

**Canadian Spine
Society**

**Société canadienne
du rachis**

Seventh Annual Meeting

Septième réunion annuelle

**Mont Tremblant Ski Resort,
Mont Tremblant, Quebec**

**Mont Tremblant Ski Resort,
Mont Tremblant (Québec)**

**Wednesday, March 21 to
Saturday March 24, 2007**

**Du mercredi 21 mars au
samedi 24 mars 2007**

Program • Programme

Abstracts • Résumés

**Canadian Spine Society
Seventh Annual Meeting**

**Société canadienne du rachis
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Program / Programme

Wednesday, March 21, 2007 / Le mercredi 21 mars 2007

Executive committee meeting / Rencontre du comité executive

Thursday, March 22, 2007 / Le jeudi 22 mars 2007

Plenary session / Assemblée plénière

Symposium / Symposium

Medical malpractice; its effect on spine surgery / Faute professionnelle médicale ; son effet sur la chirurgie du rachis

Annual General Meeting / Assemblée générale annuelle

Friday, March 23, 2007 / Le vendredi 23 mars 2007

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Idiopathic scoliosis; a cosmetic problem? / Scoliose idiopathique ; un probleme cosmétique ?

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BMP and Graft Extenders; what is their role? / PMO et les rallonges de greffe ; qu'est-ce leur rôle?

CSS 2007 — Podium presentations

Thursday, March 22, 2007

ACCESS TO SPINAL CARE: A TALE OF 2 CITIES. *R.J. Hurlbert,* R. Mobbs,† C. Teo.†* From the *University of Calgary, Calgary, Alta., Canada and the †University of New South Wales, Sydney, NSW, Australia.

Introduction: Socialized medicine brings with it difficulties in patient access for non-life-threatening yet nonetheless disabling conditions such as elective surgical spine care. The purpose of this study was to compare wait times for patients in a completely public system to those in a public and private system. **Methods:** Data was prospectively acquired from Calgary, Alberta (January–June 2006) and Sydney, Australia (July–December 2006). Spine care access was measured in 2 time intervals: from referral to consultation and from consultation to time of surgery. Patients were stratified based on 9 indexed spine procedures previously identified by the Canadian Spine Society. **Results:** Four hundred and fifty-one patients were assessed in the Calgary system and 130 patients in the Sydney system. The overall wait time for Calgary spinal patients to see a surgeon once referred by their GP was 179 ± 12 days (mean \pm SEM [standard error of mean]). In the Sydney system the mean access time was 19 ± 3 days (private) and 89 ± 22 days (public). Overall wait time from consultation to surgery was 90 ± 4 (Calgary), 35 ± 8 (Sydney private), and 87 ± 21 (Sydney public) days. **Discussion:** On average, Calgary patients wait 5 times longer than Sydney private patients and 1.5 times longer than Sydney public patients for spinal surgery once referred to a specialist. Public patients in the Sydney system have access to a consultant twice as quickly as in the Calgary system. Operating room wait times are similar in the 2 public systems. These results suggest that private health care is an efficient alternative to the public system. In addition, private health care appears to make public health care more efficient by off-loading the public system.

DOES THE PRESENCE OF “SIGNIFICANT BACK PAIN” AFFECT OUTCOMES IN LUMBAR DECOMPRESSION SURGERY? *A. Crawford,* A. Gruszczynski,† S. Dagenais,‡ E.K. Wai.†* From the *Faculty of Medicine and the †Department of Orthopaedic Surgery and Spinal Unit, University of Ottawa and the ‡Chalmers Research Group, Children’s Hospital of Eastern Ontario, Ottawa, Ont.

Introduction: Although many authors have emphasized the importance of lumbar decompression surgery for “leg dominant pain,” there is little objective evidence on the outcomes of surgery for varying degrees of back pain compared with leg pain. Moreover, it is unclear whether patients presenting with leg pain, along with significant back pain, would benefit from surgery. **Methods:** A prospective cohort of consenting adult

patients, who have consecutively undergone elective primary lumbar decompression by subspecialty spinal surgeons, were evaluated with longitudinal follow-up using standardized outcomes instruments. The cohort was analyzed into those with (1) leg dominant pain, and those with (2) significant back pain relative to their leg pain based on preoperative VAS (Visual Analogue Scale) scores. Univariate and multivariate analyses were used to adjust for potential confounding effects of demographic, surgical, waiting list and psychosocial factors. **Results:** Of the 85 eligible patients, 69 (81.3%) had at least 1 year follow-up with a mean follow-up time of 17 months. Baseline factors were similar between the 2 groups except for waiting times for consultation after referral. Patients with significant back pain waited significantly longer ($p = 0.04$) than those with leg dominant pain. Significantly ($p = 0.002$) more patients (93%) in the leg dominant pain group reported clinically significant improvement in the Oswestry than the significant back pain group (59%). This effect remained after multivariate adjustments for other baseline factors. **Discussion:** This study is one of the first to provide objective evidence to support the notion that the primary indication and best predictor of outcome for lumbar decompression surgery is leg dominant pain. Presence of significant back pain, despite presence of leg pain, is a strong predictor of poorer postoperative results. Further research is required to determine if the current long waiting lists are a causative factor for development of significant back pain in surgical candidates.

RISK OF INCREASING MOTOR DEFICIT IN PATIENTS WITH ACUTE SCIATICA SECONDARY TO A HERNIATED DISC WHO CHOOSE NONOPERATIVE CARE. *P. Bishop, C. Bailey, C. Fisher, M. Dvorak, M. Boyd, P. Wing.* Combined Neurosurgical and Orthopaedic Spine Program, Vancouver, BC.

Introduction: In addition to experiencing severe pain, patients with acute sciatica secondary to a herniated disc (AS/HD) are often distressed by an accompanying lower extremity motor deficit. The decision to consider surgical or nonoperative care is often heavily influenced by the concern of a persisting motor deficit. The purpose of this study was to determine whether choosing nonoperative care resulted in the development of a persisting neurologic motor deficit in patients with AS/HD. **Methods:** A prospective observational cohort study. Inclusion criteria were patients between the ages of 19 and 59 years with AS/HD, choosing nonoperative care, with McCulloch scores of $\geq 4/5$ and motor scores of $\geq 3/5$. Patients with a “red flag” condition or prior history of sciatica/lumbar spine surgery were excluded. All patients were evaluated using a standardized assessment protocol. Motor function was scored out of 5. Motor scores were then recorded at 8 and 16 weeks, 6, 12 and 24 months and compared with baseline scores. The primary outcome was change

in motor score at 8 weeks post baseline assessment. The secondary outcomes were change in motor score at 6, 12 and 24 months from baseline. Ethics approval was obtained. **Results:** Of the 49 patients enrolled, 29 had motor deficits (59%). Eighty-six percent of the patients initially presenting with motor deficits had a normal motor score at 8 weeks. The secondary outcomes showed that all gains in motor score were sustained at 1 and 2 years. One hundred percent of the patients had normal motor scores at the 2-year end point. **Discussion:** This study has demonstrated that patients with AS/HD and a motor score of > 3 . Five patients who choose nonoperative treatment did not develop a permanent or progressive motor deficit.

THE IMPACT OF WAIT TIMES ON OUTCOME IN PATIENTS UNDERGOING ELECTIVE POSTERIOR LUMBAR SPINAL SURGERY. *J. Braybrooke,*† A. Galalnt,*† M. Vidmar,‡ M. Ford,*† H. Abn,§† Y. Bronstein,*† J. Finkelstein,*† A. Yee.*†* From the *Spine Program, Division of Orthopaedic Surgery, Sunnybrook Health Sciences Centre, the †University of Toronto, the ‡Institute of Work and Health and §St. Michael's Hospital, Toronto, Ont.

Purpose: To evaluate the effect of wait time to surgery on patient-derived generic and disease-specific functional outcome following posterior lumbar surgery. **Methods:** Study cohort of 70 patients undergoing elective posterior lumbar spinal surgery for degenerative conditions. Prospectively collected SF-36 (Short Form-36) and Oswestry Disability questionnaires administered preoperatively, 6 weeks, 6 months and 1 year postoperatively. Time intervals from onset of symptoms to initial consultation by family physician through investigations, spinal surgical consultation and time spent on the surgical waiting list to surgery quantified. Time intervals compared with patient-specific improvements in reported outcome following surgery using Cox regression analysis. The effect of patient and surgical parameters on wait time was evaluated using median time as a reference for patients with either a longer or shorter wait. **Results:** Patient follow-up was completed in 53 of 70 enrolled patients (76%). Improvements in patient-derived outcome were observed comparing postoperative to preoperative baseline scores ($p < 0.05$). The greatest improvements were observed in aspects relating to physical function and pain. A longer wait to surgery was associated with less improvement in surgical outcome ($p < 0.05$, SF-36 BP [bodily pain], GH [general health], RP [role physical], VT [vitality], and PCS [physical component summary]). The greatest impact observed was a prolonged surgical waiting list time on SF-36 PCS scores following surgery (hazard ratio 3.53). Patients requiring spinal fusion had a longer wait compared with those not requiring fusion ($p < 0.05$) **Conclusions:** A longer wait time to spinal surgery can negatively influence surgical results as quantified by patient-derived functional outcome measures. Surgery resulted in the greatest improvement in pain severity and physical aspects of function, however, these areas also appeared the most impacted by a longer wait to surgery.

THE VIRTUAL CONSULTATION PROJECT — ENHANCING MULTIDISCIPLINARY CARE FOR PATIENTS WITH MALIGNANT

SPINAL CORD COMPRESSION (SCC). *R. Rampersaud,*† D. Grabarz,†† A. Chung,†† K. Burrows, †† M. Fehlings,*† A. Bezjak,†† R. Wong.††* From the *Toronto Western Hospital, the †University of Toronto and ††Princess Margaret Hospital, Toronto, Ont.

Objective: To assess the feasibility and impact of virtual consultation on the management of Spinal Cord Compression (SCC). **Methods:** A virtual consultation (VC) project to facilitate the multidisciplinary interaction between surgeons and radiation oncologists for the urgent management of acute malignant SCC was established. Patients presenting with a radiologically confirmed diagnosis of SCC were eligible. Clinical (neurologic/ambulatory/performance status, pain score, previous SCC, life expectancy), spinal parameters (level(s) of SCC, stability, existing and risk of fracture, deformity, operability), and treatment recommendations were recorded. **Results:** Between July 2004 and May 2006, 83 patients were analyzed. Patient characteristics included 48 male and 35 female while the median age was 63 (range 31–87) years. Virtual consultation was requested for 23/64 (36%) of the eligible patients (19 had surgery prior to referral). Ten patients were identified for transfer for a definitive surgical opinion, while the remaining 13 were able to have a multidisciplinary opinion without a transfer. Of the 41 eligible patients who were managed by the radiation oncologist alone, after retrospective review, only 1 patient was felt to have been suitable for a surgical consult. Sixteen clinical and radiological factors were examined with only spinal stability and ASIA impairment score differentiated between patients in whom surgery was the recommended initial treatment strategy. **Conclusions:** Virtual consultation is an effective model for providing rapid access to multidisciplinary care for patients with SCC. A mature database is expected to allow the development of a diagnostic algorithm that would assist in identification of surgical candidates (by non-surgeons) to further enhance expeditious care for patients with malignant spinal cord compression.

A PROSPECTIVE RANDOMIZED CLINICAL TRIAL COMPARING CHIROPRACTIC MANIPULATION VERSUS MICRODISCECTOMY FOR THE TREATMENT OF LUMBAR DISC HERNIATION. *R.J. Hurlbert, G. McMorland, S. Casha, E. Suter, S. DuPlessis.* University of Calgary, Calgary, Alta.

Introduction: The purpose of this study was to compare clinical outcomes from patients undergoing chiropractic manipulation to those undergoing surgical microdiscectomy for the treatment of symptomatic lumbar disc herniation. **Methods:** Forty patients failing at least 3 months of conservative management for sciatica due to herniated lumbar disc and found to be suitable for surgical intervention were prospectively randomized to chiropractic manipulation or microdiscectomy. Patients could cross over to the alternate treatment if they were dissatisfied with their outcome at 3 months. Follow-up was for a minimum of 1 year. **Results:** McGill Pain and SF-36 (Short Form-36) questionnaires demonstrated significant improvement in all treatment groups compared with baseline scores over time ($p = 0.007$, $p = 0.009$, respectively; repeated-measures ANOVA). Intent to treat analysis did not reveal a significant difference in outcome between the 2 primary treat-

ment groups. Three patients crossed over from surgery to chiropractic but failed to gain further improvement ($p = 0.92$). Eight patients crossed over from chiropractic to surgery and improved to the same degree as their primary surgical counterparts. There were no adverse events reported in either group. **Discussion:** Sixty percent of patients suffering from sciatica who have failed other medical management will benefit from chiropractic manipulation to the same degree as if they underwent surgical intervention. Of the 40% left unsatisfied, subsequent surgical intervention confers excellent outcome. Eighty-five percent of patients undergoing primary surgery will obtain excellent relief of symptoms, but 15% with poor surgical results will not benefit from subsequent chiropractic manipulation. We conclude that patients with acute lumbar symptomatic disc herniation failing medical management should consider chiropractic manipulation as a primary treatment followed by surgery if unsuccessful.

A RANDOMIZED CONTROLLED TRIAL ON THE EFFECTIVENESS OF CLINICAL PRACTICE GUIDELINES IN THE MEDICAL AND CHIROPRACTIC MANAGEMENT OF PATIENTS WITH ACUTE MECHANICAL LOWER BACK PAIN. *P. Bishop, J. Quon, D. Olson, D. Nixdorf, B. Yee, C. Fisher, M. Dvorak.* Combined Neurosurgical and Orthopaedic Spine Program, Vancouver, BC.

Introduction: Evidence-based clinical practice guidelines (CPG) for the management of patients with acute mechanical lower back pain (ALBP) have been defined on an international scale. Multicentre clinical trials have demonstrated that most ALBP patients do not receive CPG-based treatment. The purpose of this study was to determine if full CPG-based care is more effective than usual care (UC) in the treatment of ALBP. **Methods:** A 2 arm, parallel design, randomized control trial. **Inclusion:** Ages 19–59; QTFSD I and II ALBP ≤ 4 weeks. **Exclusion:** “Red flag” conditions, comorbidities contraindicating chiropractic spinal manipulative therapy (CSMT). Patients were assessed by a spine physician and randomized to CPG care (reassurance; avoidance of passive treatments; acetaminophen; 4 weeks of lumbar CSMT; return to work within 8 weeks), or family physician-directed UC, the components of which were recorded. **Primary outcome:** Difference in Roland-Morris Disability Questionnaire (RDQ) scores at 16 weeks between the CPG and UC groups. **Secondary outcome:** Differences in bodily pain (BP), physical functioning (PF) SF-36 (Short Form-36) domains. Hospital/university ethics approval was obtained. **Results:** Eighty-eight patients were recruited with 39 in the CPG group and 38 in the UC group completing the study. The primary outcome showed a mean difference in RDQ scores in the CPG group (-2.52) that was statistically significantly greater than those in the UC group (-0.25) ($p < 0.001$). The secondary outcomes showed that both the BP and PF domains of the SF-36 were statistically significantly improved ($p < 0.05$) in the CPG group when compared with the UC group. **Discussion:** This is the first published randomized control trial comparing full CPG, including CSMT, to family physician-directed UC in ALBP patients. It has shown that that CPG-based care is more effective.

EFFECTS OF EPIDURAL STEROIDS IN THE LUMBAR SPINE: A DOUBLE-BLIND RANDOMIZED CONTROL TRIAL. *D. Steinitz,*

P. Lander, E. Harvey, R. Reindl, M. Aebi. McGill University Health Centre, Montréal, Que.

Study design: This study represents a double-blind prospective randomized control trial of 50 patients undergoing epidural blocks of the lumbar spine for symptoms of neurogenic claudication and spinal/foraminal stenosis. **Objectives:** To evaluate the efficacy of adding steroids to the epidural injectate. **Summary of background data:** Traditionally, steroids have been used for epidural injections. Several non-randomized and randomized studies have not clarified the efficacy or safety of the usage of steroids in epidurals. Methodological flaws have been outlined in most of the studies currently in the literature. Most physicians believe that steroid use is efficacious in epidural injections. **Methods:** Patients complaining of neurogenic and radicular pain presenting to the spine service of a single institution were included in this study. They were randomized to 2 groups receiving injections of local anesthetic with or without steroid. Functional outcomes were evaluated in a double-blind fashion with the Musculoskeletal Functional Outcome Questionnaire, Oswestry Questionnaire and a Visual Pain Analogue Score. Patients were tested pre-injection and at 2 intervals post-injection. **Results:** No statistically significant differences were found between the 2 groups in any of the validated outcome measures. **Conclusions:** No benefit was found from the addition of steroid to an epidural injectate.

HERNIATED DISC MORPHOLOGY AND OUTCOME OF SELECTIVE NERVE ROOT BLOCK IN ACUTE SCIATICA. *P. Bishop, P. Wing, M. Boyd, C. Fisher, M. Dvorak.* Combined Neurosurgical and Orthopaedic Spine Program, Vancouver, BC.

Introduction: Selective nerve root block (SNRB) involves the transforaminal application of steroid under fluoroscopic guidance adjacent to the selected nerve root. Well-defined criteria for patients who will most likely benefit from SNRB remain unclear. The goal of this study was to determine whether or not the morphology (i.e., posterolateral, sequestered, foraminal, far lateral) of herniated discs (HDs) influences the therapeutic value of SNRB treatment. **Methods:** An observational cohort study. Thirty-seven patients with acute sciatica of less than 12 weeks duration and McCulloch scores of 4 or 5 were included. Disc morphology was determined by blinded interpretation of the MRI scans by a musculoskeletal radiologist. Outcome measures included the modified Roland-Morris Disability Questionnaire (RDQ) administered on the day of, and 6 weeks following, the SNRB procedure and the Visual Analogue Scale (VAS) filled out by the patient immediately before, 30 minutes after and 6 weeks after the SNRB. **Results:** Of the 37 patients enrolled in this study, the HD morphology was classified as: posterolateral 20, sequestered 9, foraminal 6, far lateral 2. Thirty-five of 37 patients (95%) reported a 30 minute VAS score of less than 3/10. Fourteen of 20 patients (70%) with a posterolateral HD reported > 3 point improvement in RDQ and > 5 point improvement in VAS at 6 weeks post-procedure. One of 9 patients (11%) with sequestered HD showed the same level of improvement in RDQ and VAS scores. None of the patients with foraminal or far lateral HD reported > 1 point improvement in RDQ or > 2 point im-

provement in VAS scores. **Discussion:** Patients with posterolateral HD were found to have significantly more favourable outcomes from SNRB than those with sequestered, foraminal or far lateral HD morphology.

IMPROVEMENTS IN BACK PAIN FOLLOWING ENROLMENT IN A MULTIDISCIPLINARY WEIGHT MANAGEMENT PROGRAM — EARLY RESULTS. L. Ashdown,* H. Dornan,* L. Vexler,† A. Gruszczynski,† S. Dagenais,‡ R. Dent,§ E.K. Wai.† From the *Faculty of Medicine and the †Department of Orthopaedic Surgery and Spinal Unit, University of Ottawa, the ‡Chalmers Research Group, Children's Hospital of Eastern Ontario and the §Ottawa Hospital Weight Management Clinic, Ottawa, Ont.

Introduction: Weight loss is commonly recommended as a treatment for back pain. However, there is little literature to support this. A recent systematic review has identified only studies relating to bariatric surgery. There are no other studies that address whether weight loss improves back pain. **Methods:** Forty-five consecutive consenting patients were recruited following enrolment in a tertiary multidisciplinary weight-management program. These patients were referred primarily for treatment of obesity. The program consisted of consultation and ongoing supervision by a subspecialty weight-management physician, and group and individual sessions addressing diet, exercise and behaviour modification. Patients were assessed by independent observers before the start of the program and at 12 weeks into the program with standardized and validated outcomes tools measuring baseline factors, back pain and related functional disability at 12 weeks follow-up. **Results:** Prior to starting the program, 42 patients (93%) reported some degree of low back pain of whom 40% rated their pain as moderate ($n = 12$) or severe ($n = 6$). Using the Oswestry Low Back Pain Disability Index, 73% of patients reported moderate ($n = 18$) or severe disability ($n = 15$). At 12 weeks, 37 patients (82%) were available for assessment. There were significant improvement in VAS (Visual Analogue Scale) pain scores (mean change 1.5, 95% CI [confidence interval] 0.7–2.4) and in Oswestry Low Back Disability Index (mean change 8.6, 95% CI 3.9–13.2). There were significant reductions in the prevalence of moderate or severe back pain ($p = 0.04$) and moderate or severe disability ($p = 0.007$) in the entire group. **Discussion:** This is the first study to provide empirical evidence on the positive effects of a weight-loss program on back pain. These results lay the groundwork for longer follow-up and comparative studies.

Friday, March 23, 2007

DEEP WOUND INFECTION FOLLOWING SCOLIOSIS SURGERY: PREVALENCE AND ANALYSIS OF RISK FACTORS. S. Aleissa, D. Parsons, J. Grant, J. Harder, J. Howard. University of Calgary, Calgary, Alta.

Objectives: To determine the prevalence of infection following scoliosis surgery and to ascertain associated risk factors. **Introduction:** Deep wound infection after spinal surgery is a severe complication often requiring prolonged medical and surgical management. It can compromise the outcome of the

deformity correction, especially in those cases that require surgical intervention with subsequent removal of the implants. Ascertaining the prevalence and risk factors leading to infection can help in the prevention of this serious problem. **Methods:** A retrospective study. The hospital charts of all patients who have undergone spinal deformity correction at the Alberta Children's Hospital during the years 1996 to 2005 were reviewed. Two hundred and twenty-seven patients were identified (139 idiopathic, 57 neuromuscular, 8 syndromic, 6 congenital, 17 other). One hundred and ninety-one patients were treated with posterior instrumentation and fusion, 11 with anterior-only procedures, and 24 with combined anterior and posterior procedures. Final follow-up ranged from 1 to 8 years. **Results:** Overall, 14 patients developed infection. The overall rate of infection was 6.2% (1.5% in idiopathics; 16.7% in neuromuscular; and 3 infections were distributed among congenital, syndromic, and other diagnoses). Drainage and back pain were the most common presenting symptoms. The rate of infection was higher in the non-idiopathic group (Risk Ratio [RR] 8.65, $p < 0.005$). The use of allograft was associated with a higher rate of infection, (RR 11, $p < 0.005$). Further stratification of the analysis showed the use of allograft is still significant in the non idiopathic group (RR 7.6, $p = 0.012$) and in the neuromuscular group alone. *Staphylococcus epidermidis* was the most commonly identified organism followed by *Propionibacterium acnes*, and *Pseudomonas*. **Conclusion:** The development of infection following scoliosis surgery is dependant on the presence of several risk factors including a non-idiopathic diagnosis and the use of allograft. Preventative measures which address these factors may decrease the development of infection.

IDENTIFYING THE BEST SURFACE TOPOGRAPHY PARAMETERS FOR DETECTING IDIOPATHIC SCOLIOSIS CURVE PROGRESSION. E. Parent, D. Hill, D. Hedden, E. Lou, J. Raso. Capital Health, Edmonton, Alta.

Introduction: Surface topography (ST) is a non-invasive monitoring strategy for scoliosis. Although many ST parameters have been described, there is no consensus on which to use for determining progression. The goal was to determine which ST parameters are most sensitive to scoliosis progression. **Methods:** Data from 58 subjects with idiopathic scoliosis curve progression were evaluated retrospectively. Only subjects with 2 ST scans of the back obtained within 12 (SD [standard deviation] 2) months and over 5° increase in maximal Cobb angle treated conservatively were selected. Common ST parameters from the frontal (Cosmetic score, Decompenation, POTSI [posterior trunk symmetry index]), transverse (Trunk twist, DAPI [deformity in the axial plane index], Hump Sum) and sagittal (kyphotic and lordotic angles) planes were compared. Sensitivity to change was assessed using Standardized Response Mean (SRM) coefficients with 95% CIs (confidence intervals). **Results:** At the first visit, mean age and largest Cobb angle were 13.9 (SD 1.4) years and 36° (SD 13°), respectively. Maximal Cobb angle progressed on average by 11.8° (SD 7.4°) within 1 year. SRM estimates were as follows: Cobb angle 1.51, POTSI and Trunk twist 0.51, Hump Sum 0.36, Cosmetic score 0.17, lordotic angle -0.13 and kyphotic angle 0.13, DAPI 0.11 and Decompenation -0.02.

SRM of 0.20 is considered small, 0.50 is moderate and > 0.80 is large. However, differences in sensitivity to change between ST parameter were not significant (except POTSI $>$ Decompen-sation and Lumbar angle; Trunk twist $>$ Lumbar angle). All ST parameters were significantly less responsive than the Cobb angle (used to select subjects). **Discussion:** Even though the sensitivity to progression was not significantly different between most ST parameters, POTSI and Trunk twist showed moderate sensitivity (SRM > 0.50) and all other parameters showed low sensitivity to progression over a 1-year interval. Frontal and transverse measures appeared most sensitive to scoliosis progression.

SCOLIOSIS BRACE LOAD PATTERNS DURING DAYTIME AND NIGHTTIME WEAR. *E. Lou, D. Hill, I. Mak, E. Parent, D. Hedden, M. Moreau, J. Mahood.* Capital Health, Edmonton, Alta.

Introduction: The goal of this study was to determine the pattern of brace wear over time in daytime and nighttime wear by using objective force measurements within the Boston brace. **Methods:** Twenty subjects diagnosed with AIS (adolescent idiopathic scoliosis), 9–15 years old, and new to brace treatment were recruited. Only subjects who used the brace for 5 hours continuously either in daytime or nighttime were considered. For daytime wear, the selected 5-hour intervals began with an initial spike in force after a period of non-activity, which indicated that they had just put on the brace. At night, the measurements began at 1 am and ended at 6 am. **Results:** Among the 20 subjects, only 9 subjects' data were used for daytime and 11 subjects' data were used in nighttime analysis. The average wear period was 11.4 (SD [standard deviation] 4.3) days for the day group and 11.6 (SD 3.9) days for the night group. There was a statistically significant decrease in force within the first 5 hours of consecutive brace wear during daytime. The decrease was from 1.4 (SD 0.6) (140% of prescribed force) in the first hour to 1.0 (SD 0.6) in the fifth hour; a 29% drop. Most of the decrease in force happened between hours 1 and 2 (0.2 [SD 0.1]; $p = 0.001$); between hours 2 and 5 the difference did not reach statistical significance. The difference between hours 1 and 5 for the night group was 0.2 (SD 0.2); $p = 0.06$. **Discussion:** Daytime forces in a Boston brace tended to decrease over a period of time, but the nighttime forces seem to be maintained. Daily adjustment of the brace tightness may be required to maintain the tightness level and the efficiency of brace treatment.

PREDICTIVE VALUE OF INTRAOPERATIVE NEUROPHYSIOLOGICAL MONITORING DURING CERVICAL SPINE SURGERY: PROSPECTIVE SERIES OF 1055 PATIENTS. *M. Kelleher, N. Quraishi, G. Tan, R. Sarjeant, M. Feblings.* From the Krembil Neuroscience Centre, University of Toronto, and the Toronto Western Hospital, Toronto, Ont.

Introduction: Despite growing use of multimodality intraoperative monitoring (IOM) in cervical spinal surgery, limited data exist regarding the sensitivity, specificity, and predictive values for IOM techniques to detect new neurological deficits in this setting. We sought to define the incidence of significant intraoperative electrophysiological changes and new postoper-

ative neurological deficits in a prospective cohort of patients undergoing cervical surgery. **Methods:** Prospective analysis of a consecutive series of cervical surgery patients accrued over a 5-year period at a university-based neurosurgical unit, in which multimodality IOM was recorded. Sensitivity, specificity, positive predictive values (PPVs) and negative predictive values (NPVs) were determined by standard Bayesian techniques. **Results:** The study population included 1055 patients (614 male; 441 female; mean age 55 yr). Tests recorded, SSEP (somatosensory evoked potentials) 1055, motor evoked potentials (MEP) 26, EMG (electromyography) 427. Twenty-four patients (2.5%) had significant SSEP changes. EMG activity was transient in 212 (49.6%); persistent in 21 (4.9%). Postoperative neurological deficits occurred in 30 patients (2.8%): 2 quadriparetic, 7 new sensory and motor deficits, 3 new sensory findings, 8 increased motor weakness, 10 C5/root lesions. Of the 30 patients, 12 had spinal tumours, of which 7 were intramedullary. SSEP sensitivity was 71%; specificity was 100%; PPV was 100%; NPV was 98%. MEP sensitivity was 100%, specificity 96%, PPV 67%, NPV 100%. EMG sensitivity was 75%, specificity 78%, PPV 3%, with a NPV of 100%. In all, the surgeon was alerted in 139 cases out of 1055 (115 burst/train EMG activity and 24 significant SSEP/MEP changes). **Conclusion:** Combined intraoperative neurophysiologic monitoring with EMG, SSEP and selective use of MEPs is helpful for predicting and possibly preventing neurological injury during cervical spine surgery.

A DIRECT COMPARISON OF THE NEUROPROTECTIVE EFFICACY OF ERYTHROPOEITIN, DARBEPOETIN, SIMVASTATIN, AND ATORVASTATIN AFTER ACUTE SPINAL CORD INJURY. *Y. Xie, A. Stammers, J. Liu, D. Sutherland, H.M. Sohn, J. Lee, C. Mann, W. Tetzlaff, S. Paquette, M. Boyd, C. Fisher, M. Dvorak, B. Kwon.* University of British Columbia, Vancouver, BC.

Tremendous interest has been generated in the neuroprotective potential of pharmacologic agents in experimental models of acute spinal cord injury (SCI). Of particular interest are those drugs that are already in safe clinical use for other, often unrelated human indications. Such drugs which are already known to be safe, are prime candidates for clinical trials. Recognizing the enormity of undertaking a human SCI trial, it is critical to engage in such trials with the most promising neuroprotective agent possible. Thus far, however, direct comparisons of various neuroprotective treatments are lacking. Furthermore, the efficacy of these treatments has not been demonstrated when they are administered following a delay after injury, a more clinically relevant paradigm.

A T9/10 spinal cord contusion of moderate severity (OSU [Ohio State University] Impactor, 1.5 mm displacement) was performed in adult Sprague-Dawley rats. The animals were randomized 1 hour post-injury to receive: erythropoetin (Epo), darbepoetin (Arenesp), simvastatin (Zocor), atorvastatin (Lipitor), or saline. Behavioural recovery was evaluated in a blinded fashion over the subsequent 6 weeks. The spinal cords were then harvested for histological analysis. The spinal cords of a subset of animals were fresh harvested at 4 hours post-injury for a quantification of inflammatory cytokine expression.

Six weeks after SCI, locomotor scores of rats orally gavaged

with simvastatin were significantly higher than the other treatment or control groups. Histologic analysis revealed greater white and grey matter sparing in the simvastatin treated animals. This comparative study suggests that simvastatin has promising neuroprotective properties in acute SCI.

FIVE-YEAR REVERSAL IN METHYLPREDNISOLONE ADMINISTRATION PATTERNS FOR ACUTE SPINAL CORD INJURY. *R.J. Hurlbert, M.G. Hamilton. University of Calgary, Calgary, Alta.*

Introduction: A survey of Canadian spinal surgeons in 2001 revealed that 76% of treating physicians prescribed methylprednisolone (MP) for acute spinal cord injury (SCI) primarily because everyone else did and for fear of litigation. Since then the NASCIS trials have come under considerable scrutiny nationally and internationally. The purpose of this study was to follow up the original survey 5 years later to determine if practice patterns have changed. **Methods:** The original questionnaire evaluating MP administration in SCI was re-administered to spinal surgeons at the annual Canadian Spine Society Meeting and Canadian Congress of Neurological Science meetings in 2006. An additional question was added to determine the reason (if any) for change in practice. **Results:** Forty-six surgeons and 21 residents completed the survey. Seventy-six percent of surgeons currently do not prescribe MP for SCI. Of those who continue to use steroids, 2/3 do so because they feel it efficacious and 1/3 do so out of fear of litigation. Most surgeons feel MP should be considered a treatment option (54%) while others feel advice should be given against administration (27%). Some surgeons feel it should be considered experimental (12%) while a minority believe it should be a recommended treatment (7%). A combination of meetings, journal articles, and discussion with colleagues was identified as reasons for practice change. **Discussion:** Compared to the survey results from 2001, there has been a complete reversal in the practice of administering MP for SCI in Canada. Very few surgeons currently feel threatened by litigation. Meetings and journal articles have played an especially important role in this shift of practice pattern and philosophy.

REORGANIZATION OF THE PRIMARY MOTOR AND SENSORY CORTICES IN PATIENTS WITH SPINAL CORD COMPRESSION: A PRE AND POST-SURGICAL EVALUATION USING FUNCTIONAL MRI. *D. Rabin,* R. Barry,† R. Bartha,† J. Gati,† M. Fink,* N. Duggal.** From the *London Health Sciences Centre and the †Robarts Research Institute, London, Ont.

Introduction: This prospective study characterizes the reorganization that may occur within the primary motor and sensory cortices following decompressive cervical spine surgery. **Methods:** Eleven right-handed patients with symptomatic cervical myelopathy underwent blood oxygenation level-dependent functional magnetic resonance imaging (fMRI) before a decompressive cervical procedure and 6 months following surgery. Ten right-handed control subjects underwent fMRI. All subjects performed a finger-tapping paradigm with the right hand. Volume time course data was corrected for temporal serial correlation and %-normalized before inclusion in the general linear model. Group activation maps were created for

each group with a threshold of $p < 0.005$ with Bonferroni correction. Between-group differences in left hemisphere volume of activation (VOA) were measured along the precentral gyrus (PrCG) and postcentral gyrus (PoCG). Each subject completed SF-36 (Short Form-36), NDI (Neck Disability Index), JOA (Japanese Orthopedic Association) and Nurick questionnaires at the time of each fMRI. **Results:** Preoperatively, patients demonstrated 2 distinct VOAs within the PrCG that were not detected in controls. These VOAs were centred within 7 mm of Brodmann Area (BA) 4 (1234 mm^3 , $T_{\text{max}} = 11.8$) and within 5 mm of the BA 6 (473 mm^3 , $T_{\text{max}} = 9.42$). Following surgery, patient scans showed a 2989 mm^3 larger VOA ($T_{\text{max}} = 13.6$) Centred within 5 mm of BA 4, while controls demonstrated a 528 mm^3 VOA ($T_{\text{max}} = 8.28$) Centred within 3 mm of BA 3 that was not detected in patients before surgery. Following surgery, controls had a 124 mm^3 VOA ($T_{\text{max}} = 7.05$) within BA 3 not seen in patients. There were significant improvements in NDI ($p = 0.02$), JOA ($p = 0.01$) and Nurick ($p = 0.001$) scores. **Discussion:** Spinal cord compression results in loss of VOA within the PoCG and increased volume of activation within the PrCG. Surgical reversal results in cortical reorganization and improved functional status.

RESULTS OF THE CETHRIN PHASE I/IIA PROSPECTIVE CLINICAL TRIAL OF A RHO INHIBITOR FOR THE TREATMENT OF ACUTE SPINAL CORD INJURY. *M. Fehlings,* N. Theodore,† J. Harrop,‡ G. Maurais,§ C. Kuntz,¶ C. Shaffrey,** B. Kwon,†† A. Yee,* J. Chapman,‡‡ P. Tremblay,§§ L. McKerracher,¶¶* From the *University of Toronto, Toronto, Ont., Canada, the †Barrow Neurological Institute, Phoenix, Ariz., USA, ‡Thomas Jefferson University, Philadelphia, Pa., USA, the §University of Montreal, Montréal, Que., Canada, the ¶Mayfield Clinic, Cincinnati, Ohio, USA, the **University of Virginia, Charlottesville, Va., USA, the ††University of British Columbia, Vancouver, BC, Canada, the ‡‡University of Washington, Seattle, Wash., USA and ¶¶Bioaxone Thérapeutique, Montréal, Que., Canada.

Introduction: There is an urgent need for effective therapies for acute spinal cord injury (SCI). A novel Rho inhibitor (Cethrin) blocks cell death and promotes neural regeneration in animal models of SCI. Accordingly, we undertook a Phase I/IIa trial of an Rho inhibitor (Cethrin) in patients with acute SCI to evaluate safety and obtain preliminary efficacy data. **Methods:** Thirty-seven patients with ASIA A complete cervical ($n = 13$) and thoracic ($n = 24$) SCI were enrolled at 9 sites in Canada and the United States. Cethrin (escalating doses ranging from 0.3 mg to 6 mg) was administered extradurally (in fibrin sealant) to the injured cord (time window: up to 5 days after SCI). All adverse events were tracked and neurological outcomes were assessed using ASIA standards. **Results:** Complete follow-up data were obtained in all patients (100%). There were no adverse events due to Cethrin. One patient (2.7%) with a thoracic SCI died of acute respiratory distress syndrome (ARDS). To date, 6-week follow-up data has been obtained in all 36 surviving patients and 6 month follow-up data is available for 22 patients (complete data will be presented at the CSS). Preliminary analysis of the 6-month data reveals that 6/22 (27%) patients improved 1 or more ASIA grades, including 1 patient who improved to ASIA C and 2

patients who recovered to ASIA D. **Discussion:** Local application of the Rho inhibitor Cethrin is feasible and safe in patients with acute SCI. A preliminary analysis of the neurological outcomes appears promising and provides impetus to proceed with a prospective randomized trial.

THE EXPRESSION OF INFLAMMATORY CYTOKINES FOLLOWING ACUTE SPINAL CORD INJURY: A HUMAN VERSUS ANIMAL MODEL COMPARISON. *A. Stammers,* S. Casha,† T. Rice,† J. Hurlbert,† M. Dvorak,* C. Fisher,* M. Boyd,* S. Paquette,* B. Kwon.** From the *University of British Columbia, Vancouver, BC and the †University of Calgary, Calgary, Alta.

Inflammation is an important contributor to the secondary injury cascade following spinal cord injury (SCI). Almost all that is known about post-SCI inflammation and the cytokines that mediate it has been derived from animal models; much less is known about the human condition. In this study, we measured the levels of inflammatory cytokines in the cerebrospinal fluid (CSF) of patients with acute SCI who were enrolled in prospective randomized clinical trials of intravenous minocycline (Calgary) or CSF drainage (Vancouver), and compared these cytokine levels in an animal model. In acute SCI patients, CSF samples were obtained through a lumbar drain at regular intervals for up to 7 days. In parallel investigations, Sprague-Dawley rats underwent a thoracic cord contusion and the injured cord was extracted at 2, 4, 6, or 24 hours after injury. The human and rat tissues were evaluated with a multiplex array system to assess 8 rat and 25 human cytokines. In summary, a number of inflammatory cytokines were elevated in human and rat samples within 24 hours of injury, although only IL-6 was seen to be elevated in both. Most cytokine levels diminished in humans by 72 hours after injury, and in rats by 24 hours after injury. In conclusion, this study represents the first description of the temporal sequence of inflammatory cytokine expression in human CSF after spinal cord injury. It provides valuable insight into the similarities and differences between human SCI and the rat model that attempts to simulate it.

THE RELIABILITY OF THE MAXIMUM CANAL COMPROMISE AND SPINAL CORD COMPRESSION AFTER TRAUMATIC CERVICAL SPINAL CORD INJURY. *J. Furlan,*† M. Fehlings,*† E. Massicotte,*† B. Aarabi,‡ A. Vaccaro,§ G. Anderson,§ C. Bono,¶ I. Madrazo,** C. Villanueva,†† J. Grauer,‡‡ D. Mikulis.§§* From the *Spinal Program, Toronto Western Hospital, University Health Network, the †University of Toronto, Toronto, Ont., Canada, the ‡University of Maryland, Baltimore, Md., USA, §Rothman Institute, Thomas Jefferson University, Philadelphia, Pa., USA, ¶Boston University Medical Centre, Boston, Mass., USA, **Hospital Ángeles del Pedregal, Mexico City, Mexico, the ††Spine Unit, Hospital de Traumatología Vall d'Hebron, Barcelona, Spain, ‡‡Yale University, New Haven, Conn., USA and §§Toronto Western Hospital, University Health Network, Toronto, Ont., Canada.

Introduction: While preclinical and clinical studies have mainly focused on the qualitative assessment of CT or MR im-

ages, there are only a few reliable, quantitative radiologic parameters to assess canal stenosis and spinal cord compression. Maximum canal compromise (MCC) and maximum spinal cord compression (MSCC) appear to provide clinical and prognostic value in the assessment of patients with traumatic cervical spinal cord injury (SCI). Given the emerging use of digital imaging, this prospective study was undertaken to evaluate the reliability of these radiologic parameters using magnified DICOM images. **Methods:** Midsagittal MRI and CT images of cervical spine were selected from 5 individuals with acute traumatic cervical SCI. CT-MCC, T₁-weighted-MRI-MCC and T₂-weighted-MRI-MSCC were independently estimated by 13 examiners on 10 occasions, 1 week apart from each other. **Results:** The intraobserver reliability for CT-MCC, T₁-weighted-MRI-MCC and T₂-weighted-MRI-MSCC was high in the 10 rounds in each case using ANOVA with post hoc test. In addition, the mean intraobserver interclass correlation coefficient (ICC) was 0.72 (SD [standard deviation] 0.05) for the CT-MCC, 0.70 (SD 0.07) for the T₁-weighted-MRI-MCC, and 0.68 (SD 0.11) for the T₂-weighted-MRI-MSCC. The mean interobserver ICCs were 0.43 (SD 0.02) for the CT-MCC, 0.61 (SD 0.03) for the T₁-weighted-MRI-MCC, and 0.55 (SD 0.05) for the evaluation of T₂-weighted-MRI-MSCC. **Conclusion:** Our results indicate that the intraobserver reliability for the MCC and MSCC was high. The MRI parameters were slightly more reliable than the measurements using CT scans. The present study suggests that these parameters are sufficiently reliable to be used in the assessment of the severity of canal stenosis and cord compression after cervical SCI.

Saturday, March 24, 2007

INTERIM ANALYSIS ON A PROSPECTIVE RANDOMIZED ODONTOID FRACTURE CLINICAL TRIAL. *R.J. Hurlbert,* R. Fox,† S. Casha,* R. Broad,† H. Jiang,† S. DuPlessis.** From the *University of Calgary, Calgary and the †University of Alberta, Edmonton, Alta.

Introduction: The treatment of type II odontoid fractures remains controversial. Both anterior screw fixation and halo vest immobilization are widely used but no clear advantages of one over the other have been discerned. The purpose of this study is to compare radiographic and clinical outcomes in patients randomized to one of these treatments. **Methods:** Patients identified in the emergency room with type II odontoid fractures less than 14 days old were admitted to the spinal service. Patients were excluded if they harbored contraindications to odontoid screw fixation, halo immobilization, or demonstrated other spinal fractures. After the process of informed consent, patients were randomized to: (1) anterior odontoid screw fixation; or (2) halo vest orthosis. Randomization was stratified for age, smoking status, and neurologic deficit. **Results:** Twenty-nine patients have been randomized to date from the 2 participating institutions; 16 to anterior screw fixation and 13 to halo orthoses. Twelve patients were under 65 years, while 17 patients were 65 years or older. Nine patients have been smokers. There have been none with neurologic deficits. Six treatment failures have been encountered. Four patients with halos have required revisional surgery (31%) compared with 2 patients with anterior screw fixation (13%) ($p = 0.10$).

Discussion: The observed non-union rate for type II odontoid fractures is more than twice as high in the halo group compared with the anterior screw group, primarily in patients 65 years or older. Advanced age may be an important indication for anterior screw fixation. Twenty more patients are required to meet the sample size target.

OPTIMAL TIMING OF SURGICAL STABILIZATION OF SPINE FRACTURES IN THE MULTI-TRAUMA PATIENT. *H. Pakzad,* S. Dagenais,† E.K. Wai.‡* From the *Division of Orthopaedic Surgery, and the ‡Spine Unit Ottawa, University of Ottawa, and the †Chalmers Research Group, Children's Hospital of Eastern Ontario, Ottawa, Ont.

Introduction: The optimal timing for surgical stabilization of spinal fractures is controversial. Stabilization facilitates mobilization and may reduce complications. **Methods:** Consecutive patients requiring stabilization surgery for a spinal fracture without neurologic injury were identified from a prospective institutional database. Patients were stratified by time to final surgical stabilization procedure (< 12 h, 12–24 h, 24–48 h, 48–72 h and > 72 h). Outcomes compared included overall complication rates and complications related to prolonged recumbancy. Multivariate analyses were performed to explore potential confounding effects of age, comorbidity, and trauma injury severity score (ISS). **Results:** Seventy-six patients satisfied the inclusion/exclusion criteria. The median time to final surgical spinal stabilization was 71.8 hours. There were no significant relationships between timing of surgery and age, comorbidity or ISS. There were significant differences in (1) overall complication rates ($p = 0.025$) and (2) complications related to prolonged recumbancy (e.g., respiratory failure, thromboembolism, $p = 0.02$) and time to final surgical stabilization. The risk of experiencing any complication was 3.4 times greater ($p = 0.025$), and 8.6 times greater ($p = 0.02$) for complications related to prolonged recumbancy, in patients who waited > 48 hours. These effects remained significant after adjusting for age, comorbidity, and ISS. There were trends toward longer lengths of stay and lower function (measured using the FIM [functional independence measure]) in the surgical delay group. **Discussion:** This study reported an association between time to surgical stabilization of spinal fractures and complications. Patients who wait > 48 hours for surgical stabilization appear to be at greatest risk. This study is limited in that the identified relationship may be related to a number of other confounding factors not measured or inadequately adjusted for because of small numbers. Further study, using this study's developed algorithms in larger data sets, may help resolve some of these issues.

TLSO VERSUS NO ORTHOSIS FOR THE TREATMENT OF THORACOLUMBAR BURST FRACTURE WITHOUT NEUROLOGICAL DEFICIT: PRELIMINARY RESULTS FOR A RANDOMIZED, PROSPECTIVE, EQUIVALENCE TRIAL. *C. Bailey,* C. Fisher,† M. Boyd,† B. Kwon,† K. Thomas,‡ J. France,§ S. Paquette,† K. Gurr,* S. Bailey,* M. Dvorak.†* From the *University of Western Ontario, London, Ont., the †University of British Columbia, Vancouver, BC, the ‡University of Calgary, Calgary, Alta., Canada and the §University of West Virginia, WV, USA.

Introduction: The treatment of thoracolumbar burst fractures without neurological deficit is controversial. A number of retrospective studies have demonstrated successful treatment using either TLSO (thoracolumbar-sacral orthosis), prolonged bed rest or surgery. Some authors have demonstrated favourable outcomes without any treatment modality other than graduated mobilization. This treatment would avoid secondary adverse effects (muscular atrophy, deconditioning, skin irritation) resulting from the use of an orthosis and eliminate the brace's financial cost; but could prolong reactivation. The purpose of this study is to compare the disease-specific outcome between patients randomly assigned to a TLSO or no orthosis group. **Methods:** Randomized prospective equivalence trial. Consecutive patients presenting to 4 level I trauma centres with isolated AO-A3 burst fractures between T11 and L3 were included. A standardized physiotherapy protocol with immediate mobilization was implemented for all patients. Roland-Morris Disability Questionnaire (RMQ) assessed at 3 months was the primary outcome measure. Secondary outcomes included SF-36 (Short Form-36), RMQ, VAS (Visual Analogue Scale), and radiographic out to 2 years. **Results:** Forty-eight patients have completed the primary outcome. No difference in demographics and baseline variables including initial traumatic kyphosis existed between groups. There was no statistical difference between groups for any outcome measure. RMQ at 12 weeks was 7.9 (SD [standard deviation] 5.5) and 6.1 (SD 5.7) for no orthosis and brace groups respectively ($p = 0.32$). VAS pain at 2 weeks and 12 weeks was 3.6 (SD 2.4) v. 3.4 (SD 2.9) ($p = 0.79$) and 2.1 (SD 1.7) v. 1.8 (SD 2.0) ($p = 0.48$) for no orthosis and TLSO groups respectively. One patient in each group failed nonoperative management and required surgery. **Conclusion:** Preliminary results suggest that no orthosis is equivalent to TLSO with respect to RMQ at 3 months post-injury.

CLINICAL ACCURACY OF FLUOROSCOPIC COMPUTER-ASSISTED PERCUTANEOUS PEDICLE SCREW PLACEMENT: A CT ANALYSIS. *A. Zharai, B. Ravi, R. Rampersaud.* From Toronto Western Hospital and the University of Toronto, Toronto, Ont.

Purpose: To evaluate the clinical accuracy of computer-assisted fluoroscopy for the placement of percutaneous lumbosacral (LS) pedicle screws. **Methods:** A prospective CT analysis was performed in 40 consecutive patients. Three independent observers were used. Postoperative CT scans of 159 titanium pedicle screws ($n = 6$ [L3]; 38 [L4]; 65 [L5] and 50 [S1]) were reviewed. All screws were percutaneously placed using the 2-dimensional FluoroNav™ system. The relative position of the screw to the pedicle was graded as follows: I = completely in; II = < 2 mm breach; III = 2–4 mm breach; IV = > 4 mm breach. The direction of the breach was further classified as well as its trajectory. **Results:** Correlation between observers was near perfect ($\kappa = 0.7–0.9$). The 3 observers rated 74.2%, 78.6%, and 78.0% of screws were completely contained within the pedicle. The data from the observer with the most significant pedicle breaches is as follows: 35 (22%) pedicle breaches (grade II – $n = 30$; III – $n = 4$; IV – $n = 1$, $n = 11$ medial, $n = 19$ lateral; $n = 5$ superior). Only 1 clinically significant breach occurred medially (grade III) at L5. This re-

quired screw revision (performed with a minimal access technique) with complete resolution of acute postop L5 radiculopathy. **Conclusions:** The in-vivo percutaneous pedicle breach rate in this study was higher than that reported for similar open navigational techniques. The majority (85.7%) of breaches were minor (< 2 mm) and over half (54.3%) were lateral with no potential for clinical squealae. This high lateral breach rate is due to a modified lateral starting point required for the percutaneous technique. However, there is concern that this technique resulted in one clinically significant medial breach and highlights the increased risk associated with percutaneous pedicle screw placement.

KINEMATIC RESULTS AFTER PRODISC-C TOTAL DISC REPLACEMENT. *D. Rabin,* R. Bertagnoli,† N. Wharton,‡ G. Pickett,* N. Duggal.** From the *London Health Sciences Centre, London, Ont., Canada, the †Spine Centre, St. Elizabeth Klinikum, Straubing, Germany and ‡Medical Metrics, Houston, Tex., USA.

Introduction: The ProDisc-C has a ball-and-socket design allowing for semi-constrained motion about a fixed axis of rotation. The purpose of this prospective study was to assess whether the ProDisc-C preserved the kinematic parameters of the preoperative spine. **Methods:** Fifteen patients underwent single level implantation of the ProDisc-C artificial cervical disc for treatment of cervical degenerative disc disease producing radiculopathy. Lateral neutral, flexion and extension cervical radiographs were obtained preoperatively and at intervals up to 12 months postoperatively. Kinematic parameters including sagittal rotation, shear, change in disc height and centre of rotation (COR) were determined for each spinal level using quantitative motion analysis software. Absolute values within groups were analyzed, together with measures of change within individual patients. **Results:** Motion was not only preserved but significantly increased at all operated spinal segments up to 12 months following surgery (mean postoperative ROM [range of motion] 11.3° v. 6.6° preoperatively, $p = 0.0004$, paired Student's *t*-test). However, global sagittal rotation (C2-7 ROM) did not change significantly (54.1° v. 50.2°, $p = 0.11$). Disc height in the neutral position was significantly increased both anteriorly (6.0 mm v. 2.9 mm, $p < 0.0001$) and posteriorly (4.8 mm v. 2.9 mm, $p < 0.0001$), with an increase in lordosis at the operated level (mean disc space angle 4.7° v. 0.3°, $p < 0.0001$). Changes in the COR between preop and late follow-up were greatest along the anterior-posterior axis of the vertebral body. **Discussion:** The ProDisc-C provided in vivo functional spinal motion and introduced lordosis at the operated level. There is a shift in the COR following disc replacement. The significance of the observed changes in spinal kinematics will be further discussed.

RECOMBINANT BONE MORPHOGENETIC PROTEIN-2 (rhBMP-2) AUGMENTS BONE FORMATION OF HUMAN BONE MARROW DERIVED STEM CELLS (hBMSCs) IMPLANTED IN MUSCLE OF ATHYMIC MOUSE. *H. Jiang, W. Jiang, J. Mahood, D. Miller, J. Lakey, T. Gao.* University of Alberta, Edmonton, Alta.

Introduction: Recombinant bone morphogenetic protein-2 (rhBMP-2) is a recombinant osteoinductive protein and has

been used as bone graft substitute/device for spine fusion (INFUSE, Medtronic). rhBMP-2 has much less potential and slow bone induction in human comparing to rodents. The lack of inducible cells is postulated as a possible reason. We studied rhBMP-2 induced ectopic bone formation with or without hBMSCs in athymic mouse model to provide evidence of our hypothesis. **Methods:** A muscle pouch was created in the both hind legs of 16 athymic mice (nude/nude, CDI). 0.8 millions of ex vivo expanded hBMSCs or hBMSC-derived osteoblasts (OS) were implanted, with/without 15 µg of rhBMP-2, into each pouch of individual animal using the gelatine capsule as a carrier. The same dose of rhBMP-2 was used a control. Radiographs, histology and immunohistochemistry (IHC) were used to analyze observations at 2 and 4 weeks post-implantation. **Results:** Ectopic bone formation was seen in all implants of hBMSCs/OS with rhBMP-2, some of rhBMP-2 controls, and none of hBMSCs/OS without rhBMP-2 in radiograms at 2 and 4 weeks. Demineralized histology sections showed enriched bone formation in muscle pouches in hBMSCs and OS with rhBMP-2 and rhBMP-2 controls, and less residues of the capsules. IHC with anti-human collagen I antibody verified that new bone was mostly from human-origin in hBMSCs/OS with rhBMP-2, and was all from mouse origin in rhBMP-2 control. A cluster of human osteocalcin positive-stained cells were seen in hBMSCs/OS without rhBMP-2 in the mouse muscle, but no visible woven bone structure. **Discussion:** Our preliminary results showed that hBMSCs are the target cells of rhBMP-2 induced bone formation. An interaction of rhBMP-2 with hBMSCs will augment new bone formation. hBMSCs plus rhBMP-2 may create a new therapeutic option for spine fusion.

TRANEXAMIC ACID REDUCES BLOOD LOSS AND TRANSFUSION IN ADULT PATIENTS HAVING SPINAL FUSION SURGERY. *J. Wong, H. El-Beheiry, R. Rampersaud, S. Lewis, M. Fehlings, F. Chung.* From Toronto Western Hospital and the University of Toronto, Toronto, Ont.

Introduction: The objective of this study was to determine whether tranexamic acid would reduce perioperative blood loss and blood transfusion in adult patients having multilevel elective spinal fusion. **Methods:** Seventy-two adult patients undergoing elective posterior thoracic/lumbar instrumented spinal fusion were randomized (triple-blinded study) to receive either 10 mg/kg of tranexamic acid, and then a continuous infusion of 1 mg/kg/hour of tranexamic acid or an equivalent volume of placebo and then a continuous infusion of an equivalent volume of placebo intraoperatively. Perioperative blood loss was measured intraoperatively and the wound drainage from the surgical drain was recorded for the first 24 hours postoperatively. Perioperative blood transfusion, duration of hospital stay, and complications were recorded. **Results:** Other than age (52 yr v. 48 yr (placebo group); $p = 0.0016$) there was no significant difference in patient demographics. There was no difference in intraoperative blood loss between the 2 groups, however, the total perioperative blood loss (2220 mL / 2711 mL; $p = 0.0085$), transfusion of allogeneic red blood cells (262 mL / 536 mL; $p = 0.009$), autologous whole blood (419 mL / 646 mL; $p = 0.047$), and duration of hospital stay (5.2 d / 7.9 d; $p = 0.0003$) were

reduced in the tranexamic acid group compared with the placebo group. There were no thromboembolic events or complications in either group. **Discussion:** The transfusion of blood and blood products remains a concern for patients and physicians. Intraoperative administration of tranexamic acid was found to reduce the total perioperative blood loss and transfusion of allogeneic red blood cells and autologous whole blood in the tranexamic acid group. The duration of hospital stay was also significantly lower in the tranexamic acid group.

ASSESSMENT OF LUMBAR STABILITY USING DIFFERENTIAL ACCELERATION. *M. Johnson, J. Marsh, D. Taylor, D. Kriellaars.* University of Manitoba, Winnipeg, Man.

Despite substantive study, effective back injury prevention or treatment is still elusive. One major problem contributing to this is the inability to objectively assess spine stability. **Purpose:** To evaluate differential acceleration as a tool to assess spine stability and to evaluate back failure mechanics during fatigue (a contributing factor to injury) and the management of back perturbations (a leading cause of injury). **Methods:** Differential tri-axial accelerometry was monitored over L1 and L4 spinous processes ($n = 12$) during back extension to fatigue. An unexpected perturbation (ball drop) was applied before and after the fatigue trial. **Results:** Differential lumbar acceleration measured lumbar spine segment orientation and relative lumbar orientation (lordosis/kyphosis) ($R^2 = 0.99$). Short-term adaptation to perturbations was documented ($p < 0.05$). Back failure mechanics were observed during a bout of back extensions (mean 39 reps) to fatigue failure. No deviation from neutral spine was documented. Eccentric mechanomyogram (MMG) magnitude reduced (motor learning) concurrent with an increase in concentric MMG magnitude (fatigue) with successive back extension repetitions ($p < 0.01$). A dissociation in lumbar acceleration (L1-4) occurred after fatigue during perturbations. **Conclusion:** Differential lumbar acceleration had great utility in the assessment of spine stability. Evidence contrary to the neutral spine hypothesis was documented. A unique neural activation strategy of the back extensors was demonstrated during fatigue. Short-term adaptations in back perturbation management were shown as a result of learning and fatigue.

EFFECT OF NICOTINE ON DEGENERATION AND HEALING OF INJURED INTERVERTEBRAL DISC (IVD) IN RABBIT MODEL: HISTOLOGY AND GENE EXPRESSION STUDY. *H. Jiang, T. Gao, J. Chiu, D. Hart, T. van de Leur, K. Bagnall.* University of Alberta, Edmonton, Alta.

Introduction: Low back pain affects > 70% of the population and the intervertebral disc (IVD) degeneration is one common pathological cause. Studies indicated that smoking had worsened healing process and long-term outcomes of surgical intervention. The mechanism is largely unknown. This study was designed to assess the impact of nicotine on the IVD degeneration and healing of injured IVD in an established rabbit model. **Methods:** Thirty-two rabbits were divided into 4 groups: normal control, laceration of IVD, nicotine exposure, and laceration plus nicotine exposure. Laceration of IVD was

created using a special knife and nicotine delivered by an osmotic pump implanted subcutaneously. Serum levels of the nicotine/cotinine were monitored weekly for 4 weeks, and x-rays of lumbar spine taken before and at the end of the experiment. Disc height index (DHI) was used to score x-rays. IVDs were harvested for histology using Masuda's grading, and for gene expression of MMPs, fibronectin and aggrecan using real-time quantitative RT-PCR. **Results:** Serum levels of the nicotine/cotinine were correlated to doses of smoking. DHI was significantly decreased in laceration/nicotine group (90%) in comparison with control 1 (109%, $p < 0.05$), and grades of histology showed remarked injuries in laceration/nicotine (5.5), laceration (4.8), and nicotine exposure (3.5) against control (2.2, $p < 0.05$). Gene expression of MMP1, 3 and fibronectin in annula of IVD was significantly upregulated in laceration/nicotine and nicotine exposure groups versus control ($p < 0.02$); and of both aggrecan and fibronectin in nuclea of IVD downregulated in laceration/nicotine group versus control ($p < 0.03$, χ^2). **Discussion:** Nicotine seems to accelerate process of normal IVD degeneration and have a synergistic negative impact on healing of injured IVD. Stimulation of metalloproteinase and inhibition of adhesive molecules are possible mechanisms of nicotine on IVD degeneration.

INCIDENCE OF ADJACENT SEGMENT DEGENERATION IN EXTENDED THORACOLUMBAR FUSIONS. *E. Abraham, N. Manson.* Saint John Campus, Dalhousie University, Saint John, NB.

Purpose: Adjacent segment degeneration (ASD) in the form of disc degeneration, spinal stenosis, deformity, spondylolisthesis and fracture can occur after spinal fusion. The incidence is variable and its occurrence difficult to predict. Further major surgery is required to correct the clinical problem that exists, although not all cases of ASD are symptomatic. The primary purpose of this study was to identify the incidence of ASD after multilevel (≥ 3 level) thoracolumbar fusions at a minimum 5-year follow-up. Risk factors for ASD were to be determined. **Methods:** From a prospective data bank, 405 such fusion procedures were identified with a minimum 5-year follow-up. The radiological incidence of ASD was distinguished from those that were clinically significant, as determined by the Oswestry Disability Index back and leg pain Visual Analog Scales. Radiographic evaluation, pre and postoperatively, was available. Institutional review board (IRB) approval was obtained. Two hundred and seventeen cases were available for final follow-up. **Results:** The incidence of ASD after extended spinal fusions overall was 28% radiologically. The incidence of symptomatic ASD was 18%. The incidence of ASD requiring surgery was 10%. The Oswestry Disability Index was 44 in the ASD group and 28 in patients who did not have ASD. Risk factor trends were noted, particularly related to the condition of the end adjacent level at the time of surgery. **Conclusion:** At a minimum follow-up of 5 years, 217 out of 405 extended spinal fusions ≥ 3 levels demonstrated an incidence of adjacent segment degeneration of 28%. There was an 18% incidence of clinically significant ASD and, overall, 10% required surgery to address the clinical problem. ASD is a clinically significant entity that deserves future study to aid in its prevention.

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ASSESSMENT OF IMPLANTATION ACCURACY IN LUMBAR ARTIFICIAL DISCS: COMPARING CHARITÉ III AND PRODISC II. *J. Blanchard, J. Bouchard.* Foothills Medical Centre, University of Calgary, Calgary, Alta.

Introduction: As more studies are published on lumbar disc replacement, it becomes more evident that accurate surgical placement has an impact on clinical outcome. The design of the different devices available influences the position obtained during surgery. The goal of this study is to assess implantation accuracy in lumbar disc replacement done at our centre.

Method: Between November 2003 and July 2006, 59 lumbar disc replacements were done by the senior author (28 Charité III and 31 ProDisc II). Postop x-rays were available for all but 1 patient. The desired position was the centre of vertebral body on the anteroposterior (AP) x-ray and 2 mm posterior to the midline on the lateral (Lat). The distance from this position was measured for each artificial disc, and discs were classified as ideal (within 3 mm), suboptimal (3–5 mm) and poor (more than 5 mm). **Results:** The 27 Charité discs were on average 2 mm, 1 mm off the ideal position on the Lat and 2.3 mm on the AP, with 8 discs being suboptimal and 5 being poor in at least one direction. The 31 ProDiscs were on average 1.8 mm off on the Lat and 1.1 mm on the AP, with only 4 being suboptimal and none being poor. **Conclusion:** This study revealed that ProDisc artificial lumbar discs were positioned closer to the optimal position than the Charité. This difference could be related to the presence of a keel on the ProDisc, the design of implantation instruments or to a learning curve effect; Charité discs were done first.

BIOMECHANICAL COMPARISON OF THE INTACT CERVICAL DISC VERSUS TOTAL DISC ARTHROPLASTY: A FINITE ELEMENT MODEL STUDY. *R.N. Natarajan,* M. Hussain,* N.A. Manson,† G.B.J. Andersson,* H.S. An.** From *Rush University Medical Centre, Chicago, Ill., USA and the †Atlantic Health Sciences Corporation, Saint John, NB.

Introduction: Cervical total disc arthroplasty (TDA) has emerged as a promising alternative to the management of cervical disc herniation or degeneration. While segmental range of motion (ROM) may improve after TDA, the reconstitution of physiologic motion remains unproven. The effects on motion segment flexibility and loading are poorly defined after TDA. The specific role of the facet joints in this environment of motion and load changes has not been studied. These factors in the environment of a novel TDA implant require pre-clinical testing to confirm safety and efficacy. The purpose of this study was to quantify the biomechanical response of TDA on segmental motions and loads at the C5-6 motion segment. The effect on facet joint motion and load was specifically addressed. **Methods:** Three-dimensional, nonlinear finite ele-

ment models were used to evaluate the C5-6 motion segment. Analysis compared the intact motion segment versus the motion segment with TDA (SKCD, Spinalkinetics, Redwood City, USA). Motion segment ROM and facet loading were calculated after multidirectional moment loads of 2 Nm combined with a compressive preload of 100 N. **Results:** At 100 N axial loads, compressive displacements were 0.295 mm and 0.253 mm and facet loads were 8 N and 9 N for the natural disc and TDA, respectively. With 100 N axial preload, 2 Nm torque in flexion, extension, lateral bending, and torsion produced the following displacements for the natural disc and TDA: 10.73° (TDA 9.77°); 11.88° (TDA 11.98°); 4.67° (TDA 4.85°); and 11.34° (TDA 11.57°). Facet loads for the same torque directions were 0 N (TDA 0 N); 166 N (TDA 235 N); 60 N (TDA 69 N); and 36 N (TDA 49 N). **Discussion:** The natural disc and TDA showed similar results in all modes of motion. A concerning increase in facet loading for TDA during extension was observed. Finite element model (FEM) can provide some insight into the reconstitution of natural motion in a TDA motion segment.

BIOMECHANICAL EVALUATION OF A HEADLESS COMPRESSION SCREW FOR ANTERIOR ODONTOID FIXATION. *C. Bailey,* V. Rajgopal,* K. Gurr,* S. Bailey,† B. Beaton,† C. Dunning.†* From the *Victoria Hospital, London Health Sciences Centre, the †Department of Mechanical & Materials Engineering, and the ‡Jack McBain Biomechanical Testing Laboratory, University of Western Ontario, London, Ont.

Introduction: The purpose of this study was to evaluate the biomechanics of anterior odontoid fixation and compare the Acutrak screw to traditional lag-screw fixation (ACE screw) with regards to stiffness and mechanism of failure. The Acutrak screw is a headless variable-pitch screw that is self-tapping and achieves automatic compression. **Materials and methods:** Ten cadaveric C2 specimens were obtained and examined fluoroscopically for metastases, and for guide-wire passage. Pre-fracture stiffness testing used a pure extension force and a maximum load of 300 N at a rate of 0.25 mm/second. An osteotomy was created to reproduce a type II odontoid fracture. An Acutrak or ACE screw was then placed. Post-fracture stiffness testing was performed using a maximum load of 125 N at a rate of 0.25 mm/second. **Results:** There was no significant difference in stiffness between the Acutrak and ACE screws. The screws failed by similar mechanisms which was a “windshield-wiper” failure mode in the cancellous bone of the C2 body. The fixation of the screw in the odontoid was not compromised. **Conclusion:** Although the screws had similar stiffness, the Acutrak screw provides the advantage of being self-tapping, being headless, providing automatic lag effect, and having a tapered base which may resist the “windshield-wiper” mode of failure.

BIOMECHANICAL EVALUATION OF THE PRESTIGE™ CERVICAL INTERVERTEBRAL DISC PROSTHESIS. *D. Rabin,* N. Duggal,* A. Brantley,† S. Baek,† N. Crawford.†* From the *University of Western Ontario, London, Ont., Canada and the †Barrow Neurological Institute, Phoenix, Ariz., USA.

Introduction: Optimal cervical disc prosthesis design should duplicate the biomechanical response of a healthy native disc. We used biomechanical research techniques to characterize the in-vitro biomechanical properties of the Prestige™ cervical disc prosthesis. **Methods:** Range of motion (ROM), instantaneous axis of rotation (IAR), coupling pattern, and facet loads were characterized for 7 normal cadaveric cervical spines. These same parameters were quantified after the C4-5 disc was replaced with a Prestige cervical disc prosthesis. The normal and arthroplasty conditions were compared using 2-tailed paired Student's *t*-tests. **Results:** At the surgical level, ROM during flexion-extension and axial rotation did not change significantly following insertion of the Prestige disc ($p > 0.17$). Lateral bending ROM was significantly decreased following insertion of the Prestige disc (11.4° (SD [standard deviation] 4.2°) v. 7.1 (SD 4.4°); $p = 0.013$). After insertion of the Prestige disc at C4-5 the coupling factor of lateral bending during axial rotation was significantly reduced ($p < 0.001$). Relative to normal, the IAR during flexion-extension at C4-5 moved anteriorly with the Prestige disc in place ($p = 0.0163$). There were increased levels of laminar surface strain with the Prestige disc in place during extension, flexion, right axial rotation, and right lateral bending ($p < 0.05$). **Discussion:** The Prestige artificial disc maintains ROM during flexion-extension and axial rotation, but restricts motion during lateral bending and shifts the flexion-extension IAR anteriorly at the surgical level. Following insertion of the Prestige disc, lateral bending coupling during axial rotation is reduced relative to normal. Load transmission on the left facet with the Prestige disc in place is increased relative to normal.

BLOOD TRANSFUSION REQUIREMENTS IN PEDIATRIC SPINAL DEFORMITY CORRECTIVE SURGERY: COMPARISON OF IDIOPATHIC AND NEUROMUSCULAR ETIOLOGIES. *J.A. Grant, J. Howard, J. Harder, J. Luntley, S. Al Eissa, D. Parsons.* University of Calgary, Calgary, Alta.

Introduction: The purpose of this study was to first determine if neuromuscular scoliosis results in greater perioperative transfusion requirements compared to idiopathic scoliosis, and secondly to compare the effects of tranexamic acid (TXA) dosing on reducing transfusion requirements in scoliosis surgery. **Methods:** A retrospective chart review of all patients who underwent posterior instrumentation and fusion for scoliosis for the years 1999 to 2006 was performed. Perioperative transfusion requirements for idiopathic and neuromuscular scoliosis patients were compared and grouped according to TXA use. Transfusion requirements for those patients receiving either a low (10 mg/kg loading, 1 mg/kg/h infusion), or high (20 mg/kg loading, 10 mg/kg/h infusion) dose TXA were also compared. **Results:** Idiopathic patients had significantly decreased transfusion requirements overall (no TXA: idiopathic 1028.3 (SD [standard deviation] 558.7) mL v. neuromuscular 1400.7 (SD 911.3) mL, $p = 0.02$; with TXA: idiopathic 1082.9

(SD 1005.5) mL v. neuromuscular 2043.8 (SD 1397.5) mL, $p = 0.03$). In the idiopathic group, high dose TXA resulted in a significant reduction in perioperative transfusion requirements compared with low dose TXA (687.9 [SD 778.1] mL v. 1355.0 [SD 965.8] mL, $p = 0.04$). **Discussion:** Neuromuscular scoliosis patients have significantly higher transfusion requirements as compared with idiopathic patients. For patients with idiopathic scoliosis, the use of the high-dose TXA is suggested over low-dose TXA given the relative reduction in transfusion requirements for the high-dose group.

CLINICAL CORRELATION OF RADIOLOGIC SPINAL STENOSIS AFTER STANDARDIZATION FOR VERTEBRAL BODY SIZE. *A. Athiviraham, D. Yen, C. Scott, D. Soboleski.* Queen's University, Kingston, Ont.

Aim: Although previous studies have shown poor correlation between clinical symptoms due to lumbar stenosis and radiologic stenosis, no study has corrected for congenital variation in vertebral body size among individuals. This purpose of this study is to determine the relationship between the degree of radiographic lumbar spinal stenosis, adjusted with an internal control for vertebral body size, and disability from lumbar stenosis. **Methods:** One hundred and twenty-three consecutive patients with clinical and radiologic confirmation of neural impingement secondary to lumbar stenosis were enrolled prospectively. Thecal sac AP diameter (TSD) and cross sectional area (CSA), and vertebral body AP dimension (VBD) were determined. These parameters were then correlated with patients' symptoms using the modified Roland-Morris Questionnaire (RMQ) disability score. **Results:** This study found no statistically significant inverse correlation between TSD and RMQ score ($p = 0.433$) or CSA and RMQ Score ($p = 0.124$). In addition, there was no significant inverse correlation between CSA/VBD ratio and RMQ score ($p = 0.036$) or TSD/VBD ratio and RMQ score ($p = 0.109$). There was a significant difference in mean RMQ scores when the patients were divided into those with CSA greater than or equal to 70 mm^2 and those less than 70 mm^2 , with $t = -2.104$ and $p = 0.038$. **Conclusion:** The degree of radiographic lumbar spinal stenosis, even with the use of an internal control of vertebral body size and standardized disability questionnaires, does not correlate with clinical symptoms. However, patients with more severe stenosis below a cross-sectional area critical threshold of 70 mm^2 , have significantly greater functional disability.

DYNESYS FIXATION IN THE LUMBAR SPINE — DOES IT HOLD UP TO THE PROMISES? *P. de Muelenaere,* F. Theron.†* From the *University of Manitoba, Brandon, Man., Canada and the †University of Pretoria, Pretoria, South Africa.

Introduction: The concept of dynamic stabilization has taken off, and is considered one of the "new technologies" in modern spine surgical practice. One of the proposed theoretical advantages is avoiding the adjacent level problems. After an introduction to this system by its designer, Prof. G. Dubois in June 2000, a prospective study was undertaken. A total of 94 patients were operated between October 2000 and November 2002. **Aims of the study:** This was a prospective study to evaluate the efficacy of the system, and to evaluate any possible

complications. In addition it was hoped to define clearer indications and contraindications of this new system. **Methodology:** A total number of 94 patients were prospectively entered into the study. The indication for surgery was mostly for DDD and spinal stenosis. All patients completed an Oswestry and VAS (Visual Analogue Scale) scores preop and at 12 months follow-up. The original results were reported at the World Spine Meeting in Chicago in 2003. This paper however presents our results at an average 55.5 months postoperatively. Of the original patients 5 have died of unrelated causes, and only 32 others could be traced. At the final consultation, an interview was done and the patients completed a very simple questionnaire, including return to work, further surgical procedures and a VAS score. **Results:** Of the 32 patients with adequate follow-up, 9 had undergone further surgical procedures at an average of 31.5 months after the index procedure. In spite of this average VAS score was 4.3. This compares favourably with an average VAS of 3.25 of the original study group. The average age for all the patients was 55.8 years, while the age for those requiring revision was 60.6 years. In spite of this high age, 12/32 patients had returned to work. A total of 9 patients were dissatisfied and would not reconsider the same operation again. **Conclusion:** No statistical analyses were made as this was a simple cohort study. However it would appear that the Dynesys system is a very simple system with a short learning curve, effective in some patients but did not appear to diminish the adjacent level problem. The reoperation rate of 28.8% is comparable and higher than most studies in the literature.

EFFECTS OF DEGENERATIVE DISC DISEASE ON THE CERVICAL DISC HEIGHT. *M. Fink, D. Rabin, N. Duggal.* London Health Sciences Centre, London, Ont.

Introduction: The biomechanics of the cervical spine as a result of degenerative disc disease (DDD) are poorly characterized. The purpose of this retrospective study was to assess the impact of DDD on disc height of the cervical spine. **Methods:** The authors reviewed the lateral cervical radiographs, obtained preoperatively and at intervals up to 24 months postoperatively, of 27 patients being treated for single level DDD producing radiculopathy and/or myelopathy. Nine patients were treated with implantation of a ProDisc-C artificial disc, 4 with a PrestigeTM cervical disc prosthesis, and 14 with a Bryan cervical disc. Quantitative motion analysis software was used to measure the anterior disc height (ADH) and posterior disc height (PDH). **Results:** Preoperatively, the ADH was significantly greater at the adjacent levels than at the surgical level (mean at the level above 4.7 mm, surgical level 3.8 mm, level below 5.3 mm, $p < 0.01$, analysis of variance). Similarly, the PDH was greater at the adjacent levels (mean at the level above 4.0 mm, surgical level 3.4 mm, level below 3.7 mm, $p < 0.01$). At the level of surgery, the vertebral bodies had a significant tendency to become parallel (mean ADH-PDH 0.4 mm, $p < 0.01$). Significant kyphosis was introduced by the Bryan disc at the level of surgery, when compared with the inferior adjacent level (mean ADH-PDH at visit 1 -0.3 mm, $p < 0.01$). Patients who underwent implantation of a ProDisc-C showed significant restoration of lordosis after surgery (mean preoperative ADH-PDH 0.3 mm, first postoperative visit 2.5 mm,

second postoperative visit 2.5 mm, $p < 0.01$). The 4 patients treated with a PrestigeTM disc also showed improved lordosis at the second postoperative visit ($p < 0.02$, paired Student's *t*-test). **Discussion:** DDD causes loss of disc height with the ADH approaching the PDH at the level of disease. Different devices had varying degrees of impact on postoperative disc height.

EFFICACY OF DILUTED BETADINE SOLUTION IN PREVENTION OF POSTOPERATIVE INFECTION FOLLOWING SUSPENDED CERVICAL LAMINOPLASTY. *H. Li, S. Casha, S. DuPlessis, R.J. Hurlbert.* Spine Program, University of Calgary, Calgary, Alta.

Introduction: We recently described a technique of suspended laminoplasty. A limitation of our initial case series was an infection rate of 18% (5 of 28 cases). In that series, explanted laminae were soaked in hydrogen peroxide. We subsequently changed to soaking with diluted Betadine, a widely used antiseptic with bactericidal activity against a wide spectrum of pathogens. **Material and methods:** We retrospectively reviewed the charts of all patients who underwent suspended laminoplasty at our institution over the last 3 years. The follow-up period ranged from 4 months to 1 year. The laminoplasty constructs were treated either with Betadine or hydrogen peroxide. **Results:** Ten patients were treated with hydrogen peroxide and 28 patients with Betadine. Three patients developed deep wound infection with hydrogen peroxide treatment, while only 1 patient had infection in the Betadine group. All infections were treated with surgical débridement and removal of the constructs followed by a course of antibiotics. **Conclusion:** Our result demonstrated the clinical effectiveness of diluted Betadine solution for the prevention of wound infection following suspended laminoplasty. Using this modification, the rate of wound infections was significantly reduced in our series. There were no procedure-related complications in either group.

EN BLOC RESECTION OF PRIMARY THORACIC TUMOURS WITH DIRECT SPINAL COLUMN INVASION. *N. Quraishi, M. Anraku, R. Rampersaud, S. Lewis.* From the Toronto Western Hospital and the University of Toronto, Toronto, Ont.

En bloc surgery is accepted today as being the goal of tumour surgery offering the best results for survival. We report our results for en bloc extra-tumoral resection in a consecutive series of 20 patients. All patients had primary thoracic tumours (18 were bronchogenic carcinomas and 2 were chondrosarcomas) that locally invaded the adjacent spinal column and all had negative staging for systemic disease. Mean age of patients was 59.6 years (28–76 yr) with a mean follow-up of 25 months (8–56 mo). Seven patients had a one-stage procedure and 13 had en bloc resections in 2 stages. Mean length of operation was 984.5 minutes (395–1965 min). Mean estimated blood loss was 5343 mL (1430–12830 mL). Details of tumour resection and anterior/posterior reconstructions are described. There was a significant complication rate, the majority of which were medical. Five patients had positive tumour margins and of these, 3 died. A further 3 patients died from unrelated causes (1 in-hospital death).

GRANULAR HYDROXAPATITE/TRICALCIUM PHOSPHATE FOR THE AUGMENTATION OF PEDICLE SCREW PULLOUT STRENGTH IN OSTEOPOROTIC BONE. AN IN VITRO EXPERIMENT. *A. Hashemi, D. Bednar, S. Zaida.* McMaster University, Hamilton, Ont.

Introduction: In situ curing bone cements are well described for the augmentation of pedicle screw fixation but carry some risk from both failed containment and thermal injury to surrounding tissues. Granular materials may provide similar benefit with less risk. **Methods:** Standard cancellous-bone-analogue. Sawbones blocks of both normal and osteoporosis porosity were prepared for instrumentation in standard fashion with a blunt awl, instrumented with 6.5 mm pedicle screws, and pulled to failure in an Instron apparatus. The pullout tracts were then packed with a granular HA/TCP bone analogue and retested. Lastly, standard pilot holes were packed with the material and also tested to failure. **Results:** Significantly improved pullout strength after packing was uniformly documented in the more porous blocks. **Conclusion:** Granular HA/TCA bone graft analogue material may have a role in supplementing pedicle screw fixation in osteoporotic bone.

HIGH SPEED CINERADIOGRAPHIC MEASUREMENT OF SPINAL CORD DEFORMATION DURING CERVICAL SPINE INJURIES IN A CADAVER MODEL. *A. Saari,* E. Itshayak,† P.A. Cripton.** From the *Injury Biomechanics Laboratory, Department of Mechanical Engineering and the †Division of Spine, Department of Orthopaedics, and the ‡International Collaboration on Repair Discoveries, University of British Columbia, Vancouver, BC.

Introduction: Spinal cord injury has been extensively studied using rodent models and cadaver experiments. Many of these studies have focused exclusively on the neural injury (animals) or on the bony column injuries (cadavers). Little detailed information is available to explain the interaction between the bony anatomy and the spinal cord during injury. This information could be used to help clinicians interpret bony or neurological injury in patients. Our objective was to develop a dynamic head to ground impact model that allows for the visualization of the cord, within the bony spinal canal, during injury. **Methods:** Six osteo-ligamentous human cadaveric cervical spines (occiput to T2) were used. A guided cable was used to simulate musculature. Axial impact was applied using a custom drop tower with an impact speed of 3 m/second. A biofidelic and radio-opaque surrogate spinal cord was placed in the spinal canal. This material has similar material properties to that documented for in vivo animal cords. High speed cineradiography (1000 fps) was used to observe the surrogate cord during injury. **Results and discussion:** The extent of compression varied between injuries with fractures of the lower cervical spine resulting in less compression than dislocations of the upper spine. The average maximum compression in all 6 specimens was 50% ($\pm 18.7\%$) and occurred on average 12.8 ms (± 2 ms) after impact. In all cases the maximum compression was transient and it was greater than the final compression which in all cases was zero. **Conclusions:** This is the first report that we are aware of pertaining to dynamic cord compression based on high-speed direct visualization of an in situ

biofidelic spinal cord under axial impact. Our results provide an increased understanding of the relative cord compression and potential for injury resulting from high versus low cervical injuries occurring in head-first impact.

INFLATABLE DEVICE FOR CONTROLLED EXTENSION OF THE CERVICAL SPINE DURING ANTERIOR CERVICAL APPROACHES: TECHNICAL NOTE. *A. Cenic, N. Khan, K. Reddy.* McMaster University, Hamilton, Ont.

Introduction: To describe the use of an inflatable device in order to achieve and maintain controlled extension of the cervical spine during anterior approaches to the cervical spine. **Methods:** The device is a "shoulder float" placed under the superior and midline aspect of the patient's shoulders and then pumped to a desired height to achieve extension of the cervical spine intraoperatively. This device is placed before endotracheal intubation, and may be inflated or deflated easily under fluoroscopic guidance to achieve the desirable extension depending on the condition being treated. **Results:** The inflatable device has been implemented in over 100 ACDF (anterior cervical decompression and fusion) procedures and several other anterior instrumentation procedures (e.g., odontoid screw fixation) without any complications. The simplicity of this device allows for stability and minimal movement required for a patient undergoing the surgery, hence, eliminating the need for conventional methods of spinal extension (e.g., bolsters, folded blankets, IV bags) and undue manipulation during the surgery. **Conclusion:** The inflatable device has proven to be a useful tool in obtaining controlled extension of the spine for anterior cervical procedures. In our institution, several other specialties have adopted this to other procedures that require extension of the cervical spine (e.g., coronary artery bypass procedures).

KINEMATICS OF THE ENTIRE CERVICAL SPINE IN THE PRESENCE OF PHYSIOLOGIC FOLLOWER LOAD DURING HEAD-FIRST IMPACT. *A. Saari,* E. Itshayak,† P.A. Cripton.** From the *Injury Biomechanics Laboratory, Department of Mechanical Engineering and the †Division of Spine, Department of Orthopaedics, and the ‡International Collaboration on Repair Discoveries, University of British Columbia, Vancouver, BC.

Introduction: Head-first impact can occur during various transportation and sporting activities. In head-first cadaver experiments. Higher-order "snap through" and "serpentine" column buckling has been reported in these studies. Although a first order c-shaped buckling pattern may occur in real-life impact, we hypothesize that the higher-order patterns do not. Patwardhan and colleagues demonstrated that buckling could be prevented under static postures using a guided "follower preload" to simulate musculature. We hypothesize that follower preload will prevent higher-order buckling behaviour in head-first impact experiments. **Methods:** Six osteo-ligamentous human cadaveric cervical spines (occiput to T2) were used. A guided cable was used to simulate musculature with a force of 150 N. Axial impact was applied using a custom drop tower with an impact speed of 3 m/second. Two high speed video cameras were used to track motion of photoreflective markers

mounted to each vertebra at (1000 fps). Photogrammetry was then used to reconstruct the vertebral kinematics. **Results and discussion:** Qualitative analysis of the kinematic response during our impacts showed a lack of the higher-order buckling pattern. Our results indicate that neither the "snap through buckling" response nor the serpentine buckling occur in the presence of a follower load. All of the specimens underwent a compressive extension response to loading with a variety of injuries clinically associated with hyperextension and compressive loading type injuries. **Conclusions:** This is the first report that we are aware of pertaining to cadaveric spine kinematics under simulated head-first impact with simulated musculature. Our results support our hypothesis that the higher-order buckling does not occur in the presence of compressive follower load. We feel that the prevention of higher-order buckling increases the clinical relevance of our model since this leads to single level trauma, whereas cervical spines exhibiting higher-order buckling are prone to non-contiguous injury patterns.

PATIENT PREDICTORS FOR RECOVERY AFTER SPINAL CORD INJURY. *S. Casha, D. McGowan, S. DuPlessis, J. Hurlbert.* University of Calgary, Calgary, Alta.

Introduction: Recovery from spinal cord injury (SCI) remains very limited and difficult to predict. **Methods:** We present ASIA score recovery by patient characteristics from a prospective randomized placebo controlled trial examining Minocycline and perfusion pressure augmentation in SCI (> 1-year follow-up). Categorical variables by repeated-measures ANOVA; continuous variables by Pearson Correlation Coefficients with recovery at 1 year. This is an ongoing blinded study and we do not present on treatment effect. **Results:** Thirty patients (20 complete, 6 incomplete, 4 central cord syndrome) had been enrolled at abstract submission, 15 had 1-year follow-up. Male:female, 7:3; cervical:thoracic, 8:2; mean age 35 years; 67% MVA, 7% fall, 10% work injury, 17% recreational. Improvement in ASIA score was greater with cervical versus thoracic SCI ($p = 0.027$). This was seen with both sensory and motor subscores (motor $p = 0.167$; pinprick $p = 0.110$; light-touch $p = 0.04$) and thus was not due to insensitivity of ASIA motor scores in thoracic SCI. Recovery did not vary by sex ($p = 0.979$). Incompletely injured and central cord patients tended to greater motor improvement ($p = 0.236$). Older patients recovered less motor but more sensory score at 1 year ($R = 0.108$, $R = 0.221$). Patients undergoing surgery later (max 29 h) tended toward greater 1-year motor recovery ($R = 0.443$). Similarly, ASIA recovery was better in patients arriving later to our centre ($R = 0.390$). These later effects may reflect different SCI severity in rural and urban settings or that more severe injury mechanisms present earlier. **Conclusions:** Younger age, cervical level and incomplete SCI correlated with greater improvements in ASIA scores. **Support:** AANS joint section spine and peripheral nerve Apfelbaum award, AANS NREF young investigator award, PVA research grant, University of Calgary Hotchkiss Brain Institute, University of Calgary Division of Neurosurgery.

POTENTIAL TRIAGING OF LUMBAR SPINAL SURGERY CONSULTS. *E.K. Wai,* L. Vexler,* S. Dagenais.†* From the *Spinal Unit, Department of Orthopaedic Surgery Uni-

versity of Ottawa and the †Children's Hospital on Eastern Ontario, Ottawa, Ont.

Introduction: The waiting times for a spinal consultation are among the highest in the country. Moreover, the majority of patients seen by spinal surgeons are not considered appropriate surgical candidates and hence would not benefit from the surgeon's expertise in surgical management. Identifying inappropriate patients as a method of "triage" may help reduce the waiting times. **Methods:** Previous work has identified 3 simple questions, which were reliable at identifying leg and back dominant pain. These questions were independently administered to a consecutive cohort of 52 lumbar patients before consultation with one of 4 subspecialty spinal surgeons. The second phase of this study involved an acute spinal pain centre, staffed by pain specialists, who have been orientated on appropriate indications for referral. Similar questions were also independently administered to the first 90 lumbar patients attending the clinic. All patients were followed independently to determine if surgery was recommended or performed and compared against the baseline questionnaires, findings on CT/MRI scan or pain specialists' referrals. **Results:** The questionnaire identified 20 (38.5%) patients with clearly back dominant pain in Phase I and 56 (62.2%) patients in Phase II. Of the 18 patients who had surgery or were recommended to have surgery, none had clearly back dominant pain as identified by the questionnaire for a combined sensitivity of 100%. When compared against the patient's CT/MRI scans or referrals from the acute pain clinic, the questionnaire was more accurate at identifying surgical candidates. **Conclusion:** This study has demonstrated in multiple settings that a simple questionnaire of 3 questions can identify patients requiring surgery and may be more specific than standard referrals, CT/MRI scans, or pain specialists' assessments. Further work is required to refine this screening process and evaluate it prospectively.

PURELY PERCUTANEOUS C1-2 FUSION: A CADAVERIC STUDY. *M. Nikolakis, A. Nataraj, D. Livy, L. Wang, P. Lemelin, A. Walji.* University of Alberta, Edmonton, Alta.

Introduction: We sought to develop a novel method of fusing the C1 and C2 vertebrae via a purely percutaneous approach. The indications for our operation include any pathology which causes instability at the C1-2 junction (e.g., rheumatoid arthritis, transverse ligament injury). **Methods:** Four human cadavers were used for in our study. The operation was carried out with the cadaver in a prone position. The head was fixed to the operating table with a Mayfield head clamp. Intraoperative fluoroscopy was used to guide a Kirshner wire (K-wire) into the C1-2 lateral mass joints bilaterally. A cannulated drill bit was then guided over the wire and into the C1-2 joints, and this was used to lightly decorticate the top of the C2 and the bottom of the C1 facets, creating a fusion surface. Intraoperative fluoroscopy was then used to guide a K-wire to the bottom of the C2 lateral mass, and a trajectory up through C2 into the lateral mass if C1 was determined. The K-wire was drilled from C2 into C1, through the C1-2 joint. We then fed self-drilling cannulated screws over the K-wires and up from C2 into the lateral masses of C1.

Results: We were able to achieve good decortication of the C1-2 joint and accurately place our trans-articular screws all via a purely percutaneous approach. **Discussion:** Have shown that internal fixation and the creation of potential fusion surface between C1 and C2 is possible via a purely percutaneous approach. We hope to translate this new operation to our clinical practice in the near future.

QUALITATIVE SYSTEMATIC REVIEW OF TREATMENT OPTIONS FOR CERVICAL UNILATERAL FACET INJURIES. *C. Bailey, G. Chan, P. Rosas Arellano, K. Gurr, S. Bailey.* From the University of Western Ontario and Victoria Hospital, London Health Science Centre, London, Ont.

Introduction: This study evaluates the scientific literature regarding the success of operative and nonoperative management of adult traumatic unilateral cervical facet injuries. **Methods:** The methodological guideline published by the Cochrane Collaboration Review Group for spinal disorders were used. **Results:** Four databases were searched and 1192 abstracts were identified. Twenty-four articles were selected for methodological quality assessment. Seven papers were selected for data extraction, including 3 retrospective case cohort studies, 3 case series and 1 randomized control trial. Presenting neurology was variable with less than 20% of patients presenting with a spinal cord injury. Most patients with radiculopathy improved. Two patients (2.7%), initially ASIA E, did develop post-surgical radiculopathy. No correlation was found between patient reported outcome compared with post treatment alignment. No conclusions can be made regarding treatment superiority. Both anterior and posterior surgical fixation had comparable results regarding patient reported functional outcome. **Conclusions:** The quality of scientific evidence evaluating the outcomes of the treatment options for unilateral cervical facet injuries was poor.

RADIOGRAPHIC AND CLINICAL COMPARISON OF NONOPERATIVE TREATMENT AND SURGICAL STABILIZATION OF THORACIC SPINE FRACTURES. *C. Fisher, C.H. Chan, O. Keyman, M. Dvorak, M. Boyd.* From the University of British Columbia and the Vancouver General Hospital, Vancouver, BC.

Introduction: The management of thoracic spine fractures is controversial. Historically the treatments include prolonged recumbency, bracing or surgically with rod-hook or wire constructs. Recently, pedicle screw fixation has gained popularity with its advantages of 3-column fixation and avoidance of spinal canal violation. The primary purpose of this study was to compare the radiographic outcome of pedicle screws with nonoperative care for stabilizing thoracic spine fractures. Secondary objectives included a comparison of generic health-related quality of life and long-term pain level. **Methodology:** A retrospective review of a prospectively maintained spine trauma database was performed. Patients with unstable thoracic spine fractures treated between July 1995 and September 2002 were included. Initial and follow-up radiographs were assessed using the Cobb method. Patient self-assessment was made with the use of Short Form-36 questionnaire and Visual Analog Pain Scale. **Results:** Forty-eight patients were

treated operatively and 27 nonoperatively. No significant difference for baseline variables was found between the 2 groups. Individuals with neurological deficits ($p = 0.00005$), fracture dislocation/subluxation ($p = 0.00002$), multi-level fracture ($p = 0.002$) and larger kyphotic angulation ($p = 0.0001$) were more likely to be treated with transpedicular fixation. Transpedicular fixation corrected the average absolute kyphotic deformity from 29° (SD [standard deviation] 6°) to 16° (SD 8°) and resulted in less recumbent days ($p = 0.001$). In patients treated operatively there was less progressive kyphosis noted, however the difference was not statistically significant ($p = 0.134$). Quality of life differed statistically between the 2 groups with respect to the mean PCS (Physical Component Summary) score ($p = 0.001$), but not with the mean MCS (Mental Component Summary) score ($p = 0.265$). However, the scores were not comparable due to powerful confounders of injury severity and neurology. The pain scale also did not differ between the 2 groups. **Conclusions:** Severe injury morphology and neurological status are associated with pedicle screw fixation. Transpedicular screw fixation is effective in restoring and maintaining sagittal alignment, and leads to earlier mobilization.

RADIOGRAPHIC AND PRESSURE MAPPING OUTCOMES FOR SPINAL FIXATION IN PATIENTS WITH MYELOMENINGOCELE. *L. Geller,* J. Ouellet,* M. Rabzel,† V. Arlet.** From *McGill University Health Centre and the †Shriners Hospital for Children, Montréal, Que.

Introduction: The development of pressure ulcers in patients with spina bifida is a significant source of morbidity. Surgical correction of spinal balance, pelvic obliquity, and spino-pelvic deformity is aimed at reducing the risk of pressure ulcers, and improving balance and function. The goal of this study is to examine factors contributing to patients' pressure distribution before and after corrective spino-pelvic surgery. **Methods:** This prospective study included patients with spina bifida and neurogenic scoliosis. Various coronal and sagittal plane radiographic measurements as well as pressure maps were obtained preoperatively and postoperatively. **Results:** Nineteen patients were included with mean follow-up of 18 months. The majority of patients were treated for kyphoscoliosis and scoliosis. Coronal plane radiographic measurements demonstrated significant correction in Cobb angle and pelvic obliquity. Sagittal plane radiographic measurements showed significant correction in sacral slope. Pressure mapping did not demonstrate statistically significant changes from preoperatively to postoperatively. **Discussion:** Overall, large radiographic changes from preoperatively to postoperatively did not correspond to significant changes in pressure mapping. Treatment of radiographs alone is insufficient in these complex multifactorial patients.

SCREW LOADING DURING CADAVERIC SIMULATED DEFORMITY CORRECTION OF THE NOVEL SAS TSRH PEDICLE SCREW SYSTEM. *C. Larson, Q. Zhu, E. Itshayek, M. Dvorak, C. Fisher, P. Cripton.* University of British Columbia, Vancouver, BC.

Introduction: This study entails a biomechanical comparison of a novel Sagittal Adjusting Screw (SAS) from the TSRH Silo Spinal System (Medtronic, Memphis, USA) versus a fixed-an-

gle screw design. The screws' abilities to preserve the bone implant interface during routine surgical manipulations were evaluated. **Methods:** Rod implantation tests were conducted on 5 cadaveric specimens (L1-5) for 3 loading conditions. One set of fixed-angle TSRH screws was inserted unilaterally in the pedicles on the same side of L1-4 levels, and the side was randomized. The SAS screws were inserted on the other side. For the seating test, a rod initiating 15° sagittal rotation with no translation was inserted at L1-2, alternating sides. At the L3-4 level, 2 TLIF Capstone (Medtronic, USA) fusion cages were inserted bilaterally. A straight rod was then implanted across the TLIF cages on alternate sides. Distraction and compression manoeuvres were performed with the rod. Peak bending moments and axial forces of each screw were calculated from 3 uniaxial strain gauges on the screw neck, near the screw-bone interface. L3 and L4 data were aggregated for paired *t*-test statistical analysis. **Results:** For the seating test, the peak loads of the SAS screw were 31% of the fixed-angle screw in axial force ($p = 0.036$) and 54% in bending moment (NS [not significant], $p = 0.053$). Peak distraction loads of the SAS were 18% of fixed-angle axial force ($p = 0.001$), and 58% in bending ($p = 0.004$). The peak axial force of the SAS screw in compression manoeuvres was 37% of fixed angle ($p = 0.037$), and peak bending 78% (NS, $p = 0.11$). **Discussion:** These results from cadaveric testing indicate that the adjustable-angle SAS generally reduced loading at the bone-screw interface when compared with a fixed-angle screw. Several of the screw load reductions were statistically significant. We believe that reduced loading may result in lower rates of screw loosening in clinical treatment.

SPINAL CORD COMPARTMENT SYNDROME IN A PORCINE MODEL OF DISTRACTION INJURY. *M. Stiebel, P. Jarzem.* McGill University, Montréal, Que.

Introduction: Linear spinal cord distraction, in animal models, leads to elevated intra-compartmental spinal cord pressure. We developed an in vitro model of distraction, with increasing tensile force, to demonstrate the relationship between the degree of spinal curvature and the proportional elevation of intra-compartmental pressure. **Methods:** Six porcine spinal sections, 2 cervical, 2 thoracic, and 2 lumbar were harvested from 30 kg pigs. These cord sections were individually stretched in a saline solution with increasing tensile force applied. Cord interstitial pressure (CIP) was monitored with an arterial line pressure monitor. The sections were each tested 6 times fresh, and then thawed and tested an additional 6 times. An additional 10 freshly thawed cords were tested in linear distraction and over 45° and 90° curved surfaces with CIP monitoring. **Results:** Increased tension, by adding increasing weights of distraction, lead to a proportionally elevated CIP in the linear model ($R = 0.986$). We achieved a 99% confidence interval via paired *t*-testing to demonstrate that there was no significant difference between fresh specimens and recently thawed cords. As the degree of spinal curvature increased from a linear model, to a 45° and 90° (Cobb) curve, there were significant increases in CIP at the same distraction force. The more significant the curve, the greater the CIP for each increment in distraction force; 90° curves produced a 2.3 × higher pressure than linear distraction. **Conclusion:** High cord interstitial

pressure (CIP) can be achieved through spinal cord distraction (> 140 mm Hg). This CIP is not only directly proportional to tension, but also proportionally magnified by the degree of spinal curvature. It is not affected by freezing/thawing. This may suggest that spinal cord compartment syndrome is a potential mechanism for spinal cord distraction injury, and these distraction pressures are potentially magnified in the setting of scoliosis.

SPINAL CORD DEFORMATION, EXPECTED NEUROLOGIC INJURY, CLINICAL CLASSIFICATION OF COLUMN INJURY AND RESIDUAL COMPRESSION RESULTING FROM HEAD-FIRST IMPACT: A HIGH-SPEED EXPERIMENT. *E. Itshayek,†‡ A. Saari,*‡ T.S. Nelson, P.A. Cripton.*‡* From the *Injury Biomechanics Laboratory, Department of Mechanical Engineering, the †Division of Spine, Department of Orthopaedics and the ‡International Collaboration on Repair Discoveries, University of British Columbia, Vancouver, BC.

Introduction: There is a need for better understanding of the biomechanics of spinal cord injuries, especially at the level of the spinal cord itself. We report results from a series of head-first impacts using human cadaveric c-spines. **Methods:** Six human cadaveric c-spines were dropped from a custom drop tower. In order to improve the biofidelity of the column response during impact, muscles force was simulated using a constant follower load of 150 N. A radio-opaque, biofidelic surrogate cord in the canal was imaged using cineradiography at 1000 fps. **Results:** Four of the specimens had pure hyperextension injury through the intervertebral disk with vertebral body's anterior lip and spinous processes fractures. Two specimens demonstrated hyperextension injury with type II dens fracture and translation of the Axis over the Atlas. The 2 groups of injuries differed in the average velocity and the extent of cord compression (Velocity: 1.1 [SD {standard deviation} 0.6] m/s for the subaxial v. 3.7 [SD 1.8] m/s for the C1-2 group and relative compression: 40.8% [SD 17.1%] v. 65.5% [SD 17.7%], respectively). **Discussion:** Head-first impact often associated with both spinal column and spinal cord injury. Previous biomechanical models did not take into consideration the muscles force and resulted in non-contiguous fractures and buckling of the spine. When muscles force was simulated, the spine did not buckle and mainly a one level hyperextension injury was produced. We identified 2 groups of injuries; C1-2 and subaxial injuries. When trying to estimate the likelihood for any recovery from the expected cord injuries, we took into consideration the average percentage and maximal velocity of cord compression and using Kearney's model we found 86.8% (SD 8.9%) chance for neurologic improvement for the subaxial group v. 16.5% (SD 12%) for the C1-2 group. Our results strengthen the understanding of the detailed interaction between cord and bony column during injury and elucidate the relationships between column injury and expected neurologic sequelae.

SPINAL INJURY AND POLYTRAUMA IN PATIENTS PRESENTING TO A LEVEL I CANADIAN TRAUMA INSTITUTION. *O. Murnaghan, Y. Bronstein, M. Ford, A. Gallant, N. Adjei, J. Finkelstein, A. Yee.* Sunnybrook Health Sciences Centre and University of Toronto, Toronto, Ont.

Purpose: To review the demographics of spinal injury in severely polytrauma. **Methods:** Review of prospectively collected database of consecutive patients admitted between 1998 to 2005 at a level 1 trauma institution. **Inclusion criteria:** Spinal injury and Injury Severity Score (ISS) > 15. A chart and radiologic review was conducted by an independent observer. **Results:** One hundred and sixty-one consecutive patients were identified. Mean age was 45.4 9 (SD [standard deviation] 19.7) years; male:female ratio was 2:1. Mechanism of injury: falls (25.2%), pedestrian (8.4%), industrial/recreational accidents (9%), MVA (56.1%) and GSW (1.3%). Mean ISS scores were 31.7 (SD 10.9). GCS (Glasgow Coma Scale) was < 8 in 19%, 8–12 in 5%, and over 12 in 76%. Fifty percent of spinal injuries were AO A, 29% B, 21% C. Multilevel spine fractures occurred in 33%. Forty-eight percent of injuries occurred in the occipital and cervical region, 32% thoracic, 26% lumbar, 4% sacral. Frankel scores were (A 15%, B 8%, C 3%, D 4%, E 70%). Thirty-four percent of cases were treated operatively (76% posterior, 15% anterior, 9% combined). Forty-four percent required ICU admission (mean 5.6 [SD 11.5] d), mean hospital stay was 23.1 [SD 20.8] days. A higher AO grade was associated with greater neurologic dysfunction and higher rate of surgery ($p < 0.0001$). The timing of surgery was not statistically different comparing neurologic groups. More severe spinal injuries and multilevel injuries were associated with a longer hospital stay ($p < 0.01$). Mortality rate was 10%. Forty-five percent were transferred to a rehabilitation facility or another hospital. **Conclusions:** The degree and extent of spinal injury in polytraumatized patients influences the length of hospitalization. As anticipated, a higher fracture pattern grade was associated with greater neurologic injury and a higher likelihood of surgery being performed. The presence of multilevel injuries is greater than that generally reported for spine fractures and a high index of suspicion is warranted in this population.

SPINE SEVERITY SCORE FOR ELECTIVE TRIAGE OF REFERRALS.
S. Lwu, K. Thomas, J. Hurlbert. University of Calgary, Calgary, Alta.

In Canada, the demand for spine referral far exceeds our ability as surgeons to provide this service. To date, no objective method of prioritizing these referrals is available.

The Spine Severity Score is a 15-point scoring system devised for the purpose of triaging elective spine referrals. From the referral letter and the accompanying radiology report, a total score is calculated based on clinical, pathological, and radiological criteria — a maximum score of 5 within each category. A higher score represents a referral that should be seen more urgently. To follow up on preliminary data presented at a previous Canadian Spine Society meeting, verification of interobserver and intraobserver reliability for the scoring system is reported here.

Four spine surgeons and 3 secretaries scored 25 standardized referrals. A second iteration of scoring was performed with a minimum time interval elapsed of 6 weeks. Scorers were instructed to choose the most significant (the one with the highest associated score) descriptor in each category. No further instructions were given on how to interpret the referral letter or the radiology report. Preliminary analyses indicate

that there was very good interobserver and intraobserver (test-retest) reliability. Further validation study is required to compare the scoring system against the traditional gold standard for triage, the surgeon's clinical experience.

THE ACTIPORE™ IMPLANT: ACHIEVING BIOINTEGRATION.
S. Bailey, R. Campbell, C. Bailey, K. Gurr, P. Rosas Arellano. From the University of Western Ontario and Victoria Hospital, London Health Science Centre, London, Ont.

Introduction: To evaluate patients suffering from cervical spine disorders treated with anterior cervical discectomy and fusion (ACDF) using the Actipore™ (Biorthex Inc, Montréal) interbody fusion device in conjunction with anterior plating but without supplemental bone graft. **Methods:** The Actipore implant, a novel porous nitinol device, was implanted in 18 patients for various indications (radiculopathy, DDD, instability). Patients were evaluated with pre and postop questionnaires. A Visual Analog Scale was used to assess pain parameters and functional improvements were gauged using the SF-36 (Short Form-36) and modified Oswestry questionnaires. Flexion-extension lateral radiographs were obtained at 1 year postop to assess for implant biointegration. **Results:** In all, 6 patients were excluded from this study, leaving 12 with 1-year data thus far available for analysis. Significant improvements in all pain and functional outcome measures were achieved by 6 weeks postop and continued out to 1 year ($p < 0.02$), aside from the SF-36 physical domain, which demonstrated significant improvement only at the 1 year mark ($p > 0.02$). Biointegration was implied on flexion-extension views in 11 of 12 patients (92%). Neither adverse effects nor revision surgery was appreciated within this cohort. **Conclusions:** The use of the Actipore implant for ACDF seems to afford safe and comparable results to that of the same procedure supplemented by bone grafting. Associated donor site morbidity is avoided using this technique.

THE IMPACT OF ASSOCIATED CONDITIONS DUE TO SPINAL CORD INJURY (SCI) ON THE HEALTH STATUS AND QUALITY OF LIFE IN INDIVIDUALS WITH TRAUMATIC CENTRAL CORD SYNDROME (TCCS).
V. Noonan, J. Kopec, H. Zhang, M. Dvorak. From the *Departments of Health Care Epidemiology and ‡Statistics University of British Columbia, and the †Arthritis Research Centre of Canada, Vancouver, BC.

Introduction: It is not known how associated conditions resulting from a SCI (e.g., spasticity) impact patient outcome. The purpose of this study is to assess the relationship between associated SCI conditions and patients' health status and quality of life. **Methods:** A cross-sectional follow-up study was conducted on patients admitted between 1994 and 2002 with traumatic central cord syndrome (TCCS) who were 2 years post-injury. A conceptual model was developed to understand how associated SCI conditions affect health status and quality of life. The presence/absence of associated SCI conditions was assessed by a physiotherapist and patients completed questionnaires. Associated SCI conditions included: spasticity; changes in bowel/bladder/sexual function (BBS); and neurogenic pain. Health status was assessed using the Physical and Mental

Component Scores of the Short Form-36 (PCS and MCS) and symptom satisfaction. Quality of life was measured using a numerical rating scale. Statistical analyses included linear and ordinal regression and all analyses were adjusted for confounding factors and correlation between associated SCI conditions. **Results:** One hundred and fourteen patients were eligible and 70 completed the follow-up. There were 57 males and the average time to follow-up was 70 months. The presence of neurogenic pain resulted in a lower PCS (-6.16; CL [confidence limits] -10.68, -1.64), MCS (-5.42; CL -10.39, -0.46), and symptom satisfaction (OR [odds ratio] $n = 4.09$; CL 1.52, 10.96). Patients with BBS had lower PCS scores (-9.84; CL -14.65, -5.04). The relationship between many associated SCI conditions and health status/quality of life were not significant after adjusting for confounders and correlation. **Discussion:** The conceptual model elucidated how some associated conditions (neurogenic pain and BBS) lowered patients' health status but none of them impacted patients' quality of life. Further research should continue to test and refine the model.

THE INFLUENCE OF FLYWHEEL CHARACTERISTICS ON WHEELCHAIR ERGOMETER KINETICS AND KINEMATICS. *M. Johnson, T. McDowell, C. Katopolus, D. Kriellaars.* University of Manitoba, Winnipeg, Man.

Introduction: Wheelchair ergometers can be used to assess aerobic power in spinal cord injured patients, as well as for training shoulder injuries resultant from ergometer use are not uncommon. **Purpose:** This study examined the role of momentum (flywheel characteristics) used in wheelchair ergometers to simulate over-ground wheeling. **Methods:** This study mathematically modelled angular momentum effects of the flywheel on wheelchair kinetics and kinematics. A wheelchair ergometer was constructed using parameters derived from modeling. Kinematics were assessed (wireless triaxial accelerometry) on 6 subjects performing ergometer wheeling with different momentum compensation. **Results:** Peak power, rate of rise of power, peak force, torque, friction, velocity, wheel radius, push frequency and push length were computed. Angular velocity variations within revolution were proportional to the magnitude of angular momentum compensation provided by the flywheel. The modelled angular velocity profiles were entirely consistent with the measured angular velocity. Power output required to compensate for angular velocity variations arising from low momentum flywheels (0.03 kgm^2) were 15% greater than nominal momentum flywheel (1 kgm^2). The rate of rise of power (W/s) was $38 \times$ greater in the low momentum condition. **Discussion:** The importance of flywheel design was demonstrated revealing that low momentum ergometer/roller systems will require substantially greater instantaneous power generating ability of the user despite the same average power output. This has implications for injury prevention and training.

THE USE OF COMPUTERIZED TOMOGRAPHY IN THE DEVELOPMENT AND IMPLEMENTATION OF A PREOPERATIVE PROTOCOL TO AID IN PEDICLE SCREW PLACEMENT DURING SCOLIOSIS SURGERY. *D. Jamieson, A. Perdios, R. Varghese, C. Reilly.* University of British Columbia, Vancouver, BC.

Introduction: The authors describe the evolution of a low-dose multi-detector CT evaluation of the thoracolumbar spine with image manipulation to aid in pedicle screw placement for deformity correction in the pediatric spine. **Methods:** Preoperative scoliosis patients were scanned with a Phillips Brilliance 16 multislice CT scanner using 1.5 mm collimation. The imaging parameters used were 90 Kv, 105 mAs, 2 mm slice width, 0.438 pitch and a 1 second gantry rotation. Patients are imaged prone, as they would be positioned for surgery, with the added advantage of reducing breast radiation exposure. Post-processing manipulation is done at a workstation with Voxar 3D™ (v. 4.2) following review of the axial images. **Results:** A total of 28 studies have been completed between June 2005 and October 2006. Most studies were imaged between T1 and L1 with an average of 12.6 levels imaged in each patient (range 8–17 levels). A total of 706 pedicles were scanned (353 levels). The low-dose studies were diagnostic in all 28 patients; image noise did not prevent pedicle measurement. The kVp, mAs, and dose linear product (DLP) were all reduced as the protocol was refined. The kVp dose was reduced to an average of 90 from an average of 120, the mAs was reduced to a range of 100 to 125 from a range of 190 to 225 and the DLP was reduced to an average of 120 mGy/cm² from an average of 370 mGy/cm². **Discussion:** We report a low-dose multi-detector CT evaluation of the thoracolumbar spine to better evaluate pedicle size and morphology as well as spinal canal morphology, spinal cord position and vertebral body rotational angulation. Empirically, visualization of the pedicle level at which screws are being inserted was felt to be of enormous assistance to setting up dissection and angulation of the guide wire insertion and subsequent screw placement.

TISSUE-ENGINEERED ACELLULAR CANCELLOUS BONE AS BIOSCAFFOLDS FOR HUMAN BONE MARROW-DERIVED STEM CELLS IN IN VITRO BONE FORMATION. *T. Gao, D. Miller, W. Jiang, J. Lakey, T. Churchill, R. Fox, H. Jiang.* University of Alberta, Edmonton, Alta.

Introduction: Adult tissue-derived stem cells open a new approach of cell-based therapy in regenerative medicine. We have identified a unique and sustainable source of human bone marrow-derived stem cells (hBMSCs) from disposed reaming tissues, and successfully isolated and expanded hBMSCs in vitro. In the present study, we tested the feasibilities of reconstituting hBMSCs with acellular cancellous bone (ACBs) to create a biological bone substitute, which could augment and/or replace autografts for spinal fusion in the future. **Methods:** Intramedullary bone reaming tissues were collected from patients undergoing total hip replacement, and hBMSCs were isolated and expanded in cell culture. Human ACBs were prepared from discarded femoral heads and extensively washed with water, delipided with chloroform/methanol (2:1) at 4°C for 24 hours, and then deproteinized with one of following treatments: 5% bleach for 30 minutes, twice or 1% Triton X-100 in 50 mM Tris buffer for 48 hours. The ACBs were freeze-dried and sterilized with ethylene oxide before use. hBMSCs were seeded on the ACBs with different treatments and cultured in osteogenic differentiation medium in the 12-well plates for 2 and 4 weeks. In vitro bone formation was

measured with the quantitative assays for ALP and calcium content (Bioassays kits). Histology and SEM were used to evaluate cell attachment and extracellular matrix (ECM) formation in ACB's trabecula. **Results:** Preliminary results showed that different levels of ALP activity were observed between induced osteoblasts grown in bleach and Triton-treated ACBs at 2 weeks (9.62 ± 0.08 and 5.71 ± 0.68) and 4 weeks (12.01 ± 0.79 and 6.84 ± 1.07 , IU/ μ g of total protein), respectively. Calcium content was higher in osteoblasts grown in bleach-treated ACBs than that in Triton-treated ones at 4

weeks (2.2 ± 0.73 and 2.1 ± 0.56 mg/dL). Increase of cell attachment and newly formed ECM were also observed in bleach-treated ACBs than in Triton-treated ones in histology and SEM. **Discussion and conclusion:** Deplipid and deproteinized human ACBs supported osteogenic differentiation of hBMSCs in vitro. Better in vitro bone formation was observed in bleached ABCs. It seems that surface characteristics of ACBs treated with different approaches will affect the function and proliferation of hBMSCs and its osteogenic differentiation. The mechanism involved need to be further investigated.

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