was measured using the Pain Disability Index (PDI). Pre and post TOPPs opioid use and outcome measures were compared using the Wilcoxon matched-pairs signed-ranks test. Patients who started the program before surgery (Group 1, n = 12) and those who started the program after surgical intervention (Group 2, n = 12) were analyzed separately. **Results:** Patients showed a significant reduction in opioid use following completion of the TOPPS program (Group 1 median MED 0 v. 84, p = 0.0029; Group 2 median MED 0 v. 38.75, p = 0.0051). Our results also demonstrate a significant improvement in the PCS (Group 1 median PCS 11 v. 30, p = 0.0076) and PDI (Group 1 median PDI 25 v. 44, p = 0.0086; Group 2 median PDI 18 v. 38, p = 0.0086). **Conclusion:** This study suggests that opioid tapering and treatment within an interdisciplinary pain management program reduced opioid use and improved outcomes for surgical spine patients.

Presentation L75
Abstract 168
The effect of preoperative opioid use on hospital length of stay in patients undergoing elective spine surgery. ***Alexandra Stratton*, *Philippe Phan*, *Eugene Wai*, *Stephen Kingwell*, *Dita Moravek*, *Sarah Tierney*. From the University of Ottawa, Ottawa, Ont. (Stratton, Phan, Wai, Kingwell, Tierney); and the Ottawa Hospital Research Institute, Ottawa, Ont. (Moravek).**

Background: The relationship between preoperative opioid use and hospital length of stay (LOS) remains unclear. Our aims were (a) to determine the impact of preoperative opioid use on LOS in adult patients undergoing elective spine surgery at our institution and (b) to evaluate the impact of preoperative opioid dose on LOS. **Methods:** A retrospective chart review was conducted on consecutive adult patients admitted following elective spine surgery and seen by the acute pain service at a single institution for 1 year. Postoperative LOS, demographic variables and preoperative analgesics used (including dose) were obtained. The maximum prescribed opioid dose was converted to oral morphine equivalents (MEQ) and patients whose daily dose was 90 MEQ or above were considered high opioid users. Multivariate logistic regression analyses were performed to assess the effect of opioid use and dose on LOS, while adjusting for confounders. **Results:** A total of 220 patients were included in the analysis; 111 (50.5%) were not prescribed opioids preoperatively (nonopioid group), while 109 (49.5%) were prescribed opioids preoperatively (opioid group). The median maximum prescribed daily dose was 30 mg oral morphine equivalent (OME) (range 1.2–480 mg OME). A moderate correlation was found between LOS and opioid dose (R = 0.21, p = 0.0019). When the patients were categorized on the basis of the amount of preoperative opioids, high opioid users (> 90 mg OME) had significantly longer LOS than the other 2 groups (p < 0.05). **Conclusion:** High-dose preoperative opioid use was associated with increased LOS in patients undergoing elective spine surgery requiring admission at our single tertiary care centre. These findings provide support for implementation of interventions to decrease opioid use and LOS in spine surgery patients. Future research should assess the costs and benefits of such interventions.

Presentation L76
Abstract 163
Disability or pain: Which best predicts patient satisfaction with surgical outcome? A Canadian Spine Outcomes and Research Network (CSORN) study. ***Duncan Cushnie*, *John Street*. From McMaster University, Hamilton, Ont. (Cushnie); and the University of British Columbia, Vancouver, B.C. (Street).**

Background: Because the experience of pain, and its effect on quality of life, varies by individual, this study examined whether self-reported improvement in disability has a greater effect than pain reduction on satisfaction with spine surgery. **Methods:** The Canadian Spine Outcomes and Research Network (CSORN) registry was queried for patients who received surgery for degenerative lumbar disease and provided 12 months postoperation Oswestry Disability Index (ODI), pain and satisfaction data. ODI, back and leg pain improvements were assessed as to which better predicted satisfaction with surgery. Secondary analysis examined EuroQoL and SF-12 physical component score relationship to satisfaction as alternative measures of quality of life and 3- and 24-month data for effect durability over time. Analysis was conducted together and separately for each diagnosis (spondylolisthesis, disc herniation, disc degeneration, deformity and stenosis). **Results:** Patient satisfaction with surgery was similarly correlated with reductions in back pain (ρ = –0.42), leg pain (ρ = –0.39967) and ODI (ρ = –0.4368826) when all diagnoses were combined. This association was found on both univariate and multivariate analysis (p < 0.00001). The ODI correlation with satisfaction ranged across diagnoses from ρ values of –0.41 (spondylolisthesis) to –0.50 (degenerative disc disease) whereas the correlation between back or leg pain improvement and satisfaction varied much more across diagnoses (ρ = –0.24 to –0.56). **Conclusion:** Although degenerative spine patients often present with the primary complaint of pain rather than disability, improvement in disability appears to be similarly predictive of patient satisfaction with surgery in general as does improvements in pain. However, as the location of the pain being targeted by surgery (back v. leg) varies by diagnosis, mirrored by the variable correlation between a given pain location and satisfaction, ODI may be a better choice if a standard metric of surgical success is desired across multiple diagnoses.

Presentation L77
Abstract 58
Rapid access to interventional pain management for lumbar nerve root pain through collaborative interprofessional provider networks. ***Marcia Correale*, *Kala Sundararajan*, *Rachael Bosma*, *Gil Faclier*, *Tania Di Renna*, *Raja Rampersaud*. From the LB-RAC-ISAEC Model of Care,**

University Health Network, Toronto, Ont. (Correale); the Department of Physical Therapy, University of Toronto, Toronto, Ont. (Correale); the Division of Orthopaedics, Arthritis Program, University Health Network, Toronto, Ont. (Sundararajan, Rampersaud); the Toronto Academic Pain Medicine Institute, Toronto, Ont. (Bosma, Faclier, Renna); the Faculty of Dentistry, University of Toronto, Toronto, Ont. (Bosma); the Centre for the Study of Pain, University of Toronto, Toronto, Ont. (Bosma); the Department of Anesthesiology, University Health Network, Toronto, Ont. (Renna); the Department of Anesthesia, University of Toronto, Toronto, Ont. (Renna); and the Division of Orthopaedic Surgery, Department of Surgery, University of Toronto, Toronto, Ont. (Rampersaud).

Background: A pilot collaborative agreement between 2 separately funded programs, the rapid access Interprofessional Spine Assessment and Education Clinics (ISAEC) and the Toronto Academic Pain Medicine Institute (TAPMI), was created to reduce wait times for targeted nerve injections (NIs). The objective of this study was to assess the impact of this collaborative network approach on wait times for lumbar nerve injections for appropriately selected patients. **Methods:** We conducted a retrospective review of prospectively collected data from a single ISAEC site. Prior to the ISAEC–TAMPI collaborative approach, ISAEC patients were referred for NIs through existing regional institutional options (interventional radiology or anesthesia pain clinics). The ISAEC–TAPMI pilot collaborative facilitated dedicated NI slots for ISAEC patients meeting appropriate agreed-upon criteria. The following wait times were collected before and after implementation of the ISAEC–TAPMI collaboration: Primary Care Provider to ISAEC – community-based Advance Practice Provider assessment (PCP-APP); APP to ISAEC-centralized Specialty Practice Lead assessment (APP-PL); and PL to NI procedure (PL-NI). Descriptive statistics were used. **Results:** There were 67 and 76 patients in the pre- and post-collaboration groups, respectively. The average age was 50 years with 40 females in the precollaboration group and 57 years with 41 females in the postcollaboration group. Mean PCP-APP wait was 19 versus 21 days and the mean APP-PL wait was 23 versus 25 days in the precollaboration versus postcollaboration group, respectively. The mean PL-NI wait was 125 (43–426) versus 42 (1–120) days in the precollaboration versus postcollaboration group, respectively. The median PL-NI was 106 versus 40 days in the precollaboration versus the postcollaboration group, respectively. From the perspective of the TAMPI interventional pain specialist, referral appropriateness from ISAEC was 98%. **Conclusion:** Our study demonstrates that synergistically networked collaborations can improve appropriateness and significantly reduce wait times for specific limited-access interventions. Consideration should be given to more formal assessment of the efficiencies and cost-effectiveness of such models.

Presentation L78
Abstract 63

Chronic preoperative opioid use associated with higher perioperative resource utilization and complications in adult spinal deformity patients. ***Ibrahim Sadiq*, *Ariana Frederick*, *Faizal Kassam*, *Fred Nicholls*, *Ganesh Swamy*, *Peter Lewkonia*, *Ken Thomas*, *Brad Jacobs*, *Nicole Miller*, *Rob Tanguay*, *Alex Soroceanu*. From the University of Alberta, Edmonton, Alta. (Sadiq); and the University of Calgary, Calgary, Alta. (Frederick, Kassam, Nicholls, Swamy, Lewkonia, Thomas, Jacobs, Miller, Tanguay, Soroceanu).**

Background: Prior to surgical consultation, patients are frequently started on opioid medications despite growing evidence discouraging this practice. Chronic opioid use has been reported in 15% to 30% of patients with degenerative pathology, but it is poorly reported in the adult spinal deformity (ASD) population. This study quantifies the effect of preoperative opioid use on perioperative resource utilization and complications in ASD patients undergoing surgery. **Methods:** We conducted a single-centre study of consecutive ASD patients. Patients were enrolled in a registry where demographics, health-related quality of life measures, surgical metrics and complications were recorded prospectively. Opioid use and resource utilization were collected through chart reviews. The impact of opioid use on perioperative resource utilization and complications was examined using multivariate regression accounting for confounders, or univariate analysis as appropriate. **Results:** A total of 139 patients were included, and they were divided into 2 groups on the basis of preoperative opioid use: opioid naive (n = 52) and chronic opioid (n = 87). Among chronic opioid users, average preoperative opioid use was 122.5 morphine equivalents daily (MED), with 43% on doses greater than 90 MED. The chronic opioid group were more frequently revisions (68.3% v. 50%, p = 0.039). The groups were similar in regard to baseline demographics, magnitude of deformity and surgical invasiveness. The chronic opioid group had more frequent involvement of the acute pain service (48.2% v. 7.84%, p = 0.0001) and more frequent use of ketamine (36.4% v. 7.84%, p = 0.0001) and lidocaine (14.1% v. 0%, p = 0.005) infusions. Preoperative MED correlated with patient-controlled analgesia duration (r = 0.29, p = 0.0018). The chronic opioid group had higher postoperative opioid requirements (postoperative day 1 MED 388.6 v. 178.83, p = 0.004; posoperative day 7 MED 198.92 v. 86.23, p = 0.0066) and had a higher incidence of perioperative complications (incidence rate ratio 1.53, p = 0.029). Patients in the chronic opioid group showed a trend toward more frequent nonroutine discharge (home hospital, rehabilitation or skilled nursing facility) (30.4% v. 16.6%, p = 0.07). **Conclusion:** A total of 63% of ASD patients were on chronic opioid analgesia before surgery. Opioid use was associated with increased perioperative resource utilization, higher rates of complications and more frequent nonroutine discharge.

Presentation M79
Abstract 108

Cervical disc arthroplasty versus anterior cervical discectomy and fusion: a longitudinal analysis of reoperations. ***Jetan Badhiwala*, *Andrew Platt*, *Vincent Traynelis*, *Christopher Witiw*. From the University of Toronto, Toronto, Ont. (Badhiwala, Witiw); the University of Chicago, Chicago, Ill. (Platt); and Rush University, Chicago, Ill. (Traynelis).**

Background: Anterior cervical discectomy and fusion (ACDF) is an effective treatment for cervical spondylosis. A shortcoming of ACDF is the risk of adjacent-segment degeneration (ASD), owing to arthrodesis of a motion segment. Cervical disc arthroplasty (CDA) has garnered attention in efforts to mitigate ASD,

but compelling evidence of reduction in ASD requiring subsequent operation is lacking. This systematic review and meta-analysis sought to compare longitudinal adjacent-level reoperation rates with CDA versus ACDF for symptomatic 1- or 2-level cervical spondylosis out to long-term follow-up. **Methods:** An electronic literature search was conducted. Eligible studies were multicentre randomized controlled trials (RCTs) comparing CDA with ACDF for 1- or 2-level symptomatic cervical spondylosis. The primary outcome was adjacent-level reoperation. Index-level reoperation was examined as a secondary outcome. Outcomes were evaluated at 1-year intervals from the index operation to last reported follow-up by random-effects meta-analyses. **Results:** Eleven RCTs were eligible. For 1-level cervical spondylosis, there was no difference in the rate of adjacent-level reoperation between CDA (2.3%) and ACDF (3.6%) at 2 years. However, a very large difference favouring CDA became evident at 5 years and persisted at 7 years (4.3% v. 10.8%, $p < 0.001$). Significantly fewer patients who underwent CDA required index-level reoperation at all time points out to 7 years (5.2% v. 12.7%, $p < 0.001$). Similar to 1-level operations, there was no significant difference in adjacent-level reoperations with 2-level CDA (1.7%) versus 2-level ACDF (3.4%) at 2 years. At 7 years, a significant difference favouring CDA became apparent (5.1% v. 10.0%, $p = 0.014$). Two-level CDA also resulted in fewer index-level reoperations out to 7 years (4.2% v. 13.5%, $p < 0.001$). **Conclusion:** In this meta-analysis, the short-term rate of adjacent-level operation was similar with CDA or ACDF. However, around 5 years, a statistically significant divergence emerged, where the rate of adjacent-level operation rose steeply for ACDF. Index-level reoperations were less frequent with CDA in both the short and long term. These data indicate CDA may have a superior longevity to ACDF.

Presentation M80
Abstract 46
Preliminary results of randomized controlled trial investigating the role of psychological distress on cervical spine surgery outcomes: a baseline analysis. ***Peter Passias, Samantha Horn, Sherri Weiser-Horwitz, Cole Bortz, Frank Segreto, Katherine Pierce, Renaud Lafage, Aaron Hockley, Shaleen Vira, Virginie Lafage*. From NYU Langone Health, New York, N.Y. (Passias, Horn, Weiser-Horwitz, Bortz, Segreto, Pierce); the Hospital for Special Surgery, New York, N.Y. (R. Lafage, V. Lafage); the University of Calgary, Calgary, Alta. (Hockley); and UT Southwestern, Dallas, Tex. (Vira).**

Background: The objective of this study was to determine the effectiveness of brief psychological intervention on outcomes in cervical spine surgery. **Methods:** Thirty-five patients aged 18 years and older with symptomatic cervical degenerative disease have been enrolled in the study. If patients met psychological distress criteria, they were in the treatment group: Distress and Risk Assessment Method (DRAM) greater than 17 and less than 33, Fear Avoidance Beliefs Questionnaire (FABQ) greater than 49/66, Pain Catastrophizing Scale (PCS) greater than 30/52 or Outcome Expectation Questionnaire (OEQ) less than or equal to 2 (randomly assigned to cognitive behaviour therapy (CBT) or placebo). CBT and sham treatment groups had 6 sessions before surgery. The control group had no intervention before surgery. Baseline and 3- month changes were assessed for all outcome measures. **Results:** Thirty-five patients were enrolled (53.9 yr, body mass index 28.7 kg/m^2). Twenty-two patients met psychological distress criteria and were randomly assigned to a treatment group (13 CBT v. 9 placebo). There were 13 patients in the control group, with 5 having too high of DRAM scores to be CBT candidates. At enrolment, the average DRAM was 34.55, with the DRAM observational group, placebo and CBT all having higher scores than control patients (45.6 v. 13.4, $p < 0.001$). Treatment patients had higher baseline FABQ scores than controls (45.9 v. 20.4, $p = 0.004$). The overall OEQ score was 3.78, with all controls scoring 5 and CBT/placebo patients answering 3–4 out of 5. At 3 months postoperatively, all groups showed improved outcomes in all measurements. Between CBT, placebo and control patients, CBT patients had greater postoperative improvement in all questionnaires than nontreatment groups (DRAM: from 34.9 to 30.8 CBT, from 35.2 to 22.4 placebo, from 11 to no-risk controls; FABQ: from 40.8 to 35.2 CBT, from 38.3 to 37.8 placebo, from 19 to 21 no-risk controls; PCS: from 31.8 to 17.4 CBT, from 32.8 to 11.6 placebo, from 15 to 6 no risk controls; OEQ: from disagree to strongly agree CBT, from disagree to agree placebo, from strongly agree to strongly agree, no risk controls). **Conclusion:** Preliminary results of this randomized controlled study showed that patients who received cognitive behavioural treatment before surgery had better improvement in all psychological-related questionnaires compared with nontreatment patients. Long-term follow-up will assess the impact of psychological intervention for at-risk patients.

Presentation M81
Abstract 110
Operative versus nonoperative treatment of geriatric odontoid fractures: a study of North American trauma centres. ***Jetan Badhiwala, Christopher Witiw, Jefferson Wilson, Farshad Nassiri, Leodante da Costa, Avery Nathens, Michael Fehlings*. From the University of Toronto, Toronto, Ont.**

Background: With the aging population, the optimal management of geriatric type 2 odontoid fractures has become an increasingly relevant clinical problem. This study sought to perform a head-to-head comparison of the inpatient outcomes of nonoperative treatment versus posterior C1–2 fusion for type 2 odontoid fractures in elderly patients (65 years of age and older). **Methods:** Data were derived from the American College of Surgeons (ACS) Trauma Quality Improvement Program (TQIP) database for 2016. Patients aged 65 years and older with an acute type 2 odontoid fracture were identified by ICD-10-CM codes. Cases of posterior C1–2 fusion were identified by ICD-10-PCS codes. Propensity score matching of nonoperative versus operative treatment was performed in a 1:1 ratio adjusting for age, sex, race, comorbidities, mechanism of injury and ISS. The primary outcome was inpatient mortality. Secondary outcomes included inpatient morbidity (myocardial infarction, cardiac arrest, deep vein thrombosis, pulmonary embolism, acute kidney injury, stroke, sepsis, ventilator-associated pneumonia, hospital length of stay and discharge destination. Kaplan–Meier survival curves were created for inpatient mortality by treatment group, and these were statistically compared by the log-rank test. **Results:** A final cohort had 506 elderly patients with an acute type 2 odontoid fracture (mean age 77.8 yr). Baseline characteristics were balanced between matched nonoperative ($n = 253$) and operative

(n = 253) treatment groups. Inpatient mortality was significantly greater in the nonoperative treatment group (8.7% v. 2.4%, p = 0.004). Kaplan–Meier analysis revealed significantly shorter survival among patients treated nonoperatively (p < 0.001). There were no differences in inpatient complications between treatment groups. Patients treated operatively had a longer inpatient hospital stay on average (11.6 v. 6.3 d, p < 0.001). Most patients who underwent posterior C1–2 fusion were discharged to either a rehabilitation (28.1%) or skilled nursing (41.1%) facility. **Conclusion:** These data support a short-term survival advantage among elderly patients with an acute type 2 odontoid fracture who are treated operatively with posterior C1–2 fusion, over those managed nonoperatively.

Presentation M82
Abstract 74
Clinical outcome of posterior cervical foraminotomy versus anterior cervical discectomy and fusion. ***Stuart McGregor*****,** ***Brad Jacobs*****. From the University of Calgary, Calgary, Alta.**

Background: Cervical radiculopathy is a common cause of significant distress in patients. Anterior cervical discectomy and fusion (ACDF) is a well-known and effective treatment option, but posterior cervical foraminotomy (PCF) allows for a nonfusion surgical option, possibly being less invasive and limiting the risks of surgery. However, insufficient data exist to determine the superior option. The purpose of this study was to determine which procedure leads to better patient outcomes in terms of arm and neck pain in a Canadian, multicentre data set. **Methods:** The Canadian Spine Outcomes and Research Network (CSORN) was used to identify all patients who underwent ACDF (n = 251) or PCF (n = 41) for cervical radiculopathy. Pain outcomes were then compared between the 2 groups at 6–18 weeks (ACDF n = 210; PCF n = 34), 12 months (ACDF n = 121; PCF n = 20) and 24 months (ACDF n = 69; PCF n = 11) postoperatively, as well as patient satisfaction and complication rates. **Results:** Patients significantly improved in arm and neck pain scores regardless of surgery type (Wilcoxon signed-rank test, p < 0.02). There were no significant differences between arm and neck pain scores preoperatively or at any follow-up period between the surgical groups (Mann–Whitney, all p > 0.05); however, patient satisfaction was higher for ACDF at 6–18 weeks (Mann–Whitney, p = 0.05) and 1 year follow-up (Mann–Whitney, p = 0.025) compared with PCF. There were no differences in the complication rates between the surgical approaches (χ^2 test, p > 0.05). **Conclusion:** Both ACDF and PCF are successful surgical options in treating cervical radiculopathy, showing equal improvements in pain scores; however, ACDF has better patient satisfaction within 1 year of the postoperative period. A larger sample size is needed to confirm these results.

Presentation M83
Abstract 45
"Reverse Roussouly": ratios of cervical to thoracic shape curvature in an adult cervical deformity population. ***Peter Passias*****,** ***Haddy Alas*****,** ***Katherine Pierce*****,** ***Avery Brown*****,** ***Cole Bortz*****,** ***Aaron Hockley*****,** ***Alex Soroceanu*****,** ***Shaleen Vira*****,** ***Sara Naessig*****,** ***Waleed Ahmad*****,** ***Renaud Lafage*****,** ***Virginie Lafage*****. From NYU Langone Health, New York, N.Y. (Passias, Alas, Pierce, Brown, Bortz, Naessig, Ahmad); the University of Calgary, Calgary, Alta. (Hockley, Soroceanu); UT Southwestern, Dallas, Tex. (Vira); and the Hospital for Special Surgery, New York, N.Y. (R. Lafage, V. Lafage).**

Background: The objective of this study was to explore baseline normative curvature ratios of the cervicothoracic spine and establish radiographic thresholds for severe myelopathy and disability within the context of shape. **Methods:** Patients with cervical deformity (C2–C7 Cobb angle > 10°, cervical kyphosis > 10°, C2–C7 sagittal vertical axis (cSVA) > 4 cm, or chin brow vertical angle > 25°) with baseline (BL) radiographic data were included. Cervical lordosis (CL) was measured using C2–C7 Cobb angle and thoracic kyphosis (TK) using T2–12, with negative values indicating kyphotic angles. A mathematical ratio was calculated for CL:TK ranging from –1 to +1 and correlated to cSVA (> or < 40 mm), SVA (> or < 40 mm) and modified Japanese Orthopaedic Association scale (mJOA) scores at BL (> or < 14, severe) using Pearson bivariate r. Univariate analyses including independent samples t tests analyzed differences in presence of severe myelopathy (mJOA > 14) or neck disability index (NDI) greater than 40 across CL:TK curve ratio groups. **Results:** Sixty-three patients (55.2 yr, 56% female) met the inclusion criteria. All patients had a kyphotic thoracic curvature at BL. Thirty-seven patients had a negative CL:TK ratio (more lordotic cervical spine/kyphotic thoracic spine), and 26 had a positive ratio (more kyphotic cervical spine/kyphotic thoracic spine). Positive CL:TK significantly correlated to greater SVA (r = 0.382, p = 0.013, R^2 = 0.146) but not cSVA. BL mJOA scores correlated to increasing CL:TK (r = 0.530, p = 0.001) and patients with positive CL:TK had a higher rate of severe myelopathy than patients with negative CL:TK (48% v. 13.2%, p = 0.004). CL:TK did not correlate to NDI scores, but positive CL:TK trended to higher neck disability (NDI > 40) than negative CL:TK (52% v. 26.3%, p = 0.061). Conditional tree analysis analyzed all CL:TK curvatures to establish predictive cSVA and TS-CL thresholds. Conditional forward regression controlling for CL:TK ratio revealed the following: cSVA greater than 27 mm increased the odds of severe myelopathy by 5.99 times and cSVA greater than 30 mm increased the odds of significant neck disability by 7 times. TS-CL greater than 29° increased the odds of neck disability by 4.1 times, but TS-CL cut-offs for severe mJOA were not found (p > 0.05). **Conclusion:** Patients with an increased CL:TK ratio, indicating cervical and thoracic kyphotic curves, had higher rates of baseline severe myelopathy and NDI. Specific thresholds for cSVA (> 27 mm or > 30 mm) and thoraco-sacral-cervico-lumbar TS-CL (> 29°) predicted severe myelopathy or NDI regardless of shape curvature.

Presentation M84
Abstract 109
Treatment of acute traumatic central cord syndrome: a study of North American trauma centres. ***Jetan Badhiwala*****,** ***Christopher Witiw*****,** ***Jefferson Wilson*****,** ***Leodante da Costa*****,** ***Avery Nathens*****,** ***Michael Fehlings*****. From the University of Toronto, Toronto, Ont.**

Background: The optimal management of central cord syndrome (CCS) remains unclear. We sought to evaluate variability in nonoperative versus operative treatment for CCS between trauma centres participating in the American College of Surgeons

(ACS) Trauma Quality Improvement Program (TQIP), identify patient- and hospital-level factors associated with treatment, and determine the association of treatment with outcomes. **Methods:** Adults with CCS were identified from the ACS TQIP database for 2014–2016. Mixed-effects modelling with a random intercept for trauma centre was used to examine the adjusted association of patient- and hospital-level variables with nonoperative treatment. The random-effects output of the model was used to assess the risk-adjusted variability in nonoperative treatment across trauma centres. Outlier hospitals were identified and the median odds ratio (MOR) was calculated. The adjusted effect of nonoperative treatment on mortality, morbidity and hospital length of stay (LOS) was examined at the patient and hospital level by mixed-effects regression. **Results:** In total, 3928 patients admitted to 255 TQIP centres were eligible; of these, 1523 (38.8%) were treated nonoperatively. Older age, noncommercial insurance (odds ratio [OR] 1.26), absence of fracture (OR 0.58), severe head injury (OR 1.41) and comatose presentation (1.82) were associated with nonoperative treatment. Twenty-eight hospitals were outliers (significantly more or less likely to treat nonoperatively), and the MOR was 2.02. Patients receiving nonoperative treatment had shorter LOS (MD –4.65 d). Nonoperative treatment was associated with lesser in-hospital morbidity (OR 0.49) at the patient, but not hospital, level. There was no difference in mortality. **Conclusion:** There is substantial variability between trauma centres in nonoperative versus operative treatment of CCS that is not explained by differences in case mix. Nonoperative treatment may be associated with shorter hospital LOS and lesser inpatient morbidity, but no difference in mortality. This needs to be counterbalanced against the expected efficacy of decompressive surgery in improving neurologic outcomes.

Presentation N85
Abstract 118

Comparing minimally invasive versus traditional open lumbar decompression and fusion surgery: a Canadian Spine Outcomes and Research Network (CSORN) study. ***Tan Chen, Eric Crawford, Greg McIntosh, Raja Rampersaud, the CSORN Investigators.*** **From the Division of Spine Surgery, Holland Bone and Joint Program, Sunnybrook Health Sciences Centre, Toronto, Ont. (Chen, Crawford); the Canadian Spine Outcomes and Research Network, Markdale, Ont. (McIntosh, the CSORN Investigators); and the Division of Orthopaedic Surgery, Toronto Western Hospital, Toronto, Ont. (Rampersaud).**

Background: Minimally invasive spine surgery (MIS) techniques continue to evolve and are increasingly being adapted across Canada. However, multicentre comparisons against conventional open techniques in real-world settings are limited. This study aims to evaluate acute and 1-year clinical and patient-reported outcome measures in patients who have undergone MIS versus open lumbar decompression and fusion with and without interbody construct. **Methods:** We conducted a multicentre review of prospectively collected data on consecutive spine surgery patients enrolled by the Canadian Spine Outcomes and Research Network (CSORN) from 2015 through 2019 who underwent 1- or 2-level instrumented lumbar fusions regardless of technique for principle degenerative pathology. Patient demographics, functional outcome scores and perioperative course were assessed preoperatively and at 3 months and 1 year postoperatively. Descriptive, univariate as well as adjusted analysis using multivariate logistical regression was used to determine between-group differences. **Results:** Data for a total of 407 MIS fusion and 922 open fusion patients were collected, of which 318 MIS patients and 603 open patients received an interbody fusion, respectively. Adjusted analysis between interbody-fusion cohorts indicated no significant baseline population differences in age, body mass index, comorbidities, and numerical back or leg pain, Oswestry Disability Index, EuroQol 5-dimension (EQ-5D), SF-12 and Patient Health Questionnaire (PHQ9) scores ($p > 0.05$). Significant perioperative differences were found with operative time (MIS 180 min, open 195 min, $p < 0.05$), estimated blood loss (MIS 182 mL, open 440 mL, $p < 0.001$), intraoperative adverse events (MIS 5.7%, open 10.3%, $p < 0.05$) and length of stay (MIS 3.4 d, open 4.6 d, $p < 0.001$). Patient-reported outcomes at 3- and 12-month follow-up demonstrated nonsignificant differences across all outcome measures with the exception of only EQ-5D at 3 months demonstrating a 3.2 times odds ratio of improvement favouring the MIS interbody cohort ($p < 0.05$). **Conclusion:** Our pragmatic national results confirm findings from published international literature on MIS spinal procedures, with favourable perioperative clinical outcomes including a shorter operative time for interbody fusions. Overall, 1-year patient-reported outcome measures between MIS and open techniques for 1- to 2-level degenerative pathology are comparable. System-wide assessment of the cost-utility of MIS techniques for spinal procedures is required.

Presentation N86
Abstract 54

Time to return to work after lumbar spine surgery. ***Supriya Singh, Charles Fisher, Neil Manson, Ken Thomas, Hamilton Hall, Raja Rampersaud, Nicolas Dea, Greg McIntosh; Raphaële Charest-Morin, CSORN Investigators.*** **From the Vancouver Spine Surgery Institute, Vancouver, B.C. (Singh, Fisher, Charest-Morin); the University of British Columbia, Vancouver, B.C. (Singh, Fisher, Dea, Charest-Morin); Dalhousie University, Saint John, N.B. (Manson); the University of Calgary, Calgary, Alta. (Thomas); the University of Toronto, Toronto, Ont. (Rampersaud); the Canadian Spine Outcomes and Research Network, Toronto, Ont. (McIntosh); and the Canadian Spine Outcomes and Research Network (CSORN) Investigator Group, Vancouver, B.C. (CSORN Investigators).**

Background: Return to work (RTW) after elective lumbar spine surgery is largely arbitrary and recommendations for RTW do not rely on evidence-based medicine. The primary objective was to describe time to RTW after elective lumbar spine surgery. Secondary objectives were to determine predictors of early return to work (< 90 d) as well as predictors of not returning to work. **Methods:** This is a retrospective study of a prospectively multicentric followed cohort of patients enrolled in the Canadian Spine Outcomes and Research Network (CSORN) between January 2015 and December 2018. Inclusion criteria were employed patients (currently working or not working) undergoing 1- or 2-level discectomies, laminectomies or fusion procedures. Patient demographic and surgical data were extracted and analyzed for time to RTW and factors predictive of early RTW. Multivariable logistic regression analysis was completed including predictor

variables of greatest theoretical importance. **Results:** A total of 1691 patients met the inclusion criteria (710 discectomies, 253 laminectomies and 728 fusions). In the overall cohort, median RTW was 61 days and 70.9% of the cohort returned to work after surgery. The median RTW after a discectomy, a laminectomy and a fusion was 51, 46 and 90 days, respectively. Predictive factors for early RTW (< 90 d) included patient factors (male sex, higher education level, preoperative working status, higher baseline SF-12 mental component score), surgical factors (blood loss, nonfusion procedure) and surgical treatment in a western Canadian province. **Conclusion:** This study provides useful clinical information about RTW. Most nonfusion-procedure patients will RTW within 2 months, whereas fusion-procedure patients are generally go back to work at 3 months. The second part of this study will be to survey Canadian spine surgeons to understand how they set up patients' expectations about RTW. Combining this information, we will formulate realistic time-frame recommendations for RTW after lumbar spine surgery.

Presentation N87
Abstract 28
Patient-reported outcomes following surgery for lumbar spinal stenosis: comparison of a universal and multitier health care system. ***Oliver Ayling*****,** ***Tamir Ailon*****,** ***Charles Fisher*****. From the University of British Columbia, Vancouver, B.C.**

Background: Canada has a universal health care system that is funded by the government, and access to spinal surgeons requires a referral by general practitioners. In contrast, the United States utilizes a combined public and private payer system where patients may directly access specialists. The purpose of this study is to investigate whether there are differences in clinical outcomes between those surgically treated for spinal stenosis in Canada as compared with the United States. **Methods:** This study included surgical lumbar spinal stenosis patients treated in Canada who were enrolled in the Canadian Spine Outcomes and Research Network (CSORN) prospective multicentre registry. The Canadian cohort was compared with the surgical cohort enrolled in the Spine Patients Outcomes Research Trial (SPORT) study. Baseline demographics and spine-related patient-reported outcomes were compared at 3 months and 1 year postoperatively. **Results:** The CSORN cohort consisted of 432 patients and the SPORT cohort was made up of 278 patients. The rate of females in each cohort was similar (35.9% v. 38.12%, $p = 0.78$); however, patients in the CSORN cohort were older (66.8 ± 10.9 v. 64.3 ± 12.5, $p = 0.017$), had a higher rate of smoking (16.7% v. 8.9%, $p = 0.0035$) and were less likely to be employed (29.7% v. 34.2%, $p = 0.043$). The SPORT cohort had a slightly lower physical component score of the SF-36 at baseline (33.2 ± 8.4 v. 28.6 ± 7.5, $p < 0.01$). The CSORN cohort had a higher proportion of patients with a symptom duration greater than 6 months (92.3% v. 58.3%, $p < 0.0001$). The CSORN cohort demonstrated significantly greater rates of satisfaction after surgery at 3 months (89.2% v. 60.4%, $p = 0.003$) and 1 year (86.8% v. 62.6%, $p < 0.001$). **Conclusion:** Patients undergoing surgical treatment for lumbar spinal stenosis in Canada (CSORN cohort) reported higher rates of satisfaction at 3 months and 1 year postoperatively compared with the United States cohort (SPORT) despite having longer durations of symptoms before surgery.

Presentation N88
Abstract 93
Outcomes of surgery in older adults with lumbar spinal stenosis. ***Michael Bond*****,** ***Nathan Evaniew*****,** ***Sultan Aldebeyan*****,** ***Ken Thomas*****,** ***CSORN Investigator Group*****. From the University of Calgary, Calgary, Alta.**

Background: Advanced age is seen as a barrier to surgery for lumbar stenosis as improvements in patient-reported outcomes (PROs) may be less favourable than in younger adults and the risk of complications may be high. The purpose of this study was to evaluate whether patient age influences the improvements seen in PROs or complication rates after surgery for lumbar stenosis. **Methods:** An ambispective cohort study of patients in the Canadian Spine Outcomes and Research Network (CSORN) was conducted. Patients were divided into age group by decade: 50 years of age and under, 51–60 years, 61–70 years, 71–80 years and older than 80 years. Demographic, surgical and outcome data were compared between age groups using summary statistics. A multivariate analysis was performed to determine which factors influenced achievement of the minimal clinically important difference (MCID) for the Oswestry Disability index (ODI). **Results:** In total, 1445 patients had a diagnosis of lumbar stenosis, with 728 having complete 12-month follow-up. Mean age was 66.1 (standard deviation 10.7) years and 60.3% were female. Patients were more likely to have decompression without fusion over the age of 70 years ($p < 0.05$). Intraoperative and postoperative complications were similar between all decades ($p > 0.05$). All age categories demonstrated significant improvement in visual analogue scale (VAS) leg and back pain scores, ODI, EQ-5D and the SF-12 mental (MCS) and physical (PCS) component scores. The overall proportion of patients who met MCID for back pain, leg pain and ODI was 68.2%, 71.4% and 55.2%, respectively. Age had no influence on meeting MCID for pain improvement. Patients over 80 years of age were less likely to meet the MCID for ODI, EQ-5D, SF-12 MCS and SF-12 PCS than those in younger decades ($p < 0.001$). On multivariate analysis, independent risk factors for not meeting the MCID for ODI were age over 80 years and female sex. **Conclusion:** Patients can expect similar postoperative improvements in back and leg pain regardless of age. Advancing age was not associated with an increased risk of adverse events; however, improvement in outcome metrics may be less favourable.

Presentation N89
Abstract 162
Functional objective assessment using the TUG test is a useful tool to evaluate outcome in lumbar spinal stenosis. ***Anna Rienmueller*****,** ***Kala Sundararajan*****,** ***Colby Oitment*****,** ***Stephen Lewis*****,** ***Anthony Perruccio*****,** ***Raja Rampersaud*****. From the Division of Orthopaedic Surgery, University of Toronto, Toronto, Ont. (Rienmueller, Oitment, Lewis, Rampersaud); the Arthritis Program, University Health Network, Toronto, Ont. (Sundararajan, Lewis, Perruccio, Rampersaud); and the Dalla Lana School of Public Health, Toronto, Ont. (Rampersaud).**

Background: Patient-reported outcome measures (PROMs) are typically used to assess perceived limitation in ambulation that is associated with lumbar spinal stenosis (LSS). Objective testing of

ambulatory capacity is also recommended; however, this is difficult to implement in clinical settings. The timed-up-and-go (TUG) is the simplest objective mobility measure; however, its utility in LSS patients is unclear. Our primary objective was to evaluate the change in preoperative TUG test at 3,6 and 12 months postoperatively in LSS patients. **Methods:** We performed a retrospective analysis of prospectively collected data from 287 surgical LSS patients. The time taken to stand up from a chair, walk 3 m, turn around, walk back and sit back down was measured. We compared change in TUG times as well as correlation (Spearman rank) with that of self-reported walking using question 4 of the Oswestry Disability Index (ODI-4). **Results:** Mean age at surgery was 66.8 years with 46.7% of patients were female. Decompression with and without fusion was performed in 141 and 146 patients, respectively. Mean baseline TUG time was 14.5 ± 5.7 seconds with 46.3% of patients categorized as having moderate to severe impairment in TUG. TUG time significantly improved at 3 months (12.7 ± 5.4 s) ($p < 0.001$) and 6 months (12.1 ± 4.7 s) ($p < 0.001$) and improved to 11.7 ± 3.9 seconds at 1 year postoperatively ($p = 0.3$, 6 v. 12 mo). Also, ODI-4 score improved from baseline (2.5 ± 1.2) to 3 months ($p < 0.001$) (1.6 ± 1.4), 6 months (1.5 ± 1.4) ($p < 0.001$) and 1 year, respectively (1.4 ± 1.3) ($p = 0.2$). Significant correlation ($p < 0.001$) was found between TUG time and ODI-4 at baseline ($r = 0.41$), 3 months ($r = 0.54$), 6 months ($r = 0.5$) and 1 year ($r = 0.6$). **Conclusion:** Significant postoperative functional improvement in the TUG test occurred and was moderately correlated to self-reported walking improvement over the course of 1 year postoperatively. The simple TUG test is a potentially useful tool to objectively determine LSS walking impairment in the clinic setting. Further studies are necessary to validate the TUG test in the surgical LSS population.

Presentation N90
Abstract 36

A Canadian Spine Outcomes and Research Network (CSORN) matched-cohort study comparing lumbar fusion and disk arthroplasty. ***Tan Chen, Sean Christie, Albert Yee, Charles Fisher, Peter Jarzem, Jean-Francois Roy, Jacques Bouchard.*** **From the Division of Spine Surgery, Holland Bone and Joint Program, Sunnybrook Health Sciences Centre, Toronto, Ont. (Chen, Yee); the Division of Neurosurgery, Dalhousie University, Halifax, N.S. (Christie); the Division of Spine Surgery, Vancouver General Hospital, Vancouver, B.C. (Fisher); the Division of Orthopaedic Surgery, McGill University, Montreal, Que. (Jarzem); Département de Chirurgie, Université Laval, Québec, Que. (Roy); and the Division of Orthopaedic Surgery, University of Calgary, Calgary, Alta. (Bouchard).**

Background: There is a paucity of published Canadian literature comparing lumbar total disc arthroplasty (LDA) with fusion on patient outcomes in degenerative spondylosis. The purpose of this study is to quantify and compare the long-term patient-reported outcomes following LDA and matched-fusion procedures. **Methods:** We conducted a matched-cohort study comparing consecutive patients enrolled by the Canadian Spine Outcomes and Research Network (CSORN) who underwent stand-alone primary LDA or hybrid techniques for degenerative disk disease between 2015 and 2019. Fusion patients were included by a primary diagnosis of degenerative disk disease and chief complaint of back pain, who received a primary fusion irrespective of technique. Fusion patients were matched by number of involved levels of surgery to LDA counterparts. Outcome scores and patient satisfaction were assessed preoperatively and 2 years postoperatively. **Results:** Ninety-seven patients (39 female, 58 male) underwent LDA or hybrid construct up to 4 levels. Ninety-four patients (52 female, 42 male) who underwent a lumbar fusion were selected on the basis of the inclusion criteria. Thirty-six LDA and 57 fusion patients underwent a 1-level surgery. Thirty-nine LDA and 25 fusion patients underwent 2-level surgery. Eighteen LDA and 7 fusion patients underwent 3-level surgery. Four LDA and 5 fusion patients underwent a 4-level procedure. Slight differences in average cohort age were found (LDA 43.4 yr, fusion 49.8 yr , $p < 0.01$). Cohort preoperative body mass index (LDA 27.0 kg/m^2, fusion 27.9 kg/m^2, $p = 0.29$) and total comorbidities (LDA 2.6, fusion 2.1, $p = 0.05$) demonstrated no clinically significant differences. At 2-year follow-up, no differences were found in Oswestry Disability Index score improvement (LDA 20.32 points, fusion 17.02 points, $p = 0.36$), improvement in numerical back-pain score (LDA 3.5 points, fusion 3.06 points, $p = 0.40$), improvement in numerical leg-pain score (LDA 1.67 points, fusion 1.87 points, $p = 0.76$) and improvement in Health Scale score (LDA 17.12, fusion 10.73, $p = 0.20$) between cohorts. Similar positive findings were found in subgroups stratified by number of surgical levels. Satisfaction rate at 2 years was 86.7% and 82.4% for LDA and fusion patients, respectively. **Conclusion:** There didn't appear to be significant differences in outcomes or satisfaction through 2 years comparing patients who underwent LDA (whether used in isolation or as part of a hybrid construct) for debilitating degenerative disk disease and isolated spinal fusion for back dominant pain.

Presentation o91
Abstract 171

Development of clinical practice guidelines for the management of traumatic spinal column and cord injuries in British Columbia: an approach to standardizing care of spine trauma patients. ***Oliver Lasry, Dave Evans, Brian Kwon, Jan Splawinski, Daniel Warren, John Street.*** **From the Vancouver Spine Surgery Institute, Vancouver, B.C (Lasry, Kwon, Street); the University of British Columbia, Vancouver, B.C. (Evans); the Vernon Jubilee Hospital, Vernon, B.C. (Splawinski); and Island Health, Victoria, B.C. (Warren).**

Background: Clinical practice guidelines (CPGs) for the management of spinal column and spinal cord injuries have been developed across jurisdictions by synthesizing knowledge in the literature. CPGs ensure that clinicians have access to the information required to provide appropriate care to patients, reducing variations in care across populations. However, CPGs need to be adapted to individual health care jurisdictions to ensure that they are aligned with the availability of resources. In Canada, CPGs for spinal column and cord injuries have not been developed. We aimed to develop CPGs for managing spinal column and spinal cord injuries in adults (aged > 16 yr) in British Columbia. **Methods:** A guideline development group composed of spine surgeons, trauma physicians, emergency physicians, radiologists, intensivists and Trauma Services BC administrators was formed. A systematic review of the literature was conducted to synthesize

knowledge on the best practices for managing suspected or confirmed spinal column and cord injuries. Thereafter, a modified Delphi approach was used to synthesize the knowledge into CPGs appropriate for the health care context of British Columbia. **Results:** Five published society guidelines in jurisdictions outside of Canada, in addition to the clinical expertise of the guideline development group, were used to develop the CPGs. Algorithms for suspected and confirmed injuries were developed and included recommendations on (a) the initial management, (b) diagnostic imaging requirements, (c) criteria for transferring patients to higher levels of care, (d) pretransfer care and (e) local management of stable spinal fractures. These CPGs will be rolled out over 2020. **Conclusion:** These CPGs represent the first Canadian recommendations for the management of spinal column/cord injuries. They can serve as a model for other jurisdictions aiming to develop similar CPGs. Further efforts are necessary to assess clinicians' adherence to the guidelines and to assess the impact that the guidelines have on quality of care.

Presentation o92
Abstract 22

Notes from a small island: stemming the tide of a spinal deluge. The use of encrypted software applications to ensure accountability, quality control and surgical consensus in a national acute adult spinal surgery centre. ***Frank Lyons*, *Seamus Morris*, *Jennifer Costello*, *Mark Farrell*. From the Department of Orthopaedic Surgery, Mater Misericordiae University Hospital, Dublin, Ireland, (Lyons, Morris); and Information Management Services, Mater Misericordiae University Hospital, Dublin, Ireland, (Costello, Farrell).**

Background: Since 1991, our hospital has provided the only 24-hour acute spinal centre in Ireland, with a catchment of 4 million. Initially referrals constituted major spinal trauma, critical metastases and infection. Recently referrals have included minor end-plate fractures, chronic sciatica and age-indeterminate osteoporotic fractures. With 30 or more acute referrals per week made by fax and phone call, this became a major resource problem and safety concern for continuity of care, patient data collation, follow-up and communication back to the referral centre. **Methods:** Our goal was to devise a secure referral pathway that guaranteed accountability, transparency and consistency from the referrer, and a live, centralized, visible "air-traffic control" system for our receiving unit. **Results:** We developed a fully encrypted web-based acute spine portal with a unique hospital and physician identifier login and predetermined access and visibility level. The referral cannot be submitted without a signed declaration by the referrer, including to take the patient back once deemed appropriate by our unit. Equally our residents are not allowed to take an outside referral before the online portal has been submitted. The portal has an external view and internal view, depending on the physician and hospital access level. Since July 2019 all files have been uploaded to Siilo such that our unit surgeons can view each referral in real time on a smartphone, tablet or laptop. In January 2020 a major new HL7-compatible iteration will launch and will be linked to the national integrated medical imaging system and the national critical care transfer system. **Conclusion:** Cases are traffic-lighted live according to clinical priority and bed availability. Equally cases are reviewed and updated for transfer, further investigation, outpatient follow-up, discussion at our twice weekly multidisciplinary team meeting or local follow-up. Every case since launch in August 2016 has remained hosted in the portal database including a comprehensive clinical information file, which is about to undergo a major audit.

Presentation o93
Abstract 129

Traumatic spinal cord injuries among Aboriginal and non-Aboriginal populations in Canada: an ambispective outcomes study. ***Uzair Ahmed*, *Suzanne Humphreys*, *Dilnur Kurban*, *Carly Rivers*, *Melanie Jeffrey*, *Sandra Juutilainen*, *Steve Casha*, *Sean Christie*, *Teren Clarke*, *Brian Drew*, *Karen Ethans*, *Michael Fehlings*, *Richard Fox*, *Gary Linassi*, *Travis Marion*, *Colleen O'Connell*, *Jérôme Paquet*, *Janine Reid*, *Launel Scott*, *Daryl Fourney*, *the RHSCIR Network*. From the University of Saskatchewan, Saskatoon, Sask. (Ahmed, Linassi, Fourney); the Praxis Spinal Research Institute, Vancouver, B.C. (Humphreys, Kurbam, Rivers, RHSCIR Network); the the University of Toronto, Toronto, Ont. (Jeffrey, Fehlings); Ryerson University, Toronto, Ont. (Juutilainen); the University of Calgary, Calgary, Alta. (Casha); Dalhousie University, Halifax, N.S. (Christie); Spinal Cord Injury Alberta, Edmonton, Alta. (Clarke); McMaster University, Hamilton, Ont. (Drew); the University of Manitoba, Winnipeg, Man. (Ethans, Reid); the University of Alberta, Edmonton, Alta. (Fox); the Northern Ontario School of Medicine, Thunder Bay, Ont. (Marion); Dalhousie University, Saint John, N.B. (O'Connell); Laval University, Québec, Que. (Paquet); and the Spinal Cord Injury Saskatchewan, Saskatoon, Sask. (Scott).**

Background: People of Aboriginal (Indigenous) ancestry are more likely to suffer traumatic spinal cord injury (tSCI) than other populations in Canada; however, outcome studies are limited. This study aims to compare Aboriginal and non-Aboriginal populations in Canada with acute tSCI with respect to preinjury baseline, injury severity, treatment, outcomes and length-of-stay characteristics. **Methods:** We completed a retrospective analysis of 3478 participants with tSCI enrolled in the prospective Rick Hansen Spinal Cord Injury Registry (RHSCIR) from 31 facilities across Canada between 2004 and 2018. Demographic, injury and clinical management data were assessed to identify differences between the populations. **Results:** Of the participants, 166 (4.8%) identified as Aboriginal and 3312 as non-Aboriginal. The Aboriginal cohort was significantly younger (38.0 v. 46.9 yr, $p = 0.0031$) and less likely to be male (68.1% v. 78.1%, $p = 0.0025$) than the non-Aboriginal group. Mechanism of injury was also significantly different between groups, with the Aboriginal population more likely to be injured from assault (12.2% v. 3.4%, $p < 0.0001$). There were no significant differences in neurologic severity and level of injury, comorbidity, rate/timing of surgical management, and neurologic or functional recovery. Aboriginal individuals had a 21% longer stay in acute care ($p = 0.0377$) and were more likely to be injured in (48.1% v. 28.4%, $p < 0.0001$) and discharged to (50.5% v. 26.4%, $p < 0.0001$) a rural area. **Conclusion:** This study reveals differences in the epidemiology and outcomes of Aboriginal people with tSCI in Canada. Given the significant rural disease burden in this population, better allocation of resources for transition to the community for Aboriginal peoples with tSCI should be a priority. This work fills a critical knowledge gap and opens the opportunity for unique interventions in prevention and management.

Presentation o94
Abstract 132
Traumatic spinal cord injury in New Zealand and Canada: a comparative analysis. ***Tom Inglis*, *Rowan Schouten*, *Carly Rivers*, *Melody Chen*, *Jo Nunnerley*, *Tracey Croot*, *Leah Young*, *Alpesh Patel*, *Marcel Dvorak*, *the RHSCIR Network*. From the University of Otago, Christchurch, New Zealand (Inglis, Schouten, Nunnerley); the Praxis Spinal Research Institute, Vancouver, B.C. (Rivers, Chen, RHSCIR Network); the Burwood Spinal Unit, Christchurch, New Zealand (Croot); the Auckland Spinal Rehabilitation Unit, Auckland, New Zealand (Young); Middlemore Hospital, Auckland, New Zealand (Patel); and the University of British Columbia, Vancouver, B.C. (Dvorak).**

Background: Traumatic spinal cord injury (tSCI) is a devastating injury causing a significant burden on society and individuals. New Zealand (NZ) has partnered with the Canadian-wide Rick Hansen SCI Registry (RHSCIR) to collect equivalent demographic and clinical data from patients sustaining a new tSCI. Our objective was to examine similarities and differences between these registry populations to guide further collaborative research. **Methods:** Data from 2007 to 2018 were obtained from 2 SCI observational registries from Canada (RHSCIR) and NZ (New Zealand Spinal Cord Injury Registry, NZSCIR). Variables of interest including demographics (e.g., age, sex), injury characteristics (e.g., neurological level/severity) and care management practises (e.g., time to hospital) were compared. **Results:** A total of 8596 registry participants were included: 1277 from NZ and 7319 from Canada. In both registries the male-to-female ratio was 3:1. In NZ, tSCI patients were on average younger (45 v. 50 yr, $p < 0.01$) and more likely to have sustained a higher cervical cord injury (38% v. 33%, $p = 0.02$). Falls represented the most common injury mechanism in both registries, but a higher proportion occurred in Canada (47% v. 33%) while sports were a more common injury mechanism in NZ (22% v. 13%). In Canada, patients were more likely to arrive directly at a registry site (59% v. 41%, $p < 0.01$) and more rapidly (6 v. 9 h, $p < 0.01$). Surgical intervention was higher in Canada (86% v. 78%, $p < 0.01$) with length of stay in both acute and rehabilitation facilities significantly longer. In-hospital mortality was higher in Canada (5.9% v. 1.4%, $p < 0.01$). Ethnic differences existed. In Canada 82% of tSCI patients were identified as white, compared with 73% in the general population. NZ European/Pakeha comprised 55% of the NZ registry population compared with 74% in the general population, reflecting a higher propensity of tSCI in Maori and Pacific peoples of NZ. **Conclusion:** There are notable differences in the demographics, injury and care management practices between the 2 countries. Understanding the similarities and variances between populations will inform future research. Further analysis will be conducted to identify opportunities to affect patient and system outcomes by changing processes of care.

Presentation o95
Abstract 150
Exploring the reasons for readmission following traumatic spinal cord injury. ***Zeina Waheed*, *Brian Kwon*, *Carly Rivers*, *Jerome Buenaventura*, *Suzanne Humphreys*, *Vanessa Noonan*, *Nader Fallah*, *Nathan Evaniew*, *Marcel Dvorak*. From the Praxis Spinal Cord Institute, Vancouver, B.C. (Waheed, Rivers, Buenaventura, Humphreys, Noonan, Fallah); and the University of British Columbia, Vancouver, B.C. (Kwon, Fallah, Dvorak, Evaniew).**

Background: Most studies report on unplanned hospital readmissions following traumatic spinal cord injury (tSCI) for only 1 time period but do not report the patterns over time. The objectives of this study were to determine common reasons for unplanned readmissions related to secondary complications of tSCI and examine whether these reasons change over time after injury to inform long-term care. **Methods:** A cohort of 4625 individuals admitted to hospital in British Columbia with acute tSCI over 23 years (1995–2017) was created from the hospital Discharge Abstract Database (DAD) using ICD-9 and ICD-10 codes. Ethical and other regulatory approvals were obtained before data access. Administrative data from DAD between April 1995 and December 2017 were used to determine causes of readmissions. The time periods examined were as follows: within 1 year, 1–5 years and 5–10 years after tSCI. ICD diagnosis codes for most responsible diagnosis were used to document reason for readmission. Descriptive analysis was performed. Future work includes modelling of how patient characteristics and reasons for readmissions affect the health system (i.e., patterns of readmission and costs). **Results:** Within the cohort of 4625, there were 2337 unplanned readmissions within 1 year, 4612 between 1 and 5 years and 3040 between 5 and 10 years. The most common reasons for readmission within 1 year were genitourinary (e.g., urinary tract infections) (21.3%), procedural adverse events/injuries (17.9%), musculoskeletal (10.6%) and respiratory (e.g., pneumonia) (8.3%). In addition to the complications seen within 1 year, digestive-related causes and mental/behavioural disorders (7.5%) occurred between 1 and 5 years. Between 5 and 10 years, readmissions related to skin and subcutaneous tissue conditions (e.g., pressure injuries) (9%) were reported. **Conclusion:** Common reasons for readmission within 1 year following tSCI include procedural adverse events/injuries and genitourinary, musculoskeletal and respiratory conditions. As the post-tSCI time progresses, the onset of digestive system diseases, mental/behavioural disorders and skin/subcutaneous tissue diseases occurs. These results highlight the importance of regular follow-ups and understanding the effect of tSCI over time to tailor effective tSCI care programs to prevent readmissions.

Presentation o96
Abstract 59
Exploring the epidemiology and impact of spinal cord injury in the elderly: a 15-year Canadian population-based cohort study. ***Jefferson Wilson*, *Shawna Cronin*, *Jetan Badhiwala*, *Howard Ginsberg*, *Michael Fehlings*, *Brian Kwon*, *Susan Jaglal*. From St. Michael's Hospital, Toronto, Ont. (Wilson, Badhiwala, Ginsberg); the University of Toronto, Toronto, Ont. (Wilson); ICES, Toronto, Ont. (Cronin, Jaglal); Toronto Western Hospital, Toronto, Ont. (Fehlings); and the University of British Columbia, Vancouver, B.C. (Kwon).**

Background: Although experience suggests a shift in the epidemiology of spinal cord injury (SCI) toward an older demographic, population studies are lacking. Our objectives were to investigate: (a) how the epidemiology and age profile of SCI have changed

over time and (b) how increased age affects health outcomes. **Methods:** A population-based cohort study was performed using Ontario administrative data. Adults diagnosed with traumatic SCI between 2002 and 2017 formed the primary cohort; older and younger SCI cohorts were created on the basis of an age cut-off of 65 years. An older cohort of noninjured persons was matched to the older SCI cohort on the basis of age, sex and comorbidity status. Changes in crude incidence rates were reported as average annual percentage change (AAPC). Survival, hospital readmissions and costs were compared between the older and younger SCI cohorts as well as the older SCI and older noninjured cohorts. **Results:** The incidence of SCI increased among females (AAPC 2.2, 95% confidence interval [CI] 0.1–4.3) during the study period, driven by a marked rise (4%/yr) among elderly females (AAPC 4.3, 95% CI 0.1–4.3). Although no change in incidence was detected for males, there was a trend toward increased incidence among older males (AAPC 1.2, 95% CI 1.3–3.8). There were a higher proportion of cervical, incomplete and fall-related injuries in the older versus younger SCI cohort. Age over 65 years was associated with a 6-fold increased risk of death (hazard ratio [HR] 5.75, 95% CI 4.72–7.00). In comparison with the older noninjured cohort, the older SCI cohort had double the risk of death (HR 2.23, 95% CI 2.00–2.50). Older persons with SCI had higher odds of hospital readmission at 1 and 5 years and accumulated higher costs than younger persons with SCI and older noninjured persons. **Conclusion:** The incidence of SCI among the elderly is increasing, particularly among women. Older SCI patients are at higher risk of death and hospital readmission and accumulate greater health care costs than younger persons with SCI and older noninjured persons. Prevention through fall reduction and education to improve outcomes are needed.

Poster Presentations

Presentation P1
Abstract 139
Incidence and management of spinal metastasis in Ontario: a population-based study. ***Anick Nater*, *Jefferson Wilson*, *Michael Fehlings*.** **From the Department of Neurosurgery, University of Toronto, Toronto, Ont.**

Background: Metastatic spinal cord compression (MSCC) is 1 of the most debilitating complications of cancer. To our knowledge, the incidence, management and outcome of MSCC at a population level have not been investigated since 2003. **Methods:** Patients with a diagnosis of cancer admitted at least once with a concurrent diagnosis of MSCC in Ontario, Canada (2005–2015), and the associated management of MSCC, were identified by linking unique patient identifier from the Ontario Cancer Registry to the Same Day Surgery Database, Cancer Activity Level Reporting and National Ambulatory Care Reporting System. **Results:** Overall, the number of patients with cancer admitted at least once with a concomitant diagnosis of MSCC is decreasing (n = 3619 in 2005 v. n = 677 in 2015). The median survival after the first admission with a diagnosis of MSCC was 79 days (95% confidence interval [CI] 74–84), that is, 2.6 months; patients alive at 3, 12 and 24 months were 37.81%, 13.67% and 9.64%, respectively. There was no record of receiving either radiotherapy or surgery for 36.2% of patients with MSCC while 42.9%, 16.7% and 4.2% were treated with surgery only, radiotherapy only and both surgery and radiotherapy, respectively. The proportion of patients admitted with a diagnosis of MSCC was relatively stable between 5 years, 2 years and 1 year preceding death (1.41%, 1.47% and 1.49%, respectively) and varied widely according to the type of primary tumour (leukemia 0.18% v. multiple myeloma 5.50%, at 5 yr before death). In the last year of life, the length of stay was longer for patients with cancer and MSCC (17.1 ± 19.34, median 11 v. 11.1 ± 14.24, median 7; $p < 0.001$). **Conclusion:** Overall, the number of admissions of patients with cancer and MSCC is decreasing. Approximately 1% of patients admitted with a diagnosis of cancer have a concurrent diagnosis of MSCC. There is nearly a 30-fold variation in the proportion of patients admitted with MSCC between different types of primary tumour. Over 40% of patients admitted with MSCC are treated with surgery.

Presentation P2
Abstract 91
A general population utility valuation study for the Spine Oncology Study Group Outcomes Questionnaire – 8D. ***Markian Pahuta*, *Felicity Fisk*, *Anne Versteeg*, *Charles Fisher*, *Arjun Sahgal*, *Ziya Gokaslan*, *Laurence Rhines*, *Stefano Boriani*, *Chetan Bettegowda*, *Nicolas Dea*, *the AO Spine Knowledge Forum Tumor*.** **From the Henry Ford Health System, Detroit, Mich. (Pahuta, Fisk); Utrecht University, Utrecht, the Netherlands (Versteeg); the University of British Columbia, Vancouver, B.C. (Fisher, Dea); the Sunnybrook Odette Cancer Centre and University of Toronto, Toronto, Ont. (Sahgal); the Warren Alpert Medical School, Brown University, Providence, R.I. (Gokaslan); the MD Anderson Cancer Center, Houston, Tex. (Rhines); IRCCS Istituto Ortopedico Galeazzi, Milano, Italy (Boriani); the Johns Hopkins University School of Medicine, Baltimore, Md. (Bettegowda); and AO Spine, Davos, Switzerland (AO Spine Knowledge Forum Tumor).**

Background: Treatment decision-making for metastatic spine disease is challenging because multiple patient- and treatment-related factors including patient performance status, survival prognosis and risk of adverse events must be considered. Quality-adjusted life year (QALY) analysis could help patients and clinicians jointly assess the trade-offs between survival, health-related quality of life (HRQoL) benefits, recovery and potential complications to reach an optimal treatment decision. QALYs are also required in economic analysis because economic decisions are based on the incremental cost-effectiveness ratio, which is the cost per QALY gained. QALYs are calculated using utilities, or HRQoL weights. The AOSpine Knowledge Forum Tumor (former Spine Oncology Study Group, SOSG) developed an 8-item spine oncology- specific outcome questionnaire (SOSGOQ-8D) that is suitable for developing a utility mapping. **Methods:** We recruited a sample of 3821 adults from a market research company. Quota sampling was used to ensure that the participants were representative of the United States population in terms of age, sex and state of residence. Participants were asked to rate 10 of 100 S-optimal SOSGOQ-8D health states in a discrete choice experiment (DCE). Utility mapping was developed using a random-effects conditional logit regression model. **Results:** Of 3821 individuals recruited, 749 (20%) met all quality criteria. Response quality was not

related to perceived difficulty of the DCE task. Regression parameter estimates were monotonic for each domain, which indicated sensible and valid results. Self-care and social function items were the greatest determinants of health state utility. **Conclusion:** We have provided utility estimates for the SOSGOQ-8D. The utility values derived from this study can be used to help inform population-level health care decision-making, such as allocation of limited resources for specific treatments. The ability to calculate QALYs for metastatic spine disease will enhance treatment decision-making and facilitate economic analysis. When offering treatment, clinicians should be mindful that extremity neurologic function is not the greatest determinant of utility, and thus HRQoL.

Presentation P3
Abstract 158
Metastatic vertebrae segmentation by augmented 3D convolutional neural network. ***Geoff Klein, Anne Martel, Arjun Sahgal, Joel Finkelstein, Cari Whyne, Michael Hardisty.*** **From the Sunnybrook Research Institute, Toronto, Ont. (Klein, Martel, Sahgal, Finkelstein, Whyne, Hardisty); the Department of Medical Biophysics, University of Toronto, Toronto, Ont. (Klein, Martel); the Department of Radiation Oncology and Surgery, Toronto, Ont. (Sahgal); and the Department of Surgery, University of Toronto, Toronto, Ont. (Finkelstein, Whyne, Hardisty).**

Background: Metastases of tumours to the bony spine are common complications of primary cancers that alter bone architecture, potentially leading to vertebral fracture and neurologic compromise. Quantitative radiologic measures of vertebral stability may complement existing clinical scoring for assessing fracture risk and vertebral stability. Existing quantitative methods used to generate measures are slow and require manual intervention, limiting their utility. The broader goal of this work is to develop tools for the assessment of mechanical stability that will be useful within the context of typical care and imaging for patients. **Methods:** This investigation proposes a deep learning method, specifically a 3D U-Net Convolutional Neural Network (CNN) to accurately segment individual trabecular centrum from metastatically compromised vertebrae of interest in computed tomographic (CT) imaging. Within this investigation we were focused on making the algorithm robust to changes seen typically, specifically changes in image resolution and to changes to vertebrae position. To do this, multiple augmentation techniques were investigated that target changes in medical image resolution and position of the vertebrae within the volume of interest. The networks were trained with data from 30 patients with sequential imaging taken at 4-month scan intervals, yielding approximately 530 vertebral segmentations used for training and 130 for validation. **Results:** The 3D CNN using all augmentation techniques achieved the best performance (Dice similarity coefficient [DSC] = 90.4% ± 5.6%) with the segmentation model remaining accurate with simulated lower image quality, and translation of the vertebrae within the image volume of interest, especially compared with training the network without augmentation (DSC = 77.4% ± 18.8%). **Conclusion:** Use of augmentation techniques during training of machine learning algorithms to specially address real-world concerns (changes in image resolution and vertebral position) improved the ability of the trained networks to account for these situations and created a more robust and useful algorithm. Integration of this method into a clinical tool will allow accurate and robust quantitative assessment of mechanical stability from CT imaging, aiding clinical decision-making to improve patient care.

Presentation P4
Abstract 73
Risk factors for failure of radiation therapy for spinal metastases. ***Natasha McKibben, Nikolas Baksh, Thuy Nguyen, Simon Brown, Jerry Jaboin, Clifford Lin.*** **From the Oregon Health and Science University, Portland, Ore.**

Background: The Spine Instability Neoplastic Score (SINS) was developed as a referral tool for medical providers in patients with concern for instability in metastatic spine disease. There is limited research studying how SINS correlates with rates of failure after radiation therapy. The goal of this study was to evaluate a cohort for risk factors for failure of radiation therapy. We hypothesized that a higher SINS, particularly the domains of mechanical pain and deformity, would correlate with failure of radiation therapy. **Methods:** We performed an institutional review board approved retrospective cohort study at a tertiary academic centre. All patients with spinal metastasis being treated with radiation between September 2014 and October 2018 were identified. Pediatric patients and patients with myeloma, leukemia, lymphoma, sarcoma, cord compression, history of prior radiation or surgery, or inadequate follow-up were excluded. Baseline demographics were recorded and the SINS was calculated. Other variables analyzed were primary tumour, Karnofsky and Eastern Cooperative Oncology Group (ECOG) scores, time to treatment, dosage and type of radiation. The outcome was radiation therapy failure as defined by persistent pain, need for reirradiation, or surgical intervention. χ^2 and Fisher exact tests were used for analysis of categorical variables. Continuous variables were analyzed with the Student *t* test. Univariate analysis was performed and is being used to build a multivariate regression model. **Results:** A total of 583 patients were identified, of whom 170 met the inclusion criteria. Median follow-up was 218 days. Radiation therapy was unsucessful in 43 patients, 10 required repeat radiation and 7 underwent surgery. Thirty-six reported no pain relief, including some who required reirradiation and surgery. Significant risk factors were SINS grouping (< 6, 7–12, > 12) ($p = 0.038$), percent vertebral involvement ($p = 0.002$), biologically effective dose (BED) less than 43 ($p = 0.047$), categorical Karnofsky (< 50, 50–70, > 80) ($p = 0.003$), continuous Karnofsky ($p = 0.001$) and ECOG score (0–2, 3–4) ($p = 0.025$). **Conclusion:** Lower performance scores, lower BED, higher SINS and vertebral involvement were associated with radiation failure on univariate analysis.

Presentation P5
Abstract 68
Significance of extracanalicular cement extravasation in thoracolumbar kyphoplasty. ***Faizal Kassam, Jeff Yach.*** **From the University of Calgary, Calgary, Alta. (Kassam); and Queen's University, Kingston, Ont. (Yach).**

Background: Kyphoplasty is a procedure performed for pain relief in patients with vertebral insufficiency fractures. The procedure involves augmentation of 1 or more vertebral bodies using bone cement. During cement insertion, cement extravasation may occur into the spinal canal as well as into extracanalicular regions such as paravertebral soft tissues, intervertebral disc spaces, and along anterior vascular structures. The rationale of this study is to determine if adverse functional outcomes occur because of such cement leakage during thoracolumbar kyphoplasty. **Methods:** This study is a retrospective analysis of a case series of data collected prospectively. A series of 152 thoracolumbar kyphoplasty cases in 132 patients was reviewed over a 14-year span. The primary surgical indication was back pain secondary to osteoporotic or pathologic vertebral fractures refractory to conservative management. Intra- and post-operative imaging was assessed for cement extravasation outside of the spinal canal. Length of hospital admission, reoperation rates and readmission rates were assessed and correlated with extracanalicular cement leakage. **Results:** Between 2004 and 2018 a total of 282 levels were augmented. Extracanalicular cement extravasation occurred in 62/282 (22%) levels augmented. Of these, 26/62 (42%) leaks were intradiscal, 20/62 (32%) occurred lateral to the vertebral body, 12/62 (19%) occurred along vasculature anteriorly and 4/62 (6%) involved multiple locations. There was 1 case of cement extravasation into the spinal canal; however, it did not result in any adverse clinical outcomes. There were no reoperations for cement-related complications. There was no correlation between number of levels augmented and readmission to hospital within 30 days postoperatively. **Conclusion:** Extracanalicular cement extravasation during thoracolumbar kyphoplasty for vertebral insufficiency fractures does not appear to result in adverse clinical sequelae. Cement leakage did not correlate with readmission to hospital or reoperation on the same spinal level. This study helps to demonstrate that symptoms postoperatively may be related to factors such as preexisting degenerative disc disease or inorganic causes rather than being due to cement leakage when it occurs outside the spinal canal.

Presentation P6
Abstract 120
Modelling fracture in osteoblastic vertebrae. ***Allison Clement*, *Micheal Hardisty*, *Cari Whyne*. From the Sunnybrook Research Institute, Toronto, Ont. (Clement, Hardisty, Whyne); and the University of Toronto, Toronto, Ont. (Whyne).**

Background: The negative consequences of fracture in the metastatic spine motivate improved understanding of bone quality and fracture risk. Computational models can evaluate effects of changes in structural and material properties due to the presence of pathology or intervention. This work aimed to develop and validate voxel-based micro-finite element (μFE) models of vertebrae with osteoblastic involvement that can predict fracture initiation and propagation. **Methods:** A preclinical model of osteoblastic metastatic lesions in the spine was created via intracardiac injection of ZR-75-1 breast cancer cells into athymic rats. Motion segments, T13–L1 and L1–L3, were excised 4 months after inoculation. Displacement-controlled axial and bending loads were applied to the metastatically involved motion segments with sequential μCT imaging (34 μm) to capture progression of failure. Specimen specific μFE models (n = 2) were created from unloaded μCT images using an in-house voxel-based meshing algorithm. Displacement boundary conditions were created using surface-based registration. Damage mechanics were incorporated using cohesive elements to model damage within predefined regions of interest. Healthy and metastatic bone material property assignment was implemented via spine specific thresholding and manual segmentation of osteoblastic tissue. **Results:** Failed elements were seen at anatomic sites consistent with experimental observation, with 1 model predicting failure in the pedicle and the second at the end plate. However, the μFE models predicted less displacement at the fracture sires than seen experimentally. Changes in crack propagation direction at the growth plate were not captured, as the growth plate was not specifically included in the μFE models. **Conclusion:** The specimen specific voxel-based μFE models including cohesive zone-based damage mechanics were able to accurately predict the location of damage in preclinical vertebrae with osteoblastic lesions. The assumed damage mechanics parameters and material property definitions of the osteoblastic tissue and the absence of growth-plate specific material properties may have limited the ability to predict the extent of the damage propagation and displacement. Identifying fracture initiation and propagation in osteoblastic vertebrae with μFE modelling may ultimately be useful in guiding therapeutic interventions.

Presentation P7
Abstract 97
The development of novel 2-in-1 patient-specific, 3D-printed laminar osteotomy guides with integrated pedicle screw guides. ***Andrew Kanawati*, *Renan Fernandez*, *Aaron Gee*, *Jennifer Urquhart*, *Chris Bailey*, *Parham Rasoulinejad*. From Victoria Hospital, London, Ont. (Kanawati, Fernandez, Gee, Urquhart, Bailey, Rasoulinejad); and Westmead Hospital, Sydney, Australia (Kanawati).**

Background: Laminectomy is the mainstay of treatment for spinal conditions that require decompression of neural elements. Despite being a very common procedure, spinal decompression has several risks, including dural tear, damage to neural elements and spinal instability due to iatrogenic spondylolisthesis. This study examines the novel design of 2-in-1 3D-printed patient-specific laminar osteotomy guides, with integrated pedicle screw drill guides. **Methods:** Three human cadaveric lumbar spines were meticulously cleaned after boiling. Vertebral digital models and patient-specific templates were created using 3D Slicer version 4.10.2. Longitudinal laminar osteotomy guides were placed in the appropriate position to preserve the facet joints and pars interarticularis. The guides were 2.5 mm wide to accommodate the standard-sized matchstick burr. The contour of the laminar osteotomy guides was created to match the deep surface of the lamina, set at a depth of 14 mm, so that if the burr is offset 14 mm from the tip of the handle it should safely travel along the dorsal aspect of the ligamentum flavum and dura. Pedicle screw drill guides were designed to fit into the lamina osteotomy guides. The templates were 3D printed and tested. The undersurface of the lamina was filmed using a high-definition digital camera, to determine the burr tip position compared with the inner table of the lamina. Computed tomographic (CT) scans were obtained to analyze screw and laminectomy positions.

Results: There was no difference between the preoperative and postoperative laminectomy positions. The burr tip did not pass deep to the inner table of the lamina in any specimen. There were no pedicle screw breaches, and mean axial and sagittal screw error was 2.5° (standard deviation [SD] 1.7) and 0.6° (SD 1.2), respectively. Average surgical time was 4 minutes 46 seconds per level. **Conclusion:** Our novel 2-in-1 3D-printed laminar osteotomy guides are an accurate and efficient way of performing spinal decompression and instrumentation.

Presentation P8
Abstract 56
Effect of pelvic retroversion on pelvic geometry and muscle morphometry from upright magnetic resonance imaging. ***Noor Shaikh*, *Honglin Zhang*, *Jason Shewchuk*, *John Street*, *David Wilson*, *Thomas Oxland*. From the School of Biomedical Engineering, University of British Columbia, Vancouver, B.C. (Shaikh); the International Collaboration on Repair Discoveries (ICORD), University of British Columbia, Vancouver, B.C. (Shaikh, Street, Wilson, Oxland); the Department of Mechanical Engineering, University of British Columbia, Vancouver, B.C. (Shaikh, Oxland); the Centre for Hip Health and Mobility, University of British Columbia, Vancouver, B.C. (Zhang, Wilson); the Department of Radiology, Vancouver General Hospital, Vancouver, B.C. (Shewchuk); and the Department of Orthopaedics, University of British Columbia, Vancouver, B.C. (Street, Wilson, Oxland).**

Background: With adult spinal deformity positive sagittal imbalance, pelvic retroversion is typically the first compensatory step. Consequently, there is interest in better understanding the underlying mechanisms in such compensatory changes. First, however, a better understanding of dynamic changes in pelvic musculature/geometry with asymptomatic retroversion is needed. This would help identify key muscles and could influence future treatment planning. This study aimed to assess the effect of pelvic retroversion on pelvic musculature/geometry in asymptomatic adults using upright magnetic resonance imaging (MRI). **Methods:** Six healthy volunteers were imaged in a 0.5-T upright MRI (MROpen, Paramed) using T1-weighted Spin Echo sequences in 4 postures (standing, standing pelvic retroversion, standing 30° flexion, supine). Pelvic tilt (PT), pelvic incidence (PI), sacral slope (SS) and L3–S1 lumbar lordosis (LL), as well as muscle cross-sectional area (CSA), circularity, radius and angle for the gluteus (maximus, medius, minimus combined) and iliopsoas were measured. Effects of posture, correlations and repeatability were evaluated by analysis of variance ($p < 0.05$), Pearson ($p < 0.05$) and intraclass correlation coefficient (ICC [3,1]) respectively. **Results:** Posture and level had a significant effect and interaction on the gluteus (CSA, circularity, radius, angle). Generally, CSA/circularity decreased supine to standing and CSA/circularity increased standing/standing flexion to retroversion (up to 22%). Posture and level also significantly affected the iliopsoas (angle), with some significant interactions (circularity, radius). Additionally, posture affected PT, SS and LL, but not PI. On average PT increased 6° supine to standing and 7° standing to retroversion. Muscle CSA/circularity also had significant correlation with PT (positive), SS (negative) and LL (negative) at specific levels. Repeatability (ICC [3,1]) was 0.86–0.99 for posture and 0.76–0.99 for intrarater. Across postures, PI repeatability was 0.85–0.92. **Conclusion:** The effects, interactions and correlations of posture and level with pelvic muscles/geometry notably between supine to standing and standing to retroversion confirm some expected trends such as muscle narrowing with elongation. Promising repeatability supports imaging feasibility, with interrater repeatability evaluation planned before scanning patients.

Presentation P9
Abstract 161
Anatomic relationship between the accessory process of the lumbar spine and the pedicle screw entry point. ***Andrew Kanawati*, *Renan Fernandez*, *Aaron Gee*, *Jennifer Urquhart*, *Chris Bailey*, *Parham Rasoulinejad*. From Victoria Hospital, London, Ont. (Kanawati, Fernandez, Gee, Urquhart, Bailey, Rasoulinejad); and Westmead Hospital, Sydney, Australia (Kanawati).**

Background: Pedicle screws are a common medical device being used for treatment of several spine disorders. The precision of screw entry point is crucial, with several freehand placement techniques being described. The majority of the techniques are based on anatomic landmarks using the midpoint of the transverse process and the facet joints. However, in degenerative diseases, the facet becomes hypertrophied and normal bony anatomy is distorted. The vertebra accessory process (or tubercle) of the lumbar spine is an understated anatomic landmark that lies below the mammillary process at the base of the transverse process. No studies have compared its relation to the pedicle isthmus and entry point. We proposed to evaluate the relationship between the accessory process and the projected pedicle axis. **Methods:** Computed tomographic (CT) scan DICOM files of 6 lumbar cadaveric spines were imported into 3D Slicer, version 4.10.2, and 3D mesh models were created. The largest axial diameter of the pedicle was measured to template screw size. A cylinder model with the equivalent width of the planned screw was positioned in the centre of the pedicle in the ideal trajectory, avoiding breach of the facet joint. The distance between the tip of the accessory process and the centre of the cylinder (the entry point of the pedicle screw) was measured. The angle between this axis and the midline was measured. Interrater reliability was assessed using intraclass correlation coefficients for 2 raters. Statistical analysis of the results was performed using SPSS. **Results:** The mean distance between the tip of accessory process and the pedicle screw entry point was 6.5 mm (standard deviation [SD] 2.05), and the mean angle between this axis and the midline was 29.4° medial (SD 10.08). The calculated mean distance between the tip of the accessory process and pedicle screw entry point was 3.2 mm (SD 1.3) and 5.7 mm (SD 1.9) medial and cranial, respectively. **Conclusion:** The accessory process is a reliable and consistent landmark to guide pedicle screw entry point. To our knowledge, this is the first study in the published literature to assess this relationship.

Presentation P10
Abstract 20
Novel chair to measure lumbar spine extensors strength in adults. ***Abdullah Alshammari*, *Nizar Algarni*, *Nawaf Aljarboa*, *Peter Jarzem*. From McGill University, Montreal, Que.**

Background: In this study, we examined the use of a static dynamometer chair to measure the strength of lumbar spine extensors in a sample of 79 healthy adults. **Methods:** A total of 79 subjects, 25–63 years of age, were included. Subjects were placed in a seated position on the novel chair, secured tightly with a lap belt. The vertical rail, positioned upright against the backside of the chair, was used to manipulate the height of the force transducer, allowing it to be at the level of the apex of the thoracic curve. The height of the force transducer on the rail was recorded and used for subsequent measurements. The unit of measure for the extensor strength is pounds. The subjects were asked to extend their back against the force transducer at maximum capacity, maintaining the extension for 5 seconds. The maximal force delivered over that period was recorded. Subjects had a practice trial followed by 3 forceful extensions with pausing intervals of 30 seconds. The average force of all 3 attempts were recorded. A follow-up test was carried out 1–14 days later in 60 of the 79 subjects. **Results:** The initial test mean noted was 69.474 pounds (67.047 and 71.901 pounds). The intraclass correlation coefficient for single measure was 0.853 (95% confidence interval [CI] 0.765–0.908) and for average measures, 0.921 (95% CI 0.867–0.952). The follow-up test mean noted was 71.661 pounds (71.615 and 71.706 pounds). The intraclass correlation coefficient for single measure was 0.798 (95% CI 0.683–0.874) and for average measures, 0.888 (95% CI 0.812–0.933). There is a strong correlation between the first set and the follow-up set of measurements ($r = 0.80$, $p < 0.001$, $R^2 = 0.62$). **Conclusion:** On the basis of the data collected from 79 patients, the measurement of the novel chair is reliable and consistent. It is a noninvasive, cost-effective test that facilitates the assessment of the strength of the lumbar spine extensors in adult patients.

Presentation P11
Abstract 95
Error measurement between human spine, 3D scans, CT-based models, and 3D-printed models. ***Andrew Kanawati, Renan Fernandez, Aaron Gee, Jennifer Urquhart, Chris Bailey, Parham Rasoulinejad*. From Victoria Hospital, London, Ont. (Kanawati, Fernandez, Gee, Urwuhart, Bailey, Rasoulinejad); and Westmead Hospital, Sydney, Australia (Kanawati).**

Background: There is a paucity of evidence validating the accuracy of 3D models, when compared with the organ that has been scanned and with the digital models from which they are created. This study will examine the differences between human lumbar vertebrae, computed tomography (CT)-based 3D models and 3D-printed models. **Methods:** Five cadaveric lumbar spines were meticulously cleaned after boiling, in order to not inadvertently damage or distort bony details. The individual bones were 3D scanned using a NextEngine 3D Scanner Ultra UH. We created 3D mesh models by importing CT scan DICOM files into 3D Slicer version 4.10.2. The models were aligned using at least 3 fiducial points. Hausdorff distances and Dice coefficients were calculated to determine the digital similarities of the CT models and 3D scans of the vertebral bones. For each vertebra, 3D digital model and 3D-printed model, 15 different anatomic measurements were recorded with a digital caliper. Statistical analysis was performed with SPSS, using one-way analysis of variance and interclass correlation coefficients. We performed ***t*** tests for each of the groups (bone v. 3D scan and CT v. 3D print) to validate the other statistical methods. **Results:** There was no statistically significant difference between the human vertebral bone, 3D scanned model, 3D digital model and 3D-printed model for each of the 15 measurements, except for vertebral width and spinal canal width. The mean Hausdorff distance was 0.99 mm (standard deviation [SD] 0.55 mm) when comparing the 3D scanned model to the CT model, indicating that the CT model was larger by 0.99 mm. The mean Dice coefficient was 0.9 (SD 0.07), indicating excellent geometric overlap. **Conclusion:** There is no difference between the difference in manual measurements between human lumbar vertebrae, CT-based 3D models and 3D-printed models. However, when digital comparisons are made, CT models are approximately 1 mm larger than the corresponding vertebra. This is the first study to compare human spine bones with CT-based 3D models and 3D-printed models. This is clinically important when using CT scans to make 3D-printed biomodels and patient-specific templates.

Presentation P12
Abstract 52
The diagnostic precision of computed tomography for traumatic cervical spine injury: an in vitro investigation. ***Shun Yamamoto, Tom Whyte, Carolyn Van Toen, Angela Melnyk, Jason Shewchuk, John Street, Peter Cripton, Thomas Oxland*. From the International Collaboration on Repair Discoveries (ICORD), Vancouver, B.C. (Yamamoto, Whyte, Van Toen, Cripton, Oxland); the Orthopaedic and Injury Biomechanics Group, Departments of Mechanical Engineering and Orthopaedics, University of British Columbia, Vancouver, B.C. (Yamamoto, Whyte, Van Toen, Melnyk, Street, Cripton, Oxland); the Department of Radiology, University of British Columbia, Vancouver, B.C. (Shewchuk); and the Vancouver Spine Surgery Institute, Department of Orthopaedics, University of British Columbia, Vancouver, B.C. (Street).**

Background: We recently performed biomechanical tests applying dynamic axial compression and lateral bending to in vitro cervical spine specimens, simulating high-energy traumatic loads. The purpose of this study is to evaluate the precision of computed tomography (CT) and whether it could be the gold standard to diagnose cervical spine fractures, by comparing it with detailed dissection of the injured spine specimens. **Methods:** Dynamic axial compression was applied to 35 3-vertebra human cervical spine specimens with 3 lateral eccentricities and 2 end conditions. Two clinicians diagnosed vertebral fractures on the basis of high-resolution CT images, using OsiriX software. Each vertebra was divided into 34 anatomic structures. The CT diagnosis was compared with detailed dissection. **Results:** The interobserver agreement was moderate (0.523) by the Cohen statistic. The average sensitivity of CT was highest for fractures of the facet joint (59%) and lowest for fractures of the pedicle (13%) and lateral mass (23%). The precision was highest for fractures of the spinous process (83%) and lowest for the fractures of pedicle (21%). The specificity was above 90% for all components. **Conclusion:** In this axial compression lateral bending cervical spine fracture mode common to rollover accidents, and perhaps other loading modes, care should be taken in diagnosing lateral mass and pedicle fractures through CT, particularly if subsequent surgery will utilize this anatomy for implant stabilization.

Presentation P13
Abstract 94
Epidural abscess causing spinal cord infarction. ***Kirsty Hamilton, Mauricio Avila, Robin John Hurlbert.*** **From Banner University Medical Center, Tucson, Ariz.**

Background: The risk of spinal cord infarction related to spinal epidural abscess (SEA) is not clearly understood. The pathophysiology may involve arterial or venous compromise. We reviewed our hospital experience with spinal cord infarction associated with epidural abscess to better define risk factors, the pattern of neurologic impairment, and prognosis. **Methods:** A retrospective analysis was performed at Banner University Medical Center in Tucson, Arizona. Relevant cases between February 2012 and July 2019 were identified in the neurosurgical database. Magnetic resonance imaging (MRI) data and electronic records were reviewed. Patient details were documented pertaining to age, sex, neurologic examinations, known SEA risk factors, abscess location, number of spinal levels affected, surgical intervention and culprit pathogen. **Results:** A total of 119 cases of SEA were identified. Eight patients experienced a precipitous decline in their neurologic condition during their admission. Seven of these patients underwent emergency decompressive surgery. All patients were male. Mean age was 53.1 years. The mean number of spinal segments affected was 6.0. Five of the 8 cases involved the cervical spine, and 6 cases involved the thoracic spine. *Staphylococcus aureus* was the culprit organism in 7 cases. Decline in neurologic condition was evident over the course of several hours or days in all cases. History of alcohol or intravenous drug abuse, diabetes and immunosuppression was frequent. Of the 4 cases of infarct, T2 cord signal hyperintensity was present in all. Epidural abscess location was anterior in 2 cases and circumferential in 2. Two patients suffered American Spinal Injury Association (ASIA) A impairment and 2 patients ASIA B. Two patients recovered to nonfunctional antigravity motor strength. **Conclusion:** Our findings suggest that 6% of SEA patients may go on to develop spinal cord infarction irrespective of the degree of spinal cord compression or institution of antibiotic therapy. The pattern of variable neurologic impairment and variable spinal cord signal change on MRI suggests venous rather than arterial infarction. Prognosis for meaningful return of function is poor even with emergent decompression.

Presentation P14
Abstract 83
The nerve root sedimentation sign on magnetic resonance imaging is not only correlated with neurogenic claudication: association with all types of leg-dominant mechanical pain. ***Zachary Huschi, Laura Neuburger, Syed Uzair Ahmed, Yanzhao Cheng, Daryl Fourney.*** **From the University of Saskatchewan, Saskatoon, Sask.**

Background: Many studies have found a correlation between the nerve root sedimentation sign on MRI (SedSign) and neurogenic claudication; however, they have failed to account for patients with constant leg-dominant pain (i.e., sciatica). The objective of this study was to analyze the clinical utility of SedSign to diagnose leg-dominant pain that is intermittent (neurogenic claudication) or constant (sciatica) by comparison with a validated classification for low back and leg pain (Saskatchewan Spine Pathway classification; SSPc). **Methods:** Prospectively collected data were retrospectively reviewed for 367 consecutive patients with back and/or leg pain presenting between Jan. 1, 2012, and May 31, 2018. Baseline clinical characteristics included SSPc, Oswestry Disability Index (ODI) score, visual analogue pain scores for back and leg (VAS) and EuroQol Group 5-Dimension Self-Report (EQ-5D) score. Inter- and intra-rater reliability for SedSign was 73% and 91%, respectively (3 examiners). **Results:** SedSign was positive in 111 (30.2%) and negative in 256 (69.8%) patients. On univariate analysis, a positive SedSign was correlated with age, male sex, several ODI components, EQ-5D mobility, cross-sectional area (CSA) of stenosis, anteroposterior diameter of stenosis, neurogenic claudication and leg-dominant pain; negative SedSign was correlated with back-dominant pain and sciatica. On multivariate analysis, SedSign was associated with age, male sex, CSA stenosis and ODI walking distance. The sensitivity and specificity of SedSign for detecting leg-dominant pain was 37.4 and 81.8, respectively (positive and negative predictive values, 77.5 and 43.8). **Conclusion:** The SedSign has high specificity for neurogenic claudication, sciatica or leg-dominant pain, but the sensitivity is poor. The strength of correlation between SedSign and either neurogenic claudication or sciatica is similar, but both are lost on multivariate analysis.

Presentation P15
Abstract 3
Accuracy of robot-assisted compared with freehand pedicle screw placement in spine surgery: a meta-analysis of randomized controlled trials. ***Yu-Ning Peng, Horng-Chaung Hsu, Chia-Hung Kao.*** **From China Medical University Hospital, Taichung City, Taiwan.**

Background: The objective of this study was to investigate the differences in accuracy between robot-assisted and freehand technique for pedicle screw insertion. **Methods:** Two investigators independently searched for articles on randomized controlled trials (RCTs) from 2012 to 2019 in PubMed, Web of Science and the Cochrane Library. The final meta-analysis included 7 RCTs. Statistical analysis was performed using Review Manager 5.3. We compared the accuracy of pedicle screws placement between robot-assisted and conventional freehand groups. **Results:** The 7 RCTs included 540 patients and 2476 screws. The combined results showed that Gertzbein–Robbins classification grade A (odds ratio [OR] 1.68, 95% confidence interval [CI] 0.82–3.44, $p = 0.16$) and grade A + B (OR 1.67, 95% CI 0.44–6.3, $p = 0.45$) accuracy rate showed no significant difference. Subgroup analysis showed that TiRobot (TINAVI Medical Technologies) significantly improve pedicle screw accuracy in both grade A (OR 3.22, 95% CI 2.07–5.01, $p < 0.00001$) and grade A + B (OR 5.10, 95% CI 2.31–11.23, $p < 0.0001$) classification. Robot-assisted by SpineAssist (Mazor Robotics Ltd.) showed an inferior pedicle screw accuracy rate, in both grade A (OR 0.63, 95% CI 0.39–1.00, $p = 0.05$) and grade A + B (OR 0.40, 95% CI 0.19–0.84, $p = 0.02$) classification. Surgery assisted by Renaissance (Mazor Robotics Ltd.) showed no difference between the 2 groups in both grade A (OR 1.58, 95% CI 0.85–2.96, $p = 0.15$) and grade A + B (OR 2.20, 95% CI 0.39–12.43, $p = 0.37$) classification. **Conclusion:** The accuracy rate differed among different robot systems. Surgery assisted by TiRobot (TINAVI Medical Technologies) is superior to the conventional method in terms of

accuracy of pedicle screw insertion. However, SpineAssist (Mazor Robotics Ltd.) reduces pedicle screw accuracy compared with the conventional freehand technique, and Renaissance (Mazor Robotics Ltd.) shows no difference between the 2 groups.

Presentation P16
Abstract 82
A positive nerve root sedimentation sign on magnetic resonance imaging is associated with improved surgical outcomes in patients with back dominant pain. ***Zachary Huschi, Laura Neuburger, Syed Uzair Ahmed, Yanzhao Cheng, Daryl Fourney*. From the University of Saskatchewan, Saskatoon, Sask.**

Background: Our group has previously shown that a positive nerve root sedimentation sign on magnetic resonance imaging (MRI) (SedSign) has no prognostic value for lumbar laminectomy outcomes, although others have found a weak association. We also found that SedSign correlates equally well with neurogenic claudication and other types of leg-dominant pain (i.e., sciatica). In addition, there is a negative correlation between SedSign and back-dominant pain. The objective of this study was to compare the outcomes of all types of lumbar surgery (decompression with or without instrumented fusion) with respect to SedSign using a validated classification for low back and leg pain (Saskatchewan Spine Pathway Classification, SSPc). **Methods:** Prospectively collected data were retrospectively reviewed for 243 consecutive patients receiving elective surgery for back and/or leg pain due to degenerative conditions presenting between Jan. 1, 2012, and May 30, 2019. Baseline clinicoradiologic characteristics included SSPc, dural sac cross-sectional area (CSA) and anteroposterior diameter (AP) at maximal stenosis. Outcome measures included Oswestry Disability Index (ODI) score, visual analogue pain scores for back and leg (VAS) and EuroQol Group 5-Dimension Self-Report (EQ-5D) score. **Results:** SedSign was associated with older age and more severe radiologic stenosis. For SSPc 1 (back-dominant pain, worse in flexion), a positive SedSign was associated with a statistically significant decrease in both VAS leg pain ($p = 0.024$) and ODI pain intensity ($p = 0.023$). **Conclusion:** This is the largest analysis of SedSign with respect to surgery outcomes and the only study to analyze for any correlation between SedSign and outcomes for back-dominant pain. Although the indications for lumbar spine surgery in patients with back-dominant pain are hotly debated, this study demonstrates that a positive SedSign on MRI is associated with better pain relief outcomes.

Presentation P17
Abstract 16
Thoracolumbar burst fracture: McCormack load-sharing classification —systematic review and single-arm meta-analysis. ***Ériko Filgueira, Robert Meves, Aline Imoto de Oliveira, Helbert Cardoso da Silva*. From the Faculdade de ciências médicas da Santa Casa de São Paulo, São Paulo, SP, Brazil (Filgueira, Meves); and the FEPECS, Brasilia, Brazil (de Oliveira, da Silva).**

Background: We conducted a systematic review and single-arm meta-analysis of randomized clinical trials to evaluate if load-sharing classification (LSC) is reliable in predicting the best surgical approach for thoracolumbar burst fracture (TBF). There is no previous review evaluating the efficacy of LSC as a guide for surgical treatment in burst fractures. **Methods:** On Apr. 19, 2019, a broad search was performed of the following databases: Embase, PubMed, Cochrane Library, Scopus, Web of Science, LILACS and grey literature. The protocol of this study was registered in the International Prospective Register of Systematic Reviews (PROSPERO) under number CRD42019126382. We included clinical trials that had patients with TBF undergoing isolated posterior surgical treatment, classified by load-sharing score, and for which we could analyze the following outcomes: loss of segmental kyphosis and implant failure. We performed random or fixed effects model meta-analyses depending on data homogeneity. Heterogeneity between studies was estimated by I^2 and τ^2 statistic. **Results:** The initial search identified 189 references, of which 9 studies were eligible for this review. All papers with LSC up to 6 proved to be reliable in indicating that only posterior intrumentation is necessary, without screw failures or loss of kyphosis correction. For cases with LSC greater than 6, only 2.5% of the individuals presented implant failure with isolated posterior approach ($I^2 = 7\%$, $\tau^2 < 0{,}0001$, $p = 0.37$). For loss of kyphosis corretion, only 5% of patients had this outcome if LSC was greater than 6 ($I^2 = 76\%$, $\tau^2 < 0{,}0011$, $p < 0.01$). For both outcomes, we had 6% of postoperative problems ($I^2 = 77\%$, $\tau^2 < 0{,}0015$, $p < 0.01$). **Conclusion:** Load-sharing score up to 6 is 100% reliable and only posterior intrumentation is sufficient for stabilization. For scores greather than 6, the incidence of implant breakage and loss of kyphosis correction in isolated posterior fixation is low. So other factors should be taken into account to define the best surgical approach.

Presentation P18
Abstract 86
Morphological features of thoracolumbar burst fractures associated with neurologic recovery after thoracolumbar traumatic spinal cord injury. ***Julien Goulet, Andreane Richard-Denis, Yvan Petit, Lucien Diotalevi, Jean-Marc Mac-Thiong*. From the Hôpital du Sacré-Coeur, Montreal, Que. (Goulet, Richard-Denis, Petit, Diotalevi, Mac-Thiong); Université de Montréal, Montreal, Que. (Richard-Denis, Mac-Thiong); and the École de technologie supérieure, Montreal, Que. (Petit).**

Background: The aim of this study was to identify specific morphological characteristics in thoracolumbar burst fractures associated with neurologic outcome after severe traumatic spinal cord injury (tSCI). **Methods:** We retrospectively analyzed the clinical and radiologic (computed tomographic scan of morphological characteristics specific to burst fractures) data of 25 consecutive patients admitted for tSCI secondary to a burst fracture at levels from T11 to L2 between 2010 and 2017 at a single level 1 trauma centre. We included severe tSCI, defined as American Spinal Injury Association Impairment Scale (AIS) grade A, B or C. Seven morphological parameters were assessed: mean canal compromise, comminution of vertebral body fragment retropulsed into the spinal canal, magnitude of translation of posteroinferior vertebral body corner, lamina fracture, vertebral body kyhosis, segmental kyphosis and vertebral body communition. The association between neurologic recovery (improvement by at least 1 AIS grade) and morphological and clinical parameters was

assessed from logistic regression analyses. **Results:** Among the 25 patients with severe tSCI, 14 were AIS A, 5 were AIS B and 6 were AIS C upon initial preoperative neurologic evaluation. The AIS grade and the burden of associated injuries (Injury Severity Score) were the only clinical factors significantly associated with poor neurologic recovery. The trauma level of energy was not associated with neurologic outcome. Several morphological parameters were independently related to neurologic recovery: posteroinferior corner translation, presence of retropulsed fragment comminution and complete lamina fracture. Neurologic recovery was more strongly associated with these 3 morphological parameters than with the initial AIS grade. The magnitude of sagittal kyphosis angle, vertebral kyphosis index and vertebral body comminution were not associated with the neurologic outcome. **Conclusion:** Morphological features of the bony structures involving the spinal canal in thoracolumbar burst fractures with severe tSCI are associated with the neurologic outcome, and could provide additional insight other than the AIS clinical grading. The fracture pattern may better reflect the actual level of energy transferred to the spinal cord than distinguishing between low- and high-energy trauma.

Presentation P19
Abstract 89
Radiographic parameters of listhesis and instability are not associated with health status or clinical outcomes in grade 1 degenerative spondylolisthesis. ***Aidin Kashigar, Joseph Laratta, Erica Bisson, Leah Carreon, Andrew Yew, Tino Mkorombindo, Steven Glassman*. From the Norton Leatherman Spine Center, Louisville, Ky. (Kashigar, Laratta, Carreon, Glassman); the University of Utah, Salt Lake City, Utah (Bisson); Beth Israel Lahey Health, Burlington, Mass. (Yew); and the University of Louisville, Louisville, Ky. (Mkorombimdo).**

Background: Slip magnitude and presence of motion are used in surgical planning for degenerative spondylolisthesis. Fusion is considered in patients with higher slip magnitude or instability. The purpose of this study is to identify if slip magnitude and mobility correlate with symptomatology preoperatively or postoperatively. **Methods:** From the Quality Outcomes Database, patients who had fusion for grade 1 degenerative spondylolisthesis with complete preoperative and 1-year postoperative patient-reported outcomes (PROs) were identified. The magnitude of slip and presence of motion were measured on flexion and extension x-rays. Preoperative and 1-year postoperative PROs including Back Pain (BP, 0–10), Leg Pain (LP, 0–10), Oswestry Disability Index (ODI) and EQ-5D were analyzed. **Results:** Seventy-nine patients from multiple centres were identified. Mean age was 60.7 years and there were 46 females (58%). Patients were categorized on the basis of upright slip into 3 groups: 5 mm or less, more than 5 mm to less than 7 mm, and 7 mm or more. Motion was defined as more than 3 mm slip difference between flexion and extension films. No significant differences were identified in PROs at baseline or at 1-year postoperative follow-up between the groups ($p > 0.05$). **Conclusion:** While slip magnitude and presence of motion are useful for surgical planning, they are not associated with preoperative health status or postoperative outcome in grade 1 degenerative spondylolisthesis.

Presentation P20
Abstract 37
Predictive socioeconomic factors following lumbar disk arthroplasty: a Canadian Spine Outcomes and Research Network (CSORN) study. ***Tan Chen, Sean Christie, Jacques Bouchard, Charles Fisher, Jean-Francois Roy; Albert Yee, Peter Jarzem*. From the Division of Spine Surgery, Holland Bone and Joint Program, Sunnybrook Health Sciences Centre, Toronto, Ont. (Chen, Yee); the Division of Neurosurgery, Dalhousie University, Halifax, N.S. (Christie); the Division of Orthopaedic Surgery, University of Calgary, Calgary, Alta. (Bouchard); the Division of Spine Surgery, Vancouver General Hospital, Vancouver, B.C. (Fisher); Département de chirurgie, Université Laval, Québec, Que. (Roy); and the Division of Orthopaedic Surgery, McGill University, Montreal, Que. (Jarzem).**

Background: There is a paucity of published Canadian literature investigating patient-reported outcomes following lumbar total disc arthroplasty (LDA). The purpose of this study was to compare socioeconomic factors against 2-year reported functional outcomes and satisfaction following LDA. **Methods:** We conducted a multicentre review of prospectively collected data on consecutive spine surgery patients enrolled by the Canadian Spine Outcomes and Research Network (CSORN) who underwent isolated primary LDA or hybrid constructs (LDA with adjacent fusion) for symptomatic degenerative disk disease (2015–2019). Patient socioeconomic factors, functional outcome scores and satisfaction were assessed preoperatively and at 1 and 2 years postoperatively. Descriptive and inferential statistics were performed, with multivariate logistical regression analysis to investigate predictive factors on outcome. **Results:** A total of 97 patients (39 females, 58 males) underwent LDA or a hybrid construct up to 4 levels with 1- or 2-year follow-up (1 level: 36 patients, 2 levels: 39 patients, 3 levels: 18 patients, 4 levels: 4 patients). From this cohort, 52 patients (22 females, 30 males) underwent single/multilevel LDA (1 level: 36 patients; 2 levels: 15 patients; 3 levels: 1 patient). Within the total cohort, patients who reported an impact in preoperative work status as a result of their spinal condition (change to modified duties/hours or short- or long-term disability) were found to consistently report lower satisfaction (1 yr: $r = –0.469$, $p < 0.001$; 2 yr: $r = –0.523$, $p < 0.001$), lower improvement in Oswestry Disability Index (ODI) score (1 yr: $r = –0.321$, $p < 0.01$; 2 yr: $r = –0.280$, $p < 0.05$) and lower improvements in numeric back and leg pain scale scores. Daily narcotic/antidepressant use were other significant but inconsistent predictors. Nonsignificant patient factors included sex, age, body mass index, martial/education status, living arrangement, smoking, exercise and number of comorbidities. Similar findings were found in the isolated LDA cohort regarding work status and patient satisfaction. **Conclusion:** Spinal symptoms that result in an impact on employment status (i.e., modified duties/hours or short- or long-term disability) are predictive of poorer satisfaction and functional outcomes in patients undergoing isolated or hybrid LDA for degenerative spondylosis.

Presentation P21
Abstract 25
Effect of in situ fusion in lumbar spondylolisthesis on clinical outcomes and spino-pelvic sagittal balancing. ***Shailesh***

***Hadgaonkar*, *Ketan Khurjekar*, *Ajay Kothari*, *Amogh Zawar*, *Parag Sanchetui*, *Ashok Shyam*. From the Sancheti Institute of Orthopaedics and Rehabilitation, Pune, India.**

Background: The objective of this study was to study the effect of in situ fusion of lumbar spondylolisthesis on sagittal balancing in the spine and pelvis radiographically, as well as the clinical outcomes after this procedure. **Methods:** This is a prospective study of 138 patients from June 2015 to November 2016, which includes patients from 20 to 80 years of age and excludes traumatic cases, pathologic cases and cases that were treated conservatively. Clinical evaluation included scores for a visual analogue scale (VAS) and the SF-36 and Oswestry Disability Index (ODI). For the radiographic evaluation, lumbosacral spine anteroposterior, lateral and flexion–extension views were taken, including the femoral head, preoperatively and then at 6 and 12 months postoperatively.The radiologic parameters included pelvic incidence, pelvic tilt and sacral slope. A posterior midline approach was taken and pedicle screws for fixation and transforaminal lumbar interbody fusion was used in most of the cases. **Results:** The mean pelvic tilt changed from a mean of 23.85° to 18.25° postoperatively whereas pelvic incidence changed from 61.58° to 56.34°, both of which were statistically significant. VAS scores improved from a median of 8 preoperatively to 2 at 12 months postoperatively. ODI scores improved from a mean of 39.07 to 7.92 and SF-36 scores showed a statistically significant improvement as well. Twenty-three of our patients had pseudarthrosis and 4 patients had a neurologic deficit, which recovered in a year. Four patients had superficial infections that were treated with intravenous antibiotics. **Conclusion:** Posterior instrumented stabilization with pedicle screws and transforaminal lumbar interbody fusion in situ in cases of lumbar spondylolisthesis can provide significantly better clinical outcomes with minimal complications, which can be attributed to improved spino-pelvic sagittal balancing as evidenced by measurements of pelvic tilt and pelivic incidence. This also suggests that the need for reduction to achieve near-normal anatomic alignment can be avoided.

Presentation P22
Abstract 10

Sex differences in the surgical management of lumbar degenerative disease: a systematic review.

***Mark MacLean*, *Charles Touchette*, *Jae Ho Han*, *Sean Christie*, *Gwynedd Pickett*. From Dalhousie University, Halifax, N.S. (MacLean, Ho Han, Christie, Pickett); and the University of Sherbrooke, Sherbrooke, Que. (Touchette).**

Background: The objective of this study was to systematically map and synthesize the adult surgical literature regarding sex differences in pre- and post-operative patient-reported clinical assessment scores for patients with a diagnosis of lumbar degenerative disease (disc degeneration, disc herniation, spondylolisthesis, spinal canal stenosis). **Methods:** A systematic review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) guidelines. Medline, Embase and the Cochrane Registry of Controlled Trials were searched from inception to September 2018. Study characteristics including patient demographics, diagnoses, procedures and preoperative and postoperative clinical assessment scores (pain, disability and health-related quality of life [HRQoL]) were collected. Levels of evidence were scored using the Oxford Centre for Evidence-Based Medicine grading system. **Results:** Thirty articles were identified, accounting for 32 951 patients. Six studies accounted for 84% of patients; 5 of the 6 studies were published by European groups. The most common lumbar degenerative conditions were disc herniation (59.0%), disc degeneration (20.3%) and spinal canal stenosis (15.9%). The majority of studies reported worse preoperative pain (93.3%), disability (81.3%) and HRQoL (75%) among females. The remainder reported equivalent preoperative scores between males and females. The majority of studies (63.3%) did not report preoperative duration of symptoms. Eighty percent of studies found females had worse absolute postoperative scores in at least 1 outcome category (pain, disability or HRQoL). The remainder reported equivalent absolute postoperative scores between males and females. Seventy-three percent of studies reported either an equivalent or greater interval change for females. The majority of studies provide level 4 evidence. **Conclusion:** Female patients undergoing surgery for lumbar degenerative disease (disc degeneration, disc herniation, spondylolisthesis, spinal canal stenosis) have worse absolute preoperative pain, disability and HRQoL. Following surgery, females have worse absolute pain, disability and HRQoL but demonstrate an equal or greater interval change compared with males.

Presentation P23
Abstract 35

Two-year results of lumbar disk arthroplasty: a Canadian Spine Outcomes and Research Network (CSORN) study.

***Tan Chen*, *Albert Yee*, *Jacques Bouchard*, *Sean Christie*, *Charles Fisher*, *Peter Jarzem*, *Jean-Francois Roy*. From the Division of Spine Surgery, Holland Bone and Joint Program, Sunnybrook Health Sciences Centre, Toronto, Ont. (Chen, Yee); the Division of Orthopaedic Surgery, University of Calgary, Calgary, Alta. (Bouchard); the Division of Neurosurgery, Dalhousie University, Halifax, N.S. (Christie); the Division of Spine Surgery, Vancouver General Hospital, Vancouver, B.C. (Fisher); the Division of Orthopaedic Surgery, McGill University, Montreal, Que. (Jarzem); and the Département de chirurgie, Université Laval, Québec Que. (Roy).**

Background: There is a paucity of published Canadian literature on patient outcomes following lumbar disc arthroplasty (LDA). We quantified 1- and 2-year patient-reported outcomes following LDA, comparing results to international experience. **Methods:** We conducted a multicentre review of prospectively collected data on consecutive spine surgery patients enrolled by the Canadian Spine Outcomes and Research Network (CSORN) who underwent isolated primary LDA or hybrid constructs (LDA with adjacent fusion) for symptomatic degenerative disk disease (2015–2019). Functional outcome scores, complications and patient satisfaction were assessed preoperatively, and at 1 and 2 years postoperatively. Descriptive and inferential statistics were performed with the results compared with international experience. **Results:** A total of 97 patients (39 females, 58 males) were analyzed (average age 43 yr). Thirty-six patients underwent single-level arthroplasty, 39 underwent 2-level surgery (15 LDA, 24 hybrids), 18 underwent 3-level surgery (1 LDA, 17 hybrids)

and 4 underwent 4-level surgery (4 hybrids). Mean surgical time and estimated blood loss were 118 minutes and 172 mL (1 level), 131 minutes and 250 mL (2 level), 131 minutes and 386 mL (3 level) and 179 minutes and 775 mL (4 level), respectively. No device-related complications were observed. By 2 years (76% follow-up) the total average numerical back pain scale improved from 7.21 to 3.25 and the average Oswestry Disability Index (ODI) score improved from 45.7 to 23.9 at 2 years ($p < 0.0001$), with statistical significance found in all subgroups. Similar findings were found with SF-12 and Health State questionnaires. A total of 83.0% and 86.7% of patients were satisfied or extremely satisfied at 1- and 2-year follow-up, respectively. **Conclusion:** Lumbar disk arthroplasty, whether used in isolation or as part of a hybrid construct, is an effective treatment option in clinically appropriate patients with debilitating degenerative disk disease. Significant improvements exceeding minimum clinically important differences were seen in patient-reported functional outcome scores and were maintained through 2-year follow-up, alongside high patient satisfaction rates. Our CSORN-based outcomes confirm positive and comparable results to published international literature.

Presentation P24
Abstract 78

Does disc morphology affect the success of nonoperative treatment of chronic sciatica from a lumbar disc herniation? ***Hui-Ling Kerr*, *Lukas Hashem*, *Jennifer Urquhart*, *Parham Rasoulinejad*, *Kevin Gurr*, *Fawaz Siddiqi*, *Chris Bailey*. From the Division of Orthopaedics, Department of Surgery, Schulich School of Medicine and Dentistry, Western University, London, Ont. (Kerr, Hashem, Rasoulinejad, Gurr, Siddiqi, Bailey); and the Department of Surgery, London Health Sciences Centre and Lawson Health Research Institute, London, Ont. (Urquhart, Rasoulinejad, Gurr, Siddiqi, Bailey).**

Background: This study aimed to determine whether disc morphology and the success of standardized nonoperative treatment for chronic lumbar disc herniation are related. A secondary objective was to evaluate the association between disc morphology, pelvic parameters and patient-reported outcomes (PROMs). **Methods:** Retrospective analysis was performed on patients enrolled in a previous randomized controlled trial (RCT) that examined surgery versus nonoperative treatment for sciatica lasting at least 4–12 months from a posterolateral lumbar disc herniation. During the trial 24 patients failed 36 months of nonoperative treatment and crossed over to surgery. In the present study, a comparison was made between the crossover group and those who received nonoperative care only. Two independent, blinded observers evaluated herniation type, Michigan State University (MSU) grade, canal occupancy, size, pelvic incidence, pelvic tilt and sacral slope. For secondary analysis, disc morphology and radiographic parameters were compared between patients who achieved good PROMs versus those who achieved poor PROMs. A good outcome was 30% improvement in Oswestry Disability Index (ODI) score, or a score of 0–3 numerical rating scale (NRS) for leg and back, or improvement of at least 4.9 SF-36 physical component summary score (PCS) at 6 months after enrolment. **Results:** Data were available for 24 patients in the crossover group and 35 patients in the nonoperative group. Demographics, herniation level/location/type, MSU grade, disc height ratio, sagittal area of herniation, and sacral slope were not different between the 2 groups. The crossover group had smaller herniation width ratios ($p = 0.01$), smaller herniation area ratios ($p = 0.02$) and smaller pelvic incidences ($p = 0.02$). Patients with a poor ODI outcome had smaller pelvic incidence and pelvic tilt ($p = 0.008$ and $p = 0.001$, respectively), and those with a poor SF-36 PCS outcome tended to have smaller width disc/canal ratio ($p = 0.05$). **Conclusion:** Disc morphology is not associated with the success of conservative management. However, nonoperative management of herniated discs is associated with poor outcome if the patients have smaller width disc/canal ratios and pelvic incidence.

Presentation P25
Abstract 141

Opioid prescribing patterns: preliminary investigation. ***Jenna Meagher*, *Najmedden Attabib*, *Erin Bigney*, *Eden Richardson*, *Dana El-Mughayyar*, *Mariah Darling*, *Neil Manson*, *Edward Abraham*. From the Dalhousie Medical School, Saint John, N.B. (Meagher); the Division of Neurosurgery, Zone 2, Horizon Health Network, Saint John, N.B. (Attabib); the Canada East Spine Centre, Saint John, N.B. (Attabib, Bigney, Richardson, El-Mughayyar, Darling, Manson, Abraham); the Dalhousie Department of Surgery, Saint John, N.B. (Attabib, Manson, Abraham); and the Division of Orthopaedic Surgery, Zone 2, Horizon Health Network, Saint John, N.B. (Manson).**

Background: The aim of this study was to provide a preliminary investigation into the opioid prescribing patterns of spine surgeons in Canada. **Methods:** An anonymous online survey (SurveyMonkey) was distributed by email to the Canadian Spine Society membership, a total of 179 orthopedic surgeons, neurosurgeons and affiliates. The survey included 10 questions: there were 2 demographic questions regarding region of practice and department affiliation. Four questions were posed regarding prescribing practices for patients who undergo spinal fusion surgery, and 4 in regard to decompression surgery. Descriptive statistics were used to get an initial look at overall trends in prescribing practices and to look if trends differ on the basis of region of practice, or departmental affiliation. **Results:** To date, 20.30% of the total population has responded to the survey. Of those who responded, 20% are practising in Atlantic Canada, 32.5% in central Canada and 47.5% in western Canada. Orthopedic surgeons accounted for 65% of respondents and neurosurgeons for 35%. Of surgeons surveyed, 12.5% reported providing pain medication before fusion surgery and the majority (95%) reported prescribing opioids following spine fusion surgery. Hydromorphone (52.5%), oxycodone/Percocet (15%) and codeine/Tylenol 3 (12.5%) were the opioids surgeons reported as standard for their practice. Duration of opioid prescription ranged with the majority prescribing opioids for 8–30 days (57.5%) or for 7 days or less (40%). For decompression surgery, 92.5% prescribe opioids following surgery. Prior to surgery 5% gave pain medication. Hydromorphone (37.5%) and codeine/Tylenol 3 (25%) are the opioids most frequently reported as standard of practice. A total of 35% of respondents prescribed opioids for 8–30 days. Hydromorphone and Percocet prescriptions were more likely to be prescribed for 8–30 days. A total of 12.5% of respondents provided

opioid refills following decompression surgery. For both surgery types there are emerging trends based on region and departmental affiliation. **Conclusion:** There is variability in opioid choice and duration of opioid prescriptions between spine surgeons in Canada. There would be value to increasing respondents and in discussing/implementing standardized opioid prescription guidelines based on surgical procedures.

Presentation P26
Abstract 133
Frailty is a better predictor of complications than age alone after surgical treatment of degenerative cervical myelopathy: an ambispective study of 5107 elderly patients from the National Surgical Quality Improvement Program database. ***Jamie Wilson, Jetan Badhiwala, Fan Jiang, Jefferson Wilson, Michael Fehlings*. From the University of Toronto Spine Program, Toronto, Ont. (Jamie Wilson, Badhiwala, Jiang, Fehlings); and the Department of Neurosurgery, St. Michael's Hospital, Toronto, Ont. (Jefferson Wilson).**

Background: The objective of this study was to compare whether age or frailty assessment is a better predictor of perioperative complications for surgery in degenerative cervical myelopathy (DCM). **Methods:** Patients who underwent surgery for DCM listed in the National Surgical Quality Improvement Program (NSQIP) database were included. The 5-point modified Frailty Index (mFI) was applied to each, with descriptive statistics calculated for continuous and categorical variables of demographic and complication metrics. The independent effect of age and frailty on outcomes was evaluated by multivariable regression. For each outcome, a logistic or linear regression model was constructed that included both variables and adjusted for sex, type of fusion and number of levels as covariates. Effect sizes were summarized by odds ratio (OR) (dichotomous outcomes) or mean difference (MD) (continuous outcomes) and associated 95% confidence intervals (CIs). In addition, to weigh the relative importance of age versus frailty in predicting each outcome, standardized regression coefficients were calculated and their magnitudes directly compared. **Results:** A total of 5107 patients (2248 females) were extracted for analysis (mean 71.7 yr), with 3298 (64.6%) undergoing anterior surgery, 1649 (32.3%) posterior surgery, and 160 (3.1%) combined. The mean mFI was 0.23 (standard deviation 0.16). In the regression analyses, age and mFI were found to be statistically significant predictors for 30-day mortality, unplanned readmission, unplanned reoperation, major complication, hospital length of stay and discharge home. However, mFI was found to have a greater effect size than age, as measured by the standardized beta coefficient, for mortality, unplanned reoperation, major complication and discharge home. **Conclusion:** Frailty, as measured by the mFI, is a better predictor than age for mortality, unplanned reoperation, major complication and discharge home in the first 30 days after surgical treatment for DCM. We recommend this index should be used in preference over age when considering the risks of surgical management in DCM.

Presentation P27
Abstract 26
Pathway analysis in spine surgery: a model for evaluating length of stay. ***Madison Stevens, Cynthia Dunning, William Oxner, Samuel Stewart, Andrew Glennie*. From Dalhousie University, Halifax, N.S. (Stevens, Dunning, Oxner, Stewart, Glennie); and the Nova Scotia Health Authority, Halifax, N.S. (Stevens, Dunning, Oxner, Glennie).**

Background: The aim of this study was to identify pre-, intra- and postoperative factors associated with length of stay (LOS) in patients undergoing spine surgery at a Canadian quaternary academic teaching hospital. **Methods:** This retrospective cohort study included all patients who underwent spine surgery by 2 orthopedic spine surgeons between October 2014 and 2016. Chart data were extracted on 16 factors by 2 reviewers. Factors collected included age, sex, body mass index, American Society of Anesthesiologists (ASA) class, insurance claim, transfusion, preoperative medication use, surgical procedure, Charlson Comorbidity Index score, preoperative hemoglobin, surgical time, initial versus revision surgery and intraoperative analgesics. Postoperative LOS was the outcome, calculated from date of surgery to date of discharge. Multiple quasi-Poisson regression was used to identify factors associated with LOS. **Results:** A total of 763 patients were identified. Average age of the cohort was 59 (standard deviation 16.2, range 16–97) years and 49% were female. Prominent procedures were 1-level transforaminal lumbar interbody fusion (TLIF) (29%), 2-level TLIF (8%), discectomy (17%) and laminectomy (13%). The average LOS for the cohort was 6.7 ± 12.4 days. There were 634 patients with full data included in the multivariable model. Compared with patients undergoing a laminectomy, those who had a discectomy stayed less than half as long (incidence rate ratio [IRR] 0.37, 95% confidence interval [CI] 0.21–0.64). Posterior c-spine patients (IRR 5.93, 95% CI 3.4–10.34), major deformities (IRR 2.39, 95% CI 1.53–3.72), anterior cervical decompression and fusion (ACDF) and cervical vertebrectomies (IRR 2.58, 95% CI 1.49–4.46), 1-level TLIFs (IRR 1.65, 95% CI 1.22–2.23), 2-level TLIFs (IRR 1.62, 95% CI 1.13–2.33]) and patients undergoing an incision and drainage, hardware removal or hematoma evacuation (IRR 1.83, 95% CI 1.16–2.87) all had a significantly longer LOS. Patients undergoing a reoperation (IRR 1.32) and patients who received a blood transfusion also had a significantly longer LOS (IRR 2.56). **Conclusion:** The LOS within this cohort was correlated with the procedure performed, the presence of a blood transfusion and reoperation. Other medical comorbidities and surgical, clinical and patient factors were not significantly associated with LOS. Future pathway improvement should focus on procedure-specific, postoperative rehabilitation protocols.

Presentation P29
Abstract 156
Patients with adolescent idiopathic scoliosis (AIS) have different cervical lordosis than the normal population. ***Brett Rocos, John Hutchinson*. From North Bristol NHS Trust, Bristol, United Kingdom.**

Background: An often-neglected component of sagittal balance in adolescent idiopathic scoliosis (AIS) is the cervical spine. The cervical spine can compensate for sagittal deformities by altering head position, but this may give rise to symptoms when the extremes of these mechanisms are reached. This paper seeks to define whether AIS patients have a different cervical profile when compared with normal adolescents. **Methods:** The literature was

searched to define the normal sagittal cervical profile in adolescents. A retrospective analysis of 81 patients with AIS who had received corrective surgery was carried out, and pre- and postoperative cervical lordosis was independently measured using full-length spine radiographs. These data were compared with the 95% confidence interval (CI) of cervical lordosis in controls to show if patients showed different cervical spine profile to normal patients before or after corrective surgery. **Results:** Normal cervical spine sagittal profiles values are poorly described. One study (paper A) gives values of –16° (95% CI –12° to –20°) for male C2–C7 lordosis and –15° (95% CI –12.5° to –17.5°) for female C2–C7 adolescents. Another reference (paper B) gives values of –8.4° (95% CI –6.7° to –10.1°) for male and –1.9° (95% CI –0.5° to –3.3°) for female adolescents for the same C2–C7 measurements. Our values for male patients for preoperative C2–C7 lordosis were –1.2° (95% CI –8.5° to 6.1°) and 9° (95% CI 2.9° to 15.1°) for females. Postoperative values were 10.6° (95% CI 2.4° to 18.8°) for males and 8.3° (95% CI 4.8° to 11.8°) for females. **Conclusion:** The values of cervical lordosis in our series show that patients with AIS have a significantly different cervical lordosis when compared with normal values both before and after deformity correction ($p < 0.05$). A complete understanding of how the cervical spine is positioned before surgery is critical, as flattening the thoracic spine during corrective surgery could give rise to cervical pain and sagittal imbalance if the ability of the cervical spine to compensate for the new spinal position is exceeded.

Presentation P31
Abstract 64

Investigation of thoracic spinal muscle morphology with upright magnetic resonance imaging. ***Anoosha Pai*, *Thomas Oxland*, *Honglin Zhang*, *Jason Shewchuk*, *David Wilson*, *John Street*. From the School of Biomedical Engineering, University of British Columbia, Vancouver, B.C. (Pai); the International Collaboration on Repair Discoveries (ICORD), University of British Columbia, Vancouver, B.C. (Pai, Oxland, Street); the Department of Orthopedics, University of British Columbia, Vancouver, B.C. (Oxland, Wilson, Street); the Centre for Hip Health and Mobility, University of British Columbia, Vancouver, B.C. (Zhang, Wilson); and the Department of Radiology, Vancouver General Hospital, Vancouver, B.C. (Shewchuk).**

Background: Magnetic resonance imaging (MRI) derived spinal-muscle morphology in weight-bearing postures is different from that in supine and thus has potential diagnostic, prognostic and therapeutic applications in spinal health. However, the focus to date has been on cervical and lumbar regions. Recently, larger Cobb angles have been associated with smaller cross-sectional areas (CSA) and lower density of the thoracic spine muscles. Hence, we aim to quantitatively investigate the repeatability of measuring the thoracic muscle morphology (e.g., size/shape/structure) in different postures using upright open MRI. **Methods**: Four healthy volunteers (aged 26 ± 7 yr) were imaged (0.5-T MROpen, Paramed) in 3 postures (supine, standing and standing with 30° flexion). Owing to dimensional limitations of the imaging area, 2 levels of the middle (T4–T5) and lower (T8–T9) thorax were scanned separately for each posture. A descriptive methodology for defining the regions of interest of erector spinae, transversospinalis and trapezius in axial MR images was developed, and 3D muscle volumes were generated from 2D anatomic CSA segmentation. Segmentation repeatability was examined through intraclass correlation coefficient (ICC) for 2D CSA, and Dice coefficient for the 3D muscle volumes. **Results:** The segmentation is based on the points of origin and insertion, probable size, shape and the position of the muscle groups relative to other recognizable anatomic landmarks as seen from typical axial MR images. The intrarater repeatability ranged from good to excellent (average ICC [3,1] along T4–T5 and T8–T9, respectively: erector spinae 0.83 and 0.94, transversospinalis 0.89 and 0.95, trapezius 0.98 and 0.98). The average Dice coefficient was found to be good (erector spinae 0.95 and 0.96, transversospinalis 0.92 and 0.94, trapezius 0.95 and 0.91, along T4–T5 and T8–T9, respectively). **Conclusion:** The guidelines proposed are important for reliable MRI-based measurements and allow meaningful comparisons of muscle morphometry in the thoracic spine across different studies globally. Good segmentation repeatability suggests we can further investigate the effect of posture and spinal curvature on muscle morphology in the thorax.

Presentation P32
Abstract 80

Postoperative complication prediction between spinal surgeons and a machine learning model: a comparative study. ***Stephen Kingwell*, *Szymon Wilk*, *Eugene Wai*, *Philippe Phan*, *Alexandra Stratton*, *Safraz Mohammed*, *Eve Tsai*, *Fahad Alkerayf*, *Wojtek Michalowski*. From the University of Ottawa, Ottawa, Ont. (Kingwell, Wai, Phan, Stratton, Mohammed, Tsai, Alkerayf); the Poznan University of Technology, Poznan, Poland (Wilk); and the Telfer School of Management, University of Ottawa, Ottawa, Ont. (Michalowski).**

Background: The purpose of this study is to determine the accuracy of surgeons when predicting complications in patients undergoing spinal surgery as compared with a predictive model developed using machine learning techniques. **Methods:** A single-centre National Surgical Quality Improvement Program (NSQIP) database of 893 patients undergoing spinal surgery was used to develop a prediction model, using a gradient boosted decision tree (XBT) machine learning algorithm, to predict 30-day medical and surgical complications. Thirty clinical vignettes were selected from the database describing the patient's age, sex, diagnosis, procedure, body mass index, comorbidities and procedural urgency. An online survey was developed and a request to participate was sent to spine staff and trainees at an academic hospital, including 6 staff surgeons, 8 residents and 3 fellows. The participants were asked to read the vignette and predict the presence or absence of complications. The results were analyzed to determine the agreement between participants, the performance of the participants, the difficulty of the vignettes and the performance of the XBT model. **Results:** The XBT model performance in predicting postoperative complications using 10-fold cross-validation was 0.54 AUC (area under the receiver operative characteristic curve). The XBT model's accuracy for the 30 clinical vignettes was 0.53 and this was the same as the most accurate staff surgeon. Only 3 residents and 1 fellow outperformed the model (accuracy range 0.57–0.63), while the remaining 11 respondents predicted worse than the model (accuracy range 0.37–0.50). There was fair agreement between

respondents' predictions (Fleiss κ 0.218). The average predictive accuracy of fellows was 0.50 while that of the staff surgeons was 0.47. There were 3 vignettes where only 1 respondent correctly predicted the presence or absence of complications. **Conclusion:** This study demonstrates the difficulty in predicting complications for patients having spinal surgery. Although the XBT model demonstrated relatively poor accuracy in this set of 30 vignettes, its performance was comparable to the respondents for these difficult predictions.

Presentation P33
Abstract 81
Is using a simplified procedural classification as accurate as using current procedural terminology codes to predict future complications in spinal surgery? *Jérémie Thibault, Philippe Phan, Eugene Wai, Mohamed Hoda*. From the University of Ottawa, Ottawa, Ont. (Thibault, Hoda); and the Department of Orthopedic Surgery, The Ottawa Hospital, Ottawa, Ont. (Phan, Wai).

Background: Predicting surgical complications is valuable for surgeons and patients when considering surgical intervention. To this effect, several risk calculators have been developed. The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) risk calculators already exist to predict the risk of different surgeries, but their use can be challenging because of the use of Current Procedural Terminology codes (CPT codes), which are not intuitive and complex. **Methods:** We are proposing a model using a simplified procedural classification (SPC) as an alternative to evaluate the risk of spinal surgeries. Using spinal cases from the ACS-NSQIP database, we recreated the model used by the ACS-NSQIP to evaluate the accuracy with which the SPC could predict complications. **Results:** It was found that the SPC assessment was as accurate as the ACS-NSQIP risk calculator in predicting complications following spinal surgeries. **Conclusion:** The proposed SPC model is as valid as the ACS-NSQIP for predicting complications for patients undergoing spinal surgery.

Presentation P34
Abstract 88
Preoperative patient performance status and frailty phenotype as predictive factors of outcome in surgically treated patients with metastatic spinal disease: a systematic literature review. *Charles Touchette, Mark MacLean, Tristan Brunette-Clément, Fahad Abduljabba, Michael Weber, Daryl Fourney*. From Université de Sherbrooke, Sherbrooke, Que. (Touchette, Brunette-Clément); Dalhousie University, Halifax, N.S. (MacLean); the King Abdulaziz Hospital, Jeddah, Saudi Arabia (Abduljabba); McGill University, Montreal, Que. (Weber); and the University of Saskatchewan, Saskatoon, Sask. (Fourney).

Background: Surgery for spinal metastatic disease (SMD) may be indicated for decompression of the neural elements, restoration of biomechanical stability and relief of intractable pain. Scoring systems accounting for burden of malignancy have been developed to facilitate the surgical candidate selection process. Despite the inherent importance of physical reserve and ability to tolerate surgery, preoperative patient-related "frailty" factors that may be used to prognosticate outcomes following surgery for SMD are not well described. The objective of this study was to systematically review and synthesize the adult literature regarding preoperative patient-related factors that predict postoperative outcomes following surgery for SMD. **Methods:** A systematic review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Medline, Scopus, Embase, the Cochrane Registry of Controlled Trials, CINAHL and Web of Science were searched from 1990 to April 2018. Study and patient characteristics including demographics, diagnoses, tumour histology, interventions and preoperative surrogate markers of frailty were collected. Any postoperative outcomes were recorded. Quality of the evidence was scored using the Oxford Centre for Evidence-based Medicine scoring system. **Results:** Forty articles were identified, accounting for 8364 patients. The overall quality of evidence was low; 39 of 40 studies constituted level 4 evidence. Most studies were retrospective analyses of small heterogenous patient cohorts consisting of various tumour types. Aside from age, Karnofsky Performance Status and Eastern Cooperative Oncology Group scores, few other patient-level surrogate markers of frailty influenced postoperative outcomes. The most commonly assessed outcome was overall survival, which appears to be highly influenced by the extension of systemic disease as opposed to surrogate markers of frailty. **Conclusion:** The overall quality of evidence was low. Few preoperative patient-related factors were found to predict outcomes following surgery for SMD. Larger homogenous prospective cohort studies should be conducted to examine patient-related factors that may be used to guide management decisions and prognosticate outcomes.

Presentation P35
Abstract 101
The measurements of frailty and their application to spine surgery. *Eryck Moskven, Raphaele Charest-Morin, Alana Flexman, John Street*. From the Vancouver Spine Surgery Institute and Department of Orthopaedics, University of British Columbia, Vancouver, B.C. (Moskven, Charest-Morin, Street); and the Department of Anesthesiology, Pharmacology and Therapeutics, University of British Columbia, Vancouver, B.C. (Flexman).

Background: Frailty has been demonstrated to significantly increase the risk of postoperative adverse events (AEs) in the spine population. Clinical frailty measures containing modifiable and nonmodifiable components have been developed on the basis of different operational definitions. The primary aims of this study are to identify frailty measures currently reported throughout the surgical literature; to identify measures most appropriate as risk stratification tools in the surgical spine population; and to identify measures most sensitive to capturing the effect of spinal pathology and surgical intervention on frailty trajectory in the surgical spine population. **Methods:** This systematic review was registered with PROSPERO: CRD42019109045. Publications in English from January 1950 to October 2018 were identified by a comprehensive search strategy of PubMed, Ovid, Embase and Cochrane, supplemented by manual screening. Included studies consisted of those reporting the use of clinical frailty measures in either the surgical spine or neurologic population with a mobility-related disability.

Clinical frailty measures were evaluated according to an appraisal score, which assessed objectivity, feasibility and validity. **Results:** A total of 19 frailty measures were identified. Twelve measures with nonmodifiable components and 2 measures with modifiable components were reported in the spine literature as risk stratification tools. Seven measures with modifiable components capturing frailty trajectory changes following targeted rehabilitation were reported in the neurologic population. Ten complete frailty measures and 39 individual components qualified as objective, feasible, valid and sensitive. **Conclusion:** Several clinical frailty measures have been reported in the adult surgical spine literature. Measures containing nonmodifiable accumulated deficits are most appropriate as risk stratification tools. Measures containing modifiable phenotypic components are most sensitive to capturing the effect of spinal pathology and surgical intervention on frailty trajectory. Items could be combined to create a unique spine frailty measure that is both a risk stratification tool and sensitive to capturing frailty trajectory changes. Further research is needed to determine the accuracy of these measures and the sensitivity of individual items for predicting postoperative AEs or capturing frailty trajectory changes.

Presentation P36
Abstract 131
The effect of prolonged sitting on muscle reflexes of the low back. ***Ryan Greene, Mona Frey, Sarah Mackey, Diana De Carvalho*****. From Memorial University of Newfoundland, St. John's, Nfld.**

Background: The aim of this study was to determine if prolonged sitting, a submaximally flexed posture, will delay the ability of low back muscles to respond to a sudden perturbation. **Methods:** Forty healthy participants (17 men and 23 women) were recruited for a 1-time laboratory study. Participants were instrumented with accelerometers affixed to the skin overlying the spinous process of L1 and S2, and surface electrodes on 6 low back muscles. Muscle reflex times were obtained before and after sitting. Biomechanical and neuromuscular parameters were also collected continuously during the 2-hour typing trial. **Results:** The average onset time of the low back muscle reflexes was 60.00 ms (± 27.77) before sitting and 72.89 ms (± 38.72) after sitting. Although not statistically different, the delay (approximately 12 ms) may have functional implications. No sex differences were observed. **Conclusion:** Sitting for 2 hours does not appear to directly expose an individual to a perturbation-related back injury due to delayed muscle reflexes. Future work should investigate the functional ramifications of the delay observed and explore the response in a clinical population.

Presentation P37
Abstract 87
Implementing a rapid discharge pathway for adolescent idiopathic scoliosis in Canada. ***Zachary DeVries, Nick Barrowman, Kevin Smit, Andrew Tice, Deborah Mervitz, James Jarvis, Stephen Kingwell*****. From CHEO, Ottawa, Ont.**

Background: Rapid discharge pathways (RDP) have been implemented throughout most areas of orthopedics. The goal of these pathways is to standardize the postsurgical hospital course for patients to decrease hospital length of stay (LOS). Surgical treatment of adolescent idiopathic scoliosis (AIS) remains one of the most invasive pediatric orthopedic procedures and is routinely associated with a prolonged hospital stay. Therefore, the objective of this study was to determine if implementing a RDP at a single children's hospital in Canada could decrease hospital LOS without increasing postoperative complications. **Methods:** A retrospective chart review was completed for all patients who underwent posterior spinal instrumentation and fusion (PSIF) between Mar. 1, 2010, and Feb. 28, 2019, with date of implementation being Mar. 1, 2015. Patient demographic information was collected from the charts along with the primary outcome variables: LOS, wound complication, 30-day return to the operating room, 30-day emergency department admission and 30-day hospital readmission. An interrupted time series analysis was used to assess for any differences in outcomes following implementation of the RDP. Ninety days before and after the implementation of the RDP was not included in this analysis because of variances in practice that were occurring at this time. **Results:** A total of 244 participants were identified, with 113 patients in the conventional pathway and 131 patients in the RDP cohort. No significant differences in demographic features were found between the 2 groups. Hospital LOS was found to be significantly shorter in the RDP group, with the median LOS being 5.2 (95% interquartile range [IQR] 4.3–6.1) days in the conventional group and 3.4 (95% IQR 3.3–3.5) days in the RDP group ($p < 0.05$). There were no differences in postoperative complications between the 2 groups ($p > 0.05$). **Conclusion:** This study demonstrates that implementing a RDP following PSIF for AIS can successfully decrease hospital LOS without increasing postoperative complications. The decrease in LOS could correlate with lower costs for both the health care system and the family.