Canadian Journal of Surgery
Journal canadien de chirurgie

Vol. 48, Suppl., June / juin 2005
www.cma.ca/cjs

Canadian Spine Society

Fifth Annual Meeting

Château Mont Sainte-Anne, Beaupré, Québec

Thursday, March 17 to Saturday March 19, 2005

Société canadienne du rachis

Cinquième réunion annuelle

Château Mont Sainte-Anne, Beaupré, Québec

Du jeudi 17 mars au samedi 20 mars 2005

Lifetime Achievement Award • Prix de mérite à vie

Program • Programme

Abstracts • Résumés

Lifetime Achievement Award — 2005
Prix de mérite à vie — 2005

Edward Henry Simmons
MD, BSc(Med), FRCSC, MS(Tor), FACS

Education

- MD, University of Toronto, graduating at the age of 22. Winner of Chappelle Prize in Clinical Surgery on graduation
- Postgraduate degree of Bachelor of Science in Medicine 1951
- Fellow of the Royal College of Surgeons of Canada 1954
- Master of Surgery, University of Toronto 1956
- Fellow of the American College of Surgeons 1957
- Diplomate of the American Board of Orthopaedic Surgery 1975. Recertifications by examination as a Diplomate of the American Board of Orthopaedic Surgery 1983. Recertification by examination as a Diplomate of the American Board of Orthopaedic Surgery 1992

Edward Henry Simmons

Professional honours and positions held

- President of the Canadian Orthopaedic Association 1981–1982 (7th Combined Meeting of Orthopaedic Surgery of the English Speaking World)
- President of the Cervical Spine Research Society 1974–1975
- President of the Scoliosis Research Society 1975–1976
- Commissioned a Colonel of the Commonwealth of Kentucky in recognition of contribution to the treatment of crippling deformities of the spine August 6, 1975
- American–British–Canadian Travelling Fellow (ABC Fellow) 1965
- President of the Canadian Orthopaedic Research Society 1982
- Examiner of the American Board of Orthopaedic Surgery
- President of the American Back Society 1991–1996
- Member, North American Spine Society
- Member, International Society for the Study of the Lumbar Spine
- President of the Medico-Legal Society of Toronto 1971–1972

Academic positions

- Professor of Orthopaedic Surgery, State University of New York at Buffalo
- Director of University Orthopaedic Spine Service
- Orthopaedic Department Head, Buffalo General Hospital 1982–1992
- Professor of Orthopaedic Surgery, Faculty of Medicine University of Toronto 1981
- Chairman of the Committee on Postgraduate Instruction in Orthopaedic Surgery 1958–1975
- Chairman of Committee on Postgraduate Training in Orthopaedic Surgery, University of Toronto 1975–1983
- Chief of the Orthopaedic Division of the Toronto East General and Orthopaedic Hospital 1975–1983
- Chairman of the Sub-Committee on Postgraduate Training of the Canadian Orthopaedic Association 1980–1982
- Spine Fellowship Director, University of Toronto 1966–1983
- Director of the University Orthopaedic Spine Service and Fellowship Program, State University of New York at Buffalo 1983–July 1997

These combined programs have trained 62 spine surgeons now at 58 university centres in North America, 2 in South Africa, 1 in Australia and 1 in China.

Publications

- Author of 20 book chapters, over 156 scientific articles and 5 teaching movies
- Editorial consultant, *Journal of SPINE*; consultant editor, *Clinical de Colombia*, Bogotá, Columbia

Visiting professorships and guest lectureships

These total 215, including 46 university visiting professorships and 40 designated lectureships in 75 university centres in 24 countries. Dr. Simmons has given over 900 scientific presentations to national and international meetings.

Development

- Development and standardization of technique of cervical osteotomy for flexion deformity in ankylosing spondylitis under local anesthesia
- The technique of extension osteotomy of the lumbar spine
- Surgery of anterior instrumentation of the spine for correction of spinal deformity introduced to North America in 1969
- Anterior cervical disectomy and fusion with the Keystone technique
- Chiart osteotomy for congenital dysplasia of the hip joint with arthrosis
- Rotation as the cause of cubitus varus in supracondylar fractures of the elbow

Research activities

- Include ongoing basic science and clinical research studies related to orthopedic aspects of spinal disability
- Senior faculty advisor resulting in the award of the Edouard Samson Prize of the Canadian Orthopaedic Association on 2 occasions for the most outstanding research work done in Canada that year
- The Russell Hibbs Award of the Scoliosis Research Society on 2 occasions
- The Basic Science Award of the Cervical Spine Research Society
- Two research fellows were awarded the degree of Master of Surgery, and 3 were awarded the postgraduate degree of Bachelor of Science in Medicine at the University of Toronto
- Development of a basic science research program at the University of Buffalo with 1 orthopedic candidate selected per year with a Master Degree of completion of a successful thesis. Since it was instituted, 4 successful candidates have qualified for their Masters Degree, creating an opportunity for academic postgraduate basic science activity in the Orthopaedic Department of the University of Buffalo

Member

- American Orthopaedic Association
- Canadian Orthopaedic Association
- Canadian Orthopaedic Research Society
- Fellow, American Academy of Orthopaedic Surgeons
- International Society of Orthopaedics and Traumatology
- Fellow, Scoliosis Research Society
- Founding member, Cervical Spine Research Society
- Founding member, International Society for the Study of the Lumbar Spine
- Fellow, Royal College of Physicians and Surgeons of Canada
- Fellow, American College of Surgeons
- Honorary member, Western Orthopaedic Society
- Honorary member, mid-America Orthopaedic Society
- Honorary patron, Simmons Surgical Society

Canadian Spine Society
Fifth Annual Meeting

Société canadienne du rachis
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Program / Programme

Thursday, March 17, 2005 / Le jeudi 17 mars 2005

Plenary Session / Assemblée plénière
Symposium / Symposium
Minimally invasive spinal surgery
Chirurgie de la colonne vertébrale avec effraction minimale

Annual General Meeting / Assemblée générale annuelle

Friday, March 18, 2005 / Le vendredi 18 mars 2005

Plenary Session / Assemblée plénière
Symposium / Symposium
Spinal arthroplasty
L'arthroplastie de la colonne vertébrale

Banquet / Banquet
Lifetime Achievement Award
Prix de mérite à vie

Saturday, March 19, 2005 / Le samedi 19 mars 2005

Plenary Session / Assemblée plénière
Symposium / Symposium
Pediatric spondylolisthesis
Spondylolisthésis pédiatrique

2005 Executive

E. Abraham (President) — Saint John, New Brunswick
H. Hall (Secretary/Treasurer) — Markdale, Ontario
E. Belanger — Ottawa, Ontario
D. Fourney — Saskatoon, Saskatchewan
B. Lewis — Corner Brook, Newfoundland
R. Rampersaud — Toronto, Ontario

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M. Dvorak — Vancouver, British Columbia
C. Fisher — Vancouver, British Columbia
J. Hurlbert — Calgary, Alberta
D. Wahl — Victoria, British Columbia

CSS 2005 — Podium presentations

Thursday, March 17, 2005

En-bloc resection of primary sacral tumours: classification of surgical approaches and outcome. ***D.R. Fourney, L.D. Rhines, Z.L. Gokaslan.* Division of Neurosurgery, Royal University Hospital, University of Saskatchewan, Saskatoon, Sask.; Department of Neurosurgery, University of Texas M.D. Anderson Cancer Center, Houston, Tex.; Department of Neurosurgery, Johns Hopkins University, Baltimore, Md.**

Objective: Currently, en-bloc resection with adequate margins is the only curative treatment for most primary sacral malignancies. A novel classification of surgical techniques based on the level of nerve root sacrifice is presented, and the functional and oncological outcomes are evaluated. **Methods:** Seventy-eight consecutive patients underwent 94 operations for the resection of sacral neoplasms at The University of Texas M.D. Anderson Cancer Center in Houston, Texas, between August 1993 and June 2002. Records of 29 patients with en-bloc resection of primary sacral tumours were retrospectively reviewed. **Results:** The median follow-up period was 55 months (range 1–103 mo). Chordoma was the most frequent tumour type (16 cases). Midline sacral amputation was performed in 25 patients (8 low, 4 middle, 7 high and 5 total sacrectomies; 1 hemicorporectomy). Lateral sacrectomy was performed in 4 patients (2 unilateral excisions of the sacroiliac joint and 2 hemisacrectomies). Surgical margins were wide in 19 cases, marginal in 9 and intralesional in one. The type of sacrectomy correlated with characteristic patient outcomes, with respect to bladder, bowel and ambulatory function. Length of hospital stay was related to the extent of sacrectomy (p = 0.003, Wilcoxon signed-rank test). Median disease-free survival for chordoma by Kaplan–Meier analysis was 68 months (95% CI 45.86–90.14). **Conclusions:** Classification of en-bloc sacral resection techniques by the level of nerve root transection is useful in predicting postoperative function and the potential for morbidity. Adequate surgical margins should not be compromised to preserve function when they are necessary to affect cure.

Cost-effectiveness of surgery plus radiotherapy versus radiotherapy alone for metastatic spinal cord compression. ***K.C. Thomas, C.G. Fisher, B. Nosyk, M. Dvorak, M. Boyd, B. Kwon, R. Patchell, W. Regine, D. Loblaw, A. Anis.* Vancouver Hospital and Health Sciences Centre; Centre for Health Evaluation and Outcome Sciences, St. Paul's Hospital, Vancouver, BC; University of Kentucky, Lexington, Ky.; Toronto-Sunnybrook Regional Cancer Centre, Toronto, Ont.**

Objective: To perform a cost-effectiveness analysis of surgery plus radiotherapy (S+RT) compared with radiotherapy (RT) alone for the treatment of metastatic spinal cord compression. **Summary of background data:** Radiotherapy has played a prominent role in the palliative treatment of metastatic spinal cord compression. The only randomized trial comparing S+RT to RT alone in patients with metastatic spinal cord compression has shown S+RT to be superior to RT alone. **Methods:** One hundred and one patients were randomized to receive S+RT or RT alone. Clinical effectiveness was measured by the mean number of days able to walk. Costs (related to treatment and post-treatment care) were calculated for a typical patient. Markov modelling was used to cycle each patient until death. An incremental cost-effectiveness analysis was performed from a societal perspective. **Results:** Patients randomized to S+RT had a greater mean number of days of ambulation during follow-up. Overall costs were greater for the S+RT treatment group. From a societal perspective, the baseline incremental cost-effectiveness ratio (ICER) was $ per additional day of ambulation. Probabilistic sensitivity analysis resulted in a median ICER of $, with 90% of all ICERs below $ per additional day of ambulation. **Conclusion:** Cross comparison with other health care interventions is difficult as the unit of effectiveness used is unique to this study. Whether the addition of surgery is cost-effective depends on the value placed on ambulatory function by the patient, by society, and on the alternative use of scarce resources.

Primary en-bloc resection in the treatment of primary tumours with local invasion of the spinal column. ***S.J. Lewis, Y.R. Rampersaud, G. Darling, M. Johnson, S. Keshavjee, A. Pierre, T. Waddell, S. Zhang.* Spinal Program, Toronto Western Hospital; Division of Thoracic Surgery, Toronto General Hospital, University of Toronto, Toronto, Ont.**

Purpose: To report results of patients undergoing en-bloc resection of large thoracic tumours with local invasion of the spinal column. **Results:** Fifteen patients underwent en-bloc resections of thoracic tumours with local invasion of the spinal column. Anterior and posterior approaches were performed in all cases except one. Procedures were staged a mean 16.2 days apart (range 4–51 d) in 8 patients. In group I (apical), there were 6 "Pancoast" carcinomas and in group II (non-apical) there were 4 non-small cell lung carcinomas, 2 soft-tissue sarcomas, 1 angiosarcoma, 1 chondrosarcoma and 1 neurogenic tumour with malignant rhabdoid features. Group I patients had significantly greater operative times, blood loss, length of hospital stay and perioperative complications. Further, group I had positive margins in 3/6 patients and poor 1-year survival (3 deceased at 6 mo; 3 survivors had <1-yr follow-up). Comparatively, group II had positive margins in 1(intraoperative margin)/9 and disease-free survival to date in 4 patients at 14, 18, 32 and 40 months postoperatively, 3 died after less than 1 year, and there was less than 1-year of follow-up in the remaining patients. In group II (n = 5/9), Oswestry scores were 54.5 at latest follow-up compared with 11.3 preoperatively (p = 0.007). SF-36 PCS and MCS were 35.5 and 51.1 preoperatively compared with 25.6 (p = 0.3) and 38.3 (p = 0.03) postoperatively. **Conclusions:** These are very complex cases that

offer potentially curative resections for otherwise incurable disease. Apical tumours are associated with greater technical challenge and poorer survival. Good survival is achievable in the non-apical tumours, however, at the potential cost of reduced function and quality of life.

THE GLIAL GLUTAMATE TRANSPORTERS GLAST AND GLT1 ARE POTENTIAL NEUROPROTECTIVE TARGETS IN SPINAL CORD INJURY. *M. Alhejji, F.W. Yang, S. Casha.* **University of Calgary Spine Program, the Calgary Brain Institute and the Department of Clinical Neurosciences, Calgary, Alta.**

Introduction: The role of glial glutamate transporters in the pathophysiology of neural trauma is unclear. Glial uptake may limit increased extra-cellular glutamate concentrations and thus excitotoxicity. Alternatively, reversed glutamate transport by these proteins may exacerbate changes in extra-cellular glutamate and promote excitotoxicity. **Methods:** In a rat clip compression model of spinal cord injury, protein expression of the glial glutamate transporters GLAST and GLT-1 was evaluated using western blotting and immunohistochemistry. Intraperitoneal TBOA (a pan inhibitor of these transporters) was administered prior to injury, and the effects on cell marker (NF200 and GFAP) protein levels after injury were evaluated by western blotting. **Results:** Following spinal cord injury, both GLAST and GLT1 expression increased through at 6, 12 and 24 hours. Both in uninjured and injured spinal cords, higher expression of both proteins was seen in the dorsal horn grey matter with diffuse expression in the remaining grey matter. No significant expression was seen in white matter. Degradation of NF200 seen after spinal cord injury was ameliorated at 6 and 24 hours after spinal cord injury with TBOA inhibition. GFAP expression was unchanged. **Discussion:** Changes in protein expression of glial glutamate transporters suggest that they may have a role in the pathophysiology of spinal cord injury. Inhibition of these transporters may be neuroprotective as evidenced by decreased axonal protein breakdown after spinal injury.

PRELIMINARY OBSERVATIONS ON APPLICATION OF A DOUBLE-BLIND PLACEBO-CONTROLLED STUDY OF MINOCYCLINE IN ACUTE SPINAL CORD INJURY. *S. Casha, T.K. Rice, V.W. Yong, R.J. Hurlbert.* **University of Calgary Spine Program; Department of Clinical Neurosciences; Department of Oncology, University of Calgary, Calgary, Alta.**

Introduction: It is widely anticipated that amelioration of secondary injury mechanisms after neural trauma will be neuroprotective. We have shown that minocycline is neuroprotective in mouse spinal cord injury (SCI). Laboratory studies, as well as previous clinical trials, have emphasized the need for early intervention with such neuroprotective strategies. **Methods:** We have initiated a double-blind randomized placebo-controlled pilot study of minocycline (×7 days) and spinal perfusion pressure augmentation (hypertensive therapy and lumbar CSF drainage) in SCI. We report our experience with application of this clinical trial protocol. **Results:** Nine patients have been enrolled in 4 months. Seven suffered complete SCI. Six patients that presented during the same period were not enrolled due to late presentation, other significant injuries, language barrier, conus medullaris injury or consent refusal. Following SCI, patients presented to hospital at mean 2 hours, were randomized at mean 9 hours and received surgical decompression at mean 16 hours. Two patients received surgery outside the intended 24-hour window. Seven patients have experience sustained perfusion pressure <75 mm Hg. Three lumbar drains malfunctioned, requiring replacement. One positive CSF culture has occurred. Two errors of drug administration occurred. CSF sampling (4 daily) has yielded an average of 6.1 mL/sample. Mean CSF and serum steady state minocycline levels of 0.9 ug/mL and 3.8 ug/mL have been observed in samples containing detectable minocycline. **Conclusions:** Application of a protocol including randomization within 12 hours of injury, surgical decompression within 24 hours and intensive care management with spinal perfusion pressure augmentation and lumbar CSF sampling is feasible in the SCI population.

SYNCHROTRON ANALYSIS OF SPINAL FUSION WITH DIFFRACTION ENHANCED IMAGING. *M.E.B. Kelly, R.C. Beavis, D.R. Fourney, L. Allen, E.L. Schultke, B.H.J. Juurlink, Z. Zhong, D. Chapman.* **Division of Neurosurgery; Division of Orthopaedic Surgery, Royal University Hospital; Department of Anatomy and Cell Biology, University of Saskatchewan, Saskatoon, Sask.; National Synchrotron Light Source, Brookhaven National Laboratory, Upton, NY.**

Introduction: Diffraction enhanced imaging (DEI) utilizes synchrotron radiation sources to create intense monochromatic light. X-ray beams are scattered and refracted by a silicone crystal to create the images. DEI provides dramatically improved contrast over standard imaging techniques, including excellent characterization of ligamentous and bony structures. To our knowledge, this represents the first analysis of bony fusion using DEI. **Methods:** Adult male Wistar rats were divided into groups: I, control (n = 3); II, decortication alone (n = 6); III, decortication with iliac crest bone grafting (n = 6); and IV, decortication with iliac crest bone grafting and interspinous wiring (n = 6). Surgical fusion was performed at the L5-6 level. Animals were sacrificed at 2, 4 and 6 weeks. **Results:** There was no evidence of bone fusion in groups I and II. Groups III and IV demonstrated solid fusion by 6 weeks. With DEI, the small amount of bone graft material (as little as 0.075 g) was visible at 2, 4 and 6 weeks postoperatively. DEI did not produce any metal artifact. **Conclusions:** DEI represents a novel synchrotron-based imaging technique which, in comparison with conventional radiographs, better assesses spinal fusion. DEI does not produce any metal artifact.

MODIFIABLE LIFESTYLE FACTORS IN PATIENTS PRESENTING TO A TERTIARY SPINE SURGERY CLINIC. *E. Wai, A. Gruscynski, G. Johnson, D. Chow, J. O'Neil, L. Vexler.* **Ottawa Hospital, University of Ottawa Spine Surgery Unit, Ottawa, Ont.**

Purpose: The purpose of this cross-sectional study is to evaluate the modifiable lifestyle factors that may be associated with back pain in patients presenting to a tertiary spine clinic with a primary complaint of back pain and to compare these lifestyle factors with the general population. A secondary objective is to determine whether patients with back pain were given any

instructions with regard to modifiable lifestyle factors by their primary care practitioner. **Methods:** Consecutive patients presenting to the orthopedic spine surgery clinic at the Ottawa Hospital, Civic Campus, are asked to complete a questionnaire upon presentation to the surgeon's clinic and prior to their visit with the surgeon. Data being collected includes body mass index (BMI), smoking history, physical activity history, perceived stress and disability. Information is also being collected on sources of information about back pain including instructions given by primary care practitioners (physician, chiropractor, physiotherapist, massage therapist, acupuncturist, naturopath and other). Data will be analyzed to determine the difference in modifiable risk factors between patients presenting to the spine surgery clinic and the general population. Data will also be tabulated for numbers of patients being given information on modifiable lifestyle factors by primary care practitioners. **Results to date:** Fifty-two patients have completed the questionnaire. A significant difference has been noted between the number of morbidly obese (BMI >30) patients presenting to the clinic and the general population. It has been noted that less than 20% of primary care physicians have talked about lifestyle modification with their patients prior to referring them to a spine surgeon. **Discussion:** It will be important to know what modifiable lifestyle risk factors this group of patients possesses and which of these modifiable lifestyle risk factors are actually being addressed by primary care practitioners prior to referral to spine surgeons.

A comparison of spine training in Canadian orthopedic and neurosurgery residencies. ***M. Dvorak, L. Murnaghan, J.B. Collins.*** **Department of Orthopaedics; Department of Educational Studies, University of British Columbia, Vancouver, BC.**

Purpose: The primary objective of this study was to evaluate the confidence of senior orthopedic and neurosurgical residents in performing a number of spinal surgical procedures. Furthermore, their perceived need for further training with respect to these procedures was assessed. The training environments were characterized and their anticipated practice profiles determined. **Significance:** This study represents an evaluation of surgical competence of senior and graduating orthopedic and neurosurgery residents in Canada. **Method:** All senior orthopedic and neurosurgery residents in Canada were surveyed using a self-reported questionnaire. Survey results were summarized using the SPSS statistical software, and then descriptive and comparative analyses were performed. **Summary of results:** Significant differences in time and exposure to spine training differentiated the neurosurgical and orthopedic residencies (37% and 16%, respectively). Neurosurgical residents reported significantly higher levels of confidence for all procedures. Of those residents anticipating incorporating spine into their practice, 29% of neurosurgery residents planned on entering a spine fellowship, compared with 17% of their orthopedic colleagues. **Conclusion:** Training in spine surgery constitutes a larger proportion of neurosurgery residency than orthopedic residency. Neurosurgery residents graduate with significantly higher levels of confidence to perform spine surgery. Orthopedic residents report significantly higher need for additional training in spine surgery. The majority of neurosurgery graduates will include spine in their clinical practice, while most orthopedic graduates will exclude it. **Discussion:** A significant difference in confidence between the groups and a discrepancy between perceived need for further training and practice expectations highlight differences between the 2 subspecialties in their spine training.

Funding: No funding was received from a commercial party.

Friday, March 18, 2005

Thoracoplasty in adolescent idiopathic scoliosis: a critical appraisal. ***T. Kostamo, R.L. Choit, B.J. Sawatzky, S.J. Tredwell.*** **Department of Orthopaedics, University of British Columbia, Vancouver, BC.**

The purpose was to investigate whether thoracoplasty affected spinal correction. We also compared outcomes of thoracoplasty patients and controls, as well as long-term curve maintenance. Current understanding of the scoliotic curve as a 3-dimensional helix has led to increased recognition of the importance of sagittal contour and balancing the spine's reciprocal curves to avoid problems such as flat back syndrome. Correction of the scoliotic curve intra-operatively may require the removal of spine stabilizers such as the disc and annulus, posterior facet and capsule, and thoracic cage stabilizers such as the ribs. Thirty-eight patients who had either concave paramedian or convex Steel mid-rib thoracoplasty were reviewed and compared with 18 controls. Prospective patient outcomes using the Scoliosis Research Society instrument with an average of >1-year follow-up were available for 30 patients. Degree of curve settle and maintenance of correction was measured on follow-up radiographs. Thoracoplasty had no effect on curve correction in the coronal plane. It did show a significant effect on sagittal plane correction of thoracic hypokyphosis. The paramedian group showed a mean increase of 12°, the Steel group 8.7° and the control group 3.1°. No significant difference between pain, satisfaction, function and self-image was found. Long-term radiographic follow-up showed a mean coronal curve settle of 4.6° (thoracoplasty) versus 3.1° (non-thoracoplasty), and an accompanying improvement in sagittal plane correction of 4.2° and 3.0°, respectively. Thoracoplasty did increase the correction of thoracic hypokyphosis without significant detractors in terms of patient outcome.

Patients' and parents' perceptions of postoperative appearance in adolescent idiopathic scoliosis (AIS). ***P. Smith, S. Donaldson, D. Hedden, D. Stephens, B. Alman, A. Howard, J. Wright.*** **Division of Orthopaedic Surgery; Population Health Sciences, The Hospital for Sick Children, Toronto, Ont.**

Purpose: To determine the agreement between patients' and parents' perceptions of the patient's postoperative appearance. **Method:** At 2 years postoperatively, 128 patients and parents independently rated the physical deformity of the patient's shoulder blades, shoulders, waist and overall appearance of the back (0 [best] to 5 [worst]). **Summary of results:** Fair to moderate agreement was found between patient and parent ratings of the patient's shoulder blades (kappa = 0.39, 95% CI

0.29–0.48), shoulders (kappa = 0.38, 95% CI 0.26–0.50) and waist (kappa = 0.45, 95% CI 0.25–0.55). Overall appearance, however, had the lowest agreement (kappa = 0.22, 95% CI 0.04–0.40). Patients rated the appearance of their waist (p = 0.013) and overall appearance (p = 0.039) significantly worse than their parents. **Conclusion:** Patients and parents do not strongly agree on the cosmetic outcome of AIS surgery. Patients perceive some outcomes more negatively than their parents. **Significance:** Adolescents need to play a major role in the surgical decision making process and probably the primary role in evaluating the cosmetic outcomes of surgery. **Discussion:** Cosmesis is a major aspect in surgical decision making, and improved appearance is an expectation of families. The results of this study would suggest that parents and adolescents only moderately agree about cosmetic appearance. When parents and patients disagree, surgeons should probably defer to concerns of the patient rather than the parents.

Funding: This trial was funded by (in alphabetical order) the Canadian Institutes of Health Research, DePuyAcroMed-Johnson & Johnson Medical Products, and Synthes, Canada.

THE EFFICACY OF VIDEO-ASSISTED THORACOSCOPIC SURGERY FOR ANTERIOR RELEASE AND FUSION IN THE MANAGEMENT OF PEDIATRIC SPINAL DEFORMITIES. ***C.W. Reilly, R.L. Choit, G.P. Slobogean, A. Perdios.* Department of Orthopaedics, University of British Columbia, Vancouver, BC.**

The purpose of this study was to compare the perioperative parameters and outcomes of video-assisted thoracoscopic surgery (VATS) with open thoracotomy for anterior release and fusion in the treatment of pediatric spinal deformities. VATS has the potential to decrease postoperative morbidity while still allowing the same degree of correction as traditional open thoracotomies. A detailed chart and radiographic review was undertaken to determine degree of correction, perioperative morbidity and complications, if any, of patients who underwent VATS between 1997 and 2004 at the authors' institution. A control group of patients who underwent open thoracotomy was used to determine if there is a significant difference in correction (Cobb angle) or in perioperative morbidity when using VATS versus open thoracotomy for anterior release and fusion in the correction of scoliotic deformities. There were 19 patients in each group: 17 with idiopathic scoliosis in the VATS group and 16 in the open group. Mean age, weight at surgery and preoperative Cobb angle were similar (p = 1.000, 0.8277, 0.0636, respectively). There was no significant difference in operative time per level between the VATS group and the open group (37.2 v. 34.5 min, p = 0.2254) or total blood loss (908 v. 823 mL, p = 0.4953). There were no major complications encountered in the VATS group; 1 patient in the open group experienced atelectasis and subsequent lower lobe collapse. It appears that VATS offers the same degree of correction as open thoracotomies and has the potential to decrease perioperative morbidity.

THE RELIABILITY OF USING QUESTIONNAIRES TO DETERMINE WHETHER SPINE PATIENTS HAVE LEG- OR BACK-DOMINANT PAIN. ***J. Whitcomb Pollock, E.K. Wai, L.R. Vexler, E. Belanger, G. Johnson*. Ottawa Hospital, University of Ottawa Spine Surgery Unit, Ottawa, Ont.**

Purpose: The ability to differentiate leg-dominant or back-dominant pain is important in identifying patients appropriate for surgery and stratifying populations for research purposes. The aim of this prospective, test–retest study was to determine using questionnaires whether spine patients have leg-dominant or back-dominant pain. **Methods:** Ten different measures of assessment for back or leg pain were placed randomly into questionnaires, which were completed by 34 patients along with the revised Oswestry Low Back Questionnaire. Within a 2-week interval, a randomly reorganized retest questionnaire containing the identical 10 items was distributed. Kappa statistics were used to determine the test–retest reliability and to compare against the surgeon's clinical assessment. **Results:** Thirty-four patients completed both questionnaires (87% response rate). The kappa values for the separate items in the questionnaire ranged from 0.27 to 0.54. The clinical correlation with items in the questionnaire ranged from 0.17 to 0.49. **Discussion:** All 10 items included in the questionnaire appeared to lack sufficient internal consistency and test–retest reliability for use in clinical application. **Conclusion:** Patients appear to be unable to accurately and reliably determine the predominant location of their pain.

KINEMATIC ANALYSIS OF THE CERVICAL SPINE FOLLOWING IMPLANTATION OF AN ARTIFICIAL CERVICAL DISC. ***G.E. Pickett, J.P. Rouleau, N. Duggal*. London Health Sciences Centre, University of Western Ontario, London, Ont.; Minneapolis, Minn.**

Objective: Spinal arthroplasty offers the promise of maintaining functional spinal motion, thereby potentially avoiding adjacent segment disease. Disc replacement may become the next gold standard for the treatment of degenerative cervical spine disease and must be studied rigorously to ensure in vivo efficacy and safety. We assessed the biomechanical profile of the cervical spine following cervical arthroplasty. **Methods:** Twenty patients underwent single- or two-level implantation of the Bryan® artificial cervical disc for treatment of cervical degenerative disc disease producing radiculopathy and/or myelopathy. Lateral neutral, flexion and extension cervical radiographs were obtained preoperatively and at intervals up to 24 months postoperatively. Kinematic parameters including sagittal rotation, horizontal translation, change in disc height and centre of rotation (COR) were assessed for each spinal level using quantitative motion analysis software. **Results:** Motion was preserved in the operated spinal segments (mean range of motion 7.8°) up to 24 months following surgery. The relative contribution of each spinal segment to overall spinal sagittal rotation differed depending on whether the disc was placed at C5–6 or C6–7. Overall cervical motion (C2–7) was moderately but significantly increased in late follow-up. Sagittal rotation, anterior and posterior disc height, translation and COR coordinates did not change significantly at any level following surgery. The COR was most frequently located posterior and inferior to the centre of the disc space. **Conclusions:** The Bryan® artificial cervical disc provided in vivo functional spinal motion at the operated level, reproducing the preoperative kinematics of the spondylotic disc.

Early complications with cervical arthroplasty. ***G.E. Pickett, L. Sekhon, N. Duggal.***

Objective: Spinal arthroplasty is gaining popularity in the management of degenerative cervical disc disease. While this new technology may offer benefits over arthrodesis, it requires the acquisition of new operative techniques and introduces new potential complications. We analyzed our early series of patients treated with the Bryan® cervical prosthesis to determine the frequency of perioperative complications. **Methods:** We prospectively recorded clinical and radiographic outcomes in all patients who received the Bryan® artificial cervical disc in our 2 tertiary care centres. Patients underwent standard anterior cervical discectomy followed by implantation of the Bryan® disc at 1 or 2 levels. Static and dynamic radiographs were obtained preoperatively and at defined intervals postoperatively. Operative data and perioperative complications were recorded. **Results:** Fifty-six discs were implanted in 44 patients. One patient developed transient worsening of myelopathy postoperatively. Intraoperative migration of the prosthesis was observed in 1 case of bi-level arthroplasty, while delayed migration occurred in 1 patient who developed postoperative segmental kyphosis. Heterotopic ossification and spontaneous fusion occurred in 2 cases, one of whom had exhibited excellent initial segmental motion. Motion was preserved in the remaining 54 prostheses, up to 2 years past surgery. Neck and shoulder pain were reported in late follow-up by 35% of patients. There was a trend toward increased complications and poor outcome in patients with 2-level procedures. **Conclusion:** The Bryan® disc prosthesis was effective in maintaining spinal motion. Only 3 device-related complications were encountered. Major perioperative complications were infrequent.

Anterior screw fixation for type II odontoid fractures: the trial and tribulations. ***R.J. Hurlbert, R. Fox, S. DuPlessis, J. France, R. Broad, S. Casha.*** **University of Calgary Spine Program, Calgary; University of Edmonton, Edmonton, Alta.; University of West Virginia, Morgantown, WV.**

Introduction: Anterior screw fixation and external halo immobilization are 2 of the most widely practised interventions for the treatment of type II odontoid fractures. A multicentre prospective randomized clinical trial is underway to establish superiority of one treatment over the other. **Methods:** Patients with acute type II odontoid fractures are identified on admission to hospital. Traction is used to reduce fracture dislocations where necessary. After reduction, eligible patients are randomized to 1 of 2 treatment groups: halo or anterior screw fixation. **Results:** Since September of 2002, only 15 patients have been randomized. The patients have been acquired by 3 of a total of 12 participating institutions. Eight have been treated with halo brace and 7 with anterior screw fixation. Two treatment failures have occurred in each group; all subsequently stabilized posteriorly. There has been a 20% failure rate in the screw group and a 66% failure rate in the halo group for patients over 65. **Conclusions:** Patient acquisition has been suboptimal in this multicentre randomized trial. Most physicians ascribe to the importance of PRCTs, but participation in such studies requires a high level of commitment, vigilance and perseverance. To further medical knowledge and provide accountability to our patients it is important that specialties define themselves by more than lip service toward evidence-based medicine.

Clinical accuracy of cervicothoracic pedicle screw placement: a comparison of 'open' lamino-foraminotomy and computer-assisted techniques. ***G.Y.F. Lee, E.M. Massicotte, Y.R. Rampersaud.*** **Division of Orthopaedic and Neurosurgery; Division of Neurosurgery, Spinal Program, Krembil Neuroscience Centre, Toronto Western Hospital, University Health Network, University of Toronto, Toronto, Ont.**

Introduction: Posterior transpedicular fixation at the cervicothoracic junction (CTJ) is increasing in popularity. However, the clinical accuracy of pedicle screw placement at the CTJ has not been specifically assessed. **Methods:** Between January 2000 and July 2004, 60 consecutive patients underwent a variety of posterior spinal procedures necessitating pedicle screw placement at C7, T1 and T2. Thirty-two patients had cervicothoracic screws (3.5–4.5 mm) placed by an 'open' technique (laminectomies or lamino-foraminotomies), and 28 patients with either a closed (prior to any decompression) 2-D (n = 19, fluoroscopy) or 3-D (n = 9, CT) computer-assisted technique. Screws were independently assessed for pedicle breach on postoperative CT. **Results:** The total number of screws placed was 86, 63 and 45 in the open, closed-2D and closed-3D groups, respectively. Overall, 61 (70.9%), 51 (81%) and 40 (89%) screws were completely within the pedicle. In the open group, the majority of pedicle breaches were more than 2 mm (n = 3, less than 2 mm; n = 20, 2–4 mm; n = 2, more than 4 mm). Screw violation occurred laterally in 11/25 (44%), medially in 3/25 (12%), inferiorly in 6/25 (24%) and superiorly in 5/25 (20%). In the closed technique, all breaches were lateral. Seventeen screws (n = 11 2D, n = 5 3D) breached the pedicle by a margin of less than 2 mm and 1 screw (2D) by 2–4 mm. For all patients, there were no clinically significant screw misplacements, nor any need for screw revision. **Conclusions:** Computer-assisted surgery allows for more accurate placement of pedicle screws at the CTJ. The higher percentage of breaches that were more than 2 mm in the open group may be associated with higher complication risk (e.g., neurological injury, construct failure) and warrants further study.

Saturday, March 19, 2005

Magnetic resonance evaluation of lumbar spinal stenosis: objective and subjective reporting by spine surgeons. ***S. Al Eissa, A. Alargani, R. Hu, S. Casha.*** **University of Calgary Spine Program; Department of Clinical Neurosciences; Division of Orthopaedic Surgery, University of Calgary, Calgary, Alta.**

Introduction: The availability of digital imaging tools may allow for more objective reporting of spinal magnetic resonance imaging (MRI). We undertook this study to compare the results of MRI spinal canal cross-sectional area reporting with

subjective evaluation of the images. **Methods:** Seven spine surgeons were asked to twice generate a subjective (normal, mild, moderate, severe impression) and objective (canal cross-sectional area) score at L34, L45 and L5S1 for 6 lumbar spine MRIs at different sittings. Spearman or Pearson correlation coefficients were determined to compare inter- and intraobserver variability as well as the correlation between the 2 scores. **Results:** The intraobserver correlation coefficient for the subjective score was 0.785 and 0.936 for the objective score. The mean interobserver correlation for the subjective score was 0.759 and 0.895 for the objective score. The overall correlation between the subjective and objective methods was 0.506. However, this was not uniform at all levels (0.524 at L34, 0.834 at L45 and 0.328 at L5S1). The median subjective scores at these levels were mild, moderate and normal respectively while the mean objective scores were 131.7, 99.4 and 170.5 mm^2. **Conclusion:** Objective measurements of canal cross-sectional area on MR images of the lumbar spine improved both intra- and interobserver variability over subjective assessments. The correlation between the subjective and objective scores was poor, particularly in the presence of mild disease. This suggests that while canal diameter is considered during radiological assessment of spinal stenosis, other variables greatly influence the spine surgeon's conclusions.

Postoperative change in quality of life: a comparison between primary hip osteoarthritis and spinal stenosis. ***Y.R. Rampersaud, V. Stas, N. Khattab, S. Zhang, J.R. Davey, S.J. Lewis, N. Mahomed.*** **Division of Orthopaedic and Neurosurgery; Division of Orthopaedic Surgery, Musculoskeletal Health and Arthritis Program—Spinal Program, Toronto Western Hospital, University Health Network, University of Toronto, Toronto, Ont.**

Objective: The primary objective of this study was to determine if surgical treatment for spinal stenosis is comparable with total hip arthroplasty in improving patients' self-reported quality of life. **Methods:** An age, sex and time of surgery–matched cohort of patients who had undergone elective primary 1–2 level spinal decompression (n = 90) with (n = 26/90) or without fusion for spinal stenosis (n = 40 with degenerative spondylolisthesis) and elective primary total hip arthroplasty for osteoarthritis (n = 90) were compared. The primary outcome measure was the preoperative and 1-year postoperative Medical Outcomes Study Short Form-36 (SF-36) questionnaire. **Results:** The mean Physical Component Summary (PCS) / Mental Component Summary (MCS) for the stenosis compared with hip patients were 32.0/43.3 versus 30.5/46.2 preoperatively (analysis between groups: p = 0.2/0.1) and 39.1/47.3 versus 44.1/46.1 postoperatively (analysis between groups: p = 0.003/0.4). The pre- and postoperative PCS significantly improved for both groups (p < 0.0001). However, the pre- and postoperative MCS improved in the stenosis group only (p = 0.04). **Discussion and conclusion:** Studies have shown the significant impact on overall patient quality of life and cost-effectiveness of primary total hip arthroplasty. The results of this unique study show that surgical intervention for spinal stenosis also has a very positive overall effect on patients' self-reported quality of life at 1-year follow-up. This study provides data that support the need for a long-term prospective study and advocacy regarding waiting time initiatives and surgical resources for the treatment of patients with symptomatic spinal stenosis with a similar demographic to those with primary OA of the hip.

Operative versus nonoperative treatment for thoracolumbar burst fractures without neurological deficit: a systematic review. ***K.C. Thomas, C.F. Bailey, M.F. Dvorak, B. Kwon, C. Fisher.*** **Vancouver Hospital and Health Sciences Centre, University of British Columbia, Vancouver, BC.**

Objective: The objective of this study was to evaluate the scientific literature, using the technique of systematic review, on operative and nonoperative management of thoracolumbar burst fractures without neurological deficit. **Patients and methods:** An exhaustive literature search identified all possible relevant studies concerning thoracolumbar burst fracture without neurological deficit. Two independent observers performed study selection, methodological quality assessment and data extraction in a blinded and objective manner. A qualitative literature synthesis provides evidence for each treatment option. **Results:** One hundred and thirty-six primary studies were identified, and 19 fit the inclusion criteria. Six studies were rated as having "adequate" quality. One study demonstrated improved quality of life, as measured by the SF-36, in the nonoperative group as compared with the operative group. There was no difference in pain between groups at follow-up. Various scales were used to assess function and disability, and in general, given time, all patients had improved function. One comparative study did note function to be better in the nonoperative group at follow-up. Kyphotic correction was greater with surgery; kyphosis at follow-up did not correlate well with clinical outcome. There were more complications in the operatively treated patients. **Conclusions:** There is a lack of evidence demonstrating the superiority of operative versus nonoperative treatment as measured by generic and disease-specific health-related quality of life scales. There is no scientific evidence linking kyphosis to clinical outcomes. There is strong need for improved clinical research methodology and new questions to be applied to this patient population.

Evaluation of a new rhBMP-2 formulation in 2-level posterolateral lumbar spine fusions. ***E.P. Abraham, D.I. Alexander, S. Bailey.*** **Saint John Regional Hospital, Saint John, NB; QEII Health Sciences Centre, Halifax, NS; London Health Sciences Centre, London, Ont.**

Multilevel posterolateral fusions are more challenging than single-level procedures. The purpose of this study was to compare the success of instrumented 2-level fusions using a new rhBMP-2 formulation versus iliac crest bone graft (ICBG). In this formulation, rhBMP-2 was at a concentration of 2 mg/cc in a biphasic calcium phosphate (BCP, 60% hydroxyapatite/40% tricalcium phosphate) ceramic granule carrier (Medtronic Sofamor Danek, Memphis, TN). Twenty-nine patients were enrolled in this multicentred, prospective, randomized study. Either 30 cc of rhBMP-2/BCP or fresh ICBG was used. Clinical evaluations were done preoperatively, at discharge and 1.5, 3, 6, 12 and 24 months, including

Oswestry Disability Index SF36, back pain and leg pain questionnaires. Thin-slice CT scans and x-rays were independently assessed at 6, 12 and 24 months. Fusion criteria included bilateral bridging trabecular bone on each level, less than 3 mm translation, less than 5° angulation and no revision of pseudarthrosis. Seventeen patients received ICBG, and 12 received rhBMP-2/BCP. With the use of rhBMP-2 average OR time was reduced from 3.8 to 2.9 hours. Average blood loss was reduced from 1070 to 870 ml. Twenty-nine patients (100%) have reached 24-month follow-up. Clinical improvements were similar in both groups, however, fusion success was much improved with the use of rhBMP-2. At 24 months, all patients receiving rhBMP-2/BCP were fused versus 58% of ICBG patients. These results suggest that rhBMP-2/BCP may have improved fusion success in challenging 2-level posterolateral fusions as compared with ICBG.

Results of posterolateral fusion versus combined posterolateral and interbody fusion in 1-level degenerative disorders of the lumbar spine: 2-year follow-up. ***E.P. Abraham*. Saint John Campus, Dalhousie University, Saint John Regional Hospital, Saint John, NB.**

The purpose of the study is to evaluate the outcome of 2 methods: posterolateral fusion and instrumentation versus posterolateral fusion, instrumentation and interbody fusion using clinical and radiological criteria in demographically similar groups. This is a prospective cohort study of 64 patients randomized to 2 therapeutic strategies (level II study). Sixty-four patients were randomized to either instrumented posterolateral fusion (control) or combined instrumented posterolateral and interbody fusion (study) in 1-level degenerative disorders of the lumbar spine. Demographics of the groups were similar including age, gender and other variables. Ages range from 14 to 78, mean of 48 (control) and 42 (study). Level of involvement was evenly distributed between groups including degenerative disc disease, disc herniation, spondylolysis and low-grade spondylolisthesis. Outcome was measured by blood loss, operative time, hospital stay, neuro deficit pre- and postoperatively, complications, back pain score, leg pain score, Oswestry, SF36, work return, patient satisfaction, fusion rate, disc height maintenance, adjacent segment degeneration and maintenance of deformity reduction. At 2 years, there was no statistically significant difference between the control group (no interbody fusion) and the study group (interbody fusion) with respect to pain scores, Oswestry, SF36. The ratio of disc height immediately postoperatively compared with 2-year follow-up was unchanged in the study group (100%) and unchanged in the majority of the control group (88%). This represents no statistical difference. Maintenance of deformity correction was observed in 100% of the 12 spondylo cases in the study group (interbody fusion) compared with 86% in the control group (no interbody fusion) at 2 years. Two years postoperatively, there was no evidence of adjacent segment degeneration in the control or study group.

A randomized clinical trial comparing the Moss Miami (MM) and Universal Spinal Instrumentation (USS) systems for posterior spinal fusion in adolescent idiopathic scoliosis (AIS). ***D. Stephens, A. Howard, B. Alman, D. Hedden*. Division of Orthopaedic Surgery; Population Health Sciences, The Hospital for Sick Children, Toronto, Ont.**

Purpose: To compare quality of life, surgeon satisfaction, surgical and radiographic outcomes of the Moss Miami (MM) and Universal Spine System (USS) for posterior spinal fusion in adolescent idiopathic scoliosis (AIS). **Method:** One hundred and twenty-five patients were randomly allocated to either the MM or USS for posterior fusion of AIS. The primary outcomes were quality of life and correction of Cobb angle at 2 years postoperatively. Surgeons rated their immediate postoperative satisfaction with system and their 2-year satisfaction with 'look of back' and 'results of surgery.' Perioperative surgical outcomes were also included. **Summary of results:** The quality of life for MM (mean 89.2 ± 12.7) and USS (mean 90.7 ± 11.9) were not significantly different ($p = 0.51$). Percentage Cobb angle correction for thoracic (MM mean 55.1 ± 18.3%; USS mean 54.1 ± 18.7%) ($p = 0.77$) and lumbar (MM mean 45.4 ± 24.6%; USS mean 41.9 ± 26.8%) ($p = 0.57$) curves were also not significantly different. Surgeons' immediate postoperative rating was "satisfied" for 60/62 cases using USS compared with only 36/63 cases using MM ($p < 0.0001$). Surgeons' dissatisfaction was not related to OR time ($p = 0.14$), need for blood transfusion ($p = 0.17$), overall complications ($p = 0.36$), change in quality of life ($p = 0.11$), Cobb angle correction (thoracic, $p = 0.59$; lumbar, $p = 0.91$), surgeons' rating of 'results of surgery' ($p = 0.62$) and 'look of back' ($p = 0.91$). **Conclusion:** Two spinal instrumentation systems provided similar quality of life and percentage Cobb angle correction. **Significance:** Surgeons have biases against certain systems which are not reflected in surgical outcomes. **Discussion:** Each system works using different biomechanical principles; this may be the source of surgeon preference.

Funding: This trial was funded by (in alphabetical order) Canadian Institutes of Health Research, DePuy AcroMed-Johnson & Johnson Medical Products, and Synthes, Canada.

The clinical significance of peri-implant halos in lumbar pedicle screw fusions. ***L. Ton, J. Finkelstein, M. Vidmar, M. Ford*. Sunnybrook and Women's College Health Sciences Centre, University of Toronto, Toronto, Ont.**

Study design: Independent retrospective analysis of the relationship between peri-implant (pedicle screw) halos and the presence of a pseudarthrosis in lumbar spine fusions. **Objectives:** To establish the predictive value of pedicle screw halos and the presence or absence of a pseudarthrosis. **Summary of background data:** Clinical and radiological assessment of the integrity of a posterolateral fusion mass in pedicle screw fusions is difficult. Radiological clues, such as hardware loosening and peri-implant halos are used clinically, but there is no literature establishing the predictive value of these clues with respect to whether or not there is a solid fusion mass. **Methods:** Independent retrospective review of a consecutive series of posterolateral lumbar fusions with pedical screw instrumentation. All patients who were significantly symptomatic were routinely returned to the operating room for removal of instrumentation and clinical assessment of fusion mass integrity. Radiographs of these individuals were assessed

for the presence or absence of peri-implant halos. Statistical analysis of the relationship between pseudarthrosis and halos were established. **Results:** Thirty-five patients underwent 35 repeat surgical procedures to remove hardware and inspect the fusion mass. Fifty-six percent of the 45 preoperative radiographs were positive for halos. The predictive value of the presence of a halo and pseudarthrosis was only 52%. **Conclusion:** The presence of peri-implants halos are not predictors of a pseudarthrosis.

TRAUMATIC LUMBOSACRAL SPONDYLOLISTHESIS: A SYSTEMATIC REVIEW AND CASE SERIES. ***I. Neil, C. Fisher, A. Falicov, B. Kwon, J. Hurlbert, M. Boyd, M. Dvorak.* Department of Spine Surgery, Vancouver General Hospital, Vancouver, BC.**

Objective: Primary outcome: optimal method of treatment for traumatic lumbosacral spondylolisthesis. Secondary outcomes: injury characteristics and prognosis of neurological recovery, back pain and return to pre-injury activity. **Design:** Systematic review and retrospective case series of traumatic lumbosacral spondylolisthesis. **Method:** Composite database search of both the Vancouver General Hospital database and a computer-assisted search of the Embase and PubMed/Medline public databases. Relevant cases were identified, and the data were extracted from citations that met specific inclusion criteria. **Results:** Twelve females and 50 males were identified. Mean age was 27.9 years and median follow-up was 24 months. High-energy trauma was the etiology in 85.1%; 38.7% had impact to a flexed spine; 51.6% had neurological injury of which 43.8% had a cauda equina syndrome. All isolated nerve root injuries had partial or complete recovery. Cauda equina type lesions had only a 7.1% chance of total neurological recovery. Posterolateral instrumented fusion was performed in 32.8% of cases and circumferential fusion in 34.4% with a higher failure rate in the former. There were 48 reports on return to pre-injury activity of which 54.2% had resumed activity. Of 50 reports on pain, 52% were pain free, while the others had chronic or intermittent pain. **Conclusions:** Traumatic lumbosacral dislocation is caused by high-energy trauma to the flexed spine. Neurological injury is common, and complete recovery of a cauda equina deficit is unlikely. Instrumented circumferential fusion appears to be the best treatment. About 50% patients will return to pre-injury level of activity and be pain free.

CSS 2005 — Poster presentations

Minimally invasive anterior approach to upper cervical spine: surgical technique. ***S.Y. Fong, S.J. duPlessis.* University of Calgary Spine Program; Department of Clinical Neurosciences, Foothills Hospital, Calgary, Alta.**

Summary: To provide anatomic data for anterior retropharyngeal upper cervical approach through a minimally invasive window between the hypoglossal nerve and the superior laryngeal nerve inferiorly, the carotid sheath laterally, the trachea and esophagus medially. In 2 adult cadaveric cervical spines, an approach using the METRX tubular retractor system through below the hypoglossal nerve and the superior laryngeal nerve is used to expose C1 and C2 anteriorly with the aid of an operating microscope. This minimally invasive approach may replace transoral surgery, allowing direct anterior access to C1 and C2 which can be extended to the lower cervical spine. **Purpose:** To provide anatomic data for anterior retropharyngeal upper cervical approach through a minimally invasive access below the hypoglossal nerve and the superior laryngeal nerves. **Significance:** The transoral approach of Spetzler is the classical anterior access to the upper cervical spine that provides direct exposure for anterior decompression of the spinal cord. The risks of infection, the limits in extension and the postoperative difficulties of transmucosal access suggest the use of an alternative anterior extraoral approach in upper cervical surgery. However, this approach results in complications from nerve palsy because of excessive retraction of hypoglossal nerve and superior laryngeal nerve. **Methods:** In 2 adult cadaveric cervical spines, anterior approach using the METRX tubular retractor system through a window between the hypoglossal nerve and the superior laryngeal nerve, as well as below these 2 nerves, is compared in the exposure of C1 and C2 anteriorly with the aid of an operating microscope. The anterior atlas arch can be exposed using these 2 approaches. **Results:** The superior laryngeal nerve tends to be stretched if the approach is superior to it. Conversely, the tubular retractor can retract the superior laryngeal nerve superiorly without undue tension. Better proximal exposure is possible by angling a bevelled tubular retractor on the mandible without undue compression on hypoglossal nerve, superior laryngeal nerve, mandibular branch of the facial nerve and the mandibular gland. **Conclusion:** This minimally invasive approach may replace transoral surgery, allowing direct anterior access to C1 and C2 which can be extended to the lower cervical spine.

An unconventional indication for kyphoplasty. ***S.Y. Fong M.E. MacRae, S.J. duPlessis.* University of Calgary Spine Program; Department of Clinical Neurosciences, Foothills Hospital, Calgary, Alta.**

Summary: To report a case of lower limb radiculopathy secondary to chronic osteoporotic fracture successfully treated with kyphoplasty. **Study design:** A case report. **Purpose:** To report a case of lower limb radiculopathy secondary to chronic osteoporotic fracture successfully treated with kyphoplasty. **Significance:** The literature suggests that osteoporotic fracture causing neurological problem is rare. However, morbidity and mortality following open surgery for these geriatric patients can be unacceptably high. **Methods:** An 85-year-old lady who sustained L4 osteoporotic fracture 5 months prior to diagnosis gradually developed severe disabling bilateral lower limb radicular pain but with minimal back pain. Clinical examination revealed bilateral L3 nerve roots radiculopathy. Radiological investigation confirmed bilateral L3–4 foraminal stenoses secondary to L4 vertebral body superior endplate collapse (vertebral height loss of 74%). She subsequently underwent bipedicular kyphoplasty of L4. **Results:** The patient experienced immediate dramatic pain relief in both her lower limbs after kyphoplasty, which was maintained after 3 months follow-up. This was further confirmed by improvement in her Short-Form 36 (20% to 60%) and Oswestry Disability scores (80% to 20%). Postoperative L4 vertebral height gained was 65.6% with improvement noted in the Cobbs angle (by 10.8°) and the L3–4 foraminal areas (by 73.6%) after kyphoplasty. **Conclusion:** Kyphoplasty can be an alternative less invasive method for patients with lower limb radiculopathy secondary to chronic osteoporotic fracture.

Thoracic myelopathy secondary to ossified ligamentum flavum. ***S.Y. Fong, H.K. Wo.* University of Calgary Spine Program, Calgary, Alta.; Department of Orthopaedic Surgery, National University Hospital, Singapore.**

Summary: Five patients with thoracic myelopathy due to ossified ligamentum flavum (OLF) underwent laminectomy. Laminectomy with excision of the OLF resulted in significant improvement in motor weakness and gait in 4 (1 excellent, 2 good and 1 fair) patients who had slow-onset, but progressive compression, OLF. The patient who had acute traumatic spinal injury did not recover despite decompression and rehabilitation. All improved in their gait and spasticity, but 4 patients had persistent sensory deficit. **Significance:** Focal ossification of the ligamentum flavum (OLF) is a rare cause of thoracic myelopathy. **Methods:** Five patients with thoracic myelopathy due to OLF underwent laminectomy and excision of the OLF. The lower thoracic spine is most frequently affected and the patients present initially with posterior column disturbances followed by progressively increasing spastic paraparesis. Magnetic resonance (MR) images consistently revealed a linear or beak-like excrescence, uniformly hypodense on T_1- and T_2-weighted images, situated posterior to the thecal sac. A comparison of the preoperative neurological status and at follow-up was done using the Japanese Orthopaedic Association and Nurick scores modified for thoracic myelopathy. **Results:** Laminectomy with excision of the OLF resulted in significant improvement in motor weakness and gait in 4 (1 excellent, 2 good and 1 fair) patients who had slow-onset, but progressive compression, OLF. The patient who had acute

traumatic spinal injury did not recover despite decompression and rehabilitation. All improved in their gait and spasticity, but 4 patients had persistent sensory deficit. **Conclusion:** OLF can significantly contribute to a spatial reduction of the thoracic spinal canal, resulting in slowly progressive paraparesis or acute paraplegia after trauma to the back. The T_2-weighted sagittal image of MR imaging is the modality of choice for screening the longitudinal extent of OLF, with increased diagnostic accuracy when combined with computed tomographic myelogram. Neurological improvement usually occurs following laminectomy with or without excision of the OLF. However, prognosis remains poor for acute myelopathy with pre-existing OLF, despite surgery.

Minimally invasive lateral mass plating in the treatment of posterior cervical trauma: surgical technique. ***S.Y. Fong, S.J. duPlessis.*** **University of Calgary Spine Program; Department of Clinical Neurosciences, Foothills Hospital, Calgary, Alta.**

Summary: To describe a modified technique of minimally invasive lateral mass plating for cervical spine trauma. Two clinical cases are illustrated. **Purpose:** To describe a modified technique of minimally invasive lateral mass plating for cervical spine trauma. **Significance:** The technique of lateral mass fixation restores the posterior tension band and provides effective stabilization in patients with many types of traumatic injuries. However, postoperative wound pain is not uncommon. We believe that exposure of multiple levels of lateral masses can be achieved through a single small incision. **Methods:** Patient 1 was a 64-year-old woman who had been in a motor vehicle accident and sustained bilateral C5–6 facet fracture-dislocation with posterior C5–6 distraction. She was neurologically intact, and attempts at closed reduction were not successful. Patient 2 was a 16-year-old woman who had also been in a motor vehicle accident but had an incomplete spinal cord injury. She had an unstable burst fracture of C7 with posterior C5–6 distraction. **Results:** A dilator tubular retractor system METRX was used to access the bilateral facet joints through a small midline incision under fluoroscopic guidance. Lateral mass screws were then placed by using modified Magerl technique, securing 2-hole plates on each side onto the lateral masses, performed through the METRX system. Both patients underwent anterior cervical fusion followed by staged minimally invasive posterior fusion with good results. **Conclusion:** We described successful placement of lateral mass screw and plate constructs with the use of a minimally invasive approach by means of a tubular dilator retractor system. This approach preserves the integrity of the muscles and ligaments that maintain the posterior tension band of the cervical spine.

Prospective, multicentre evaluation of outcome assessments for cord compression and canal compromise after cervical spinal cord injury. ***J.C. Furlan, M.G. Fehlings, E. Massicotte, and the Spine Trauma Study Group.*** **Krembil Neuroscience Centre, Spinal Program, Toronto Western Hospital, University Health Network; Division of Neurosurgery, Department of Surgery, University of Toronto, Toronto, Ont.**

Introduction: Only few quantitative reliable radiologic methods for evaluation of spinal cord injured individuals have been reported to date. Maximum canal compromise (MCC) and maximum spinal cord compression (MSCC) are particularly important due to their potential clinical and prognostic value. This is the first prospective study focused on the reliability of these radiologic parameters among a large cohort of spine surgeons. **Methods:** Midsagittal MRI and CT images of cervical spine were selected from 10 individuals with acute traumatic cervical SCI. A total of 28 spine surgeons estimated independently CT MCC, T_1-weighted MRI MCC and T_2-weighted MRI MSCC on 2 occasions using a calibrated ruler. In the first round of measurements, the observers estimated the radiologic parameters using only written instructions. The second measurement set was obtained after a teaching session on the methodology. **Results:** Analysis using parametric and nonparametric statistics indicated high intraobserver reliability for CT MCC, T_1-weighted MRI MCC and T_2-weighted MSCC. Intraobserver reliability of those radiologic parameters was high with interclass correlation coefficients (ICCs) of 0.925, 0.9467 and 0.9746, respectively. The interobserver reliability for all 3 radiologic parameters was considered satisfactory given limitations inherent to the measurement device. ICCs among the 28 observers varied from 0.3555 to 0.5635. **Conclusions:** Our results indicate that the observer reliability for the MCC and MSCC was high. The results further show that canal stenosis (MCC) is the most reliable measure for mild degrees of compression, whereas cord compression (MSCC) is the most useful assessment for more severe injuries.

Gender-related differences on clinical and neurological outcomes of individuals with acute traumatic cervical spinal cord injury. ***J.C. Furlan, M.G. Fehlings.*** **Spinal Program, Krembil Neuroscience Centre, Toronto Western Hospital, University Health Network; Division of Neurosurgery, Department of Surgery, University of Toronto, Toronto, Ont.**

Introduction: Although there has been reported evidence that female gonadal hormones play a neuroprotective role in traumatic brain injured animals and in vitro, the gender difference in spinal cord injury (SCI) has attracted little attention. This study addresses this issue. **Methods:** This retrospective analysis included all consecutive spinal cord injured individuals admitted to an acute care unit at the Toronto Western Hospital from 1998 to 2000. Data were analyzed using Fisher's exact, χ^2, Student's t tests and multiple linear regression (MLR). **Results:** There were 38 males (ages 17–89, mean 51.6 yr) and 17 females (ages 18–84, mean 63.2 yr). Age was treated as a covariate. Comorbidities were frequent in both groups ($p = 0.435$). Both groups showed similar mortality, discharge disposition and length of stay in acute care unit secondary complications. During hospitalization, 44.7% of men and 52.9% of women developed complications ($p = 0.771$). These were significantly related to age ($p = 0.02$) but not gender. Both groups showed similar incidences of infections, cardiovascular complications, thromboembolism and pressure sores. There was a trend for higher incidence of psychiatric complications in females ($p = 0.064$; MLR), which was not influenced by age ($p = 0.257$; MLR). A similar number of males

and females (42.1%, 47.1%) showed improvement in ASIA scores. Neurological outcome was not correlated with age or gender (MLR). **Conclusions:** Our data indicate that demographics of acute SCI are changing with an increased incidence in elderly women. Although neurological outcomes were not significantly related to age or gender, we observed an increased incidence of secondary complications in the elderly and a trend for higher rates of depression in women.

Hyponatremia after acute spinal cord injury: clinical, neuroanatomical, and molecular evidence for an autonomic nervous system dysfunction. ***J.C. Furlan, M.G. Fehlings.*** **Spinal Program, Krembil Neuroscience Centre, Toronto Western Hospital, University Health Network; Division of Neurosurgery, Department of Surgery, University of Toronto, Toronto, Ont.**

Introduction: Autonomic dysfunction is common after acute SCI and may underlie abnormalities in renal control of serum sodium (sNa). This study examines (1) the incidence of hyponatremia in the early stage (2 weeks) after cervical SCI, (2) the association of hyponatremia with SCI severity and (3) the association of descending renal sympathetic (inhibitory) pathways (DRSPs) integrity on sNa. **Methods:** The data of all acute cervical SCI cases admitted from 1998 to 2000 were retrospectively reviewed. Postmortem high thoracic spinal cord sections from 6 cases of cervical SCI (2F, 4M; ages 31–82, mean 59.2 yr) and 5 control cases (3M, 2F; ages 30–73, mean 51.4 yr) were quantitatively examined for demyelination by luxol fast blue and axonal preservation (NF200 immunohistochemistry) within descending vasomotor pathways (DVPs), DRSPs, corticospinal tracts (CST) and dorsal columns. **Results:** There were 21 SCI individuals (6F, 15M; ages 17–83, mean 57.1 yr) of whom 14 suffered motor incomplete SCI (ASIA C, D) and the remaining were motor complete (ASIA A, B; $n = 7$). Hyponatremia occurred in 85.7%. In the postmortem group, 50% of cases with SCI developed hyponatremia. The number of preserved axons within CST, DVPs and the DRSPs was significantly reduced after SCI. Mean and lowest sNa were correlated with the area of demyelination and inversely correlated with number of preserved DRSP axons. Normonatremic SCI individuals showed greater preservation of the DRSPs than those with hyponatremia. **Conclusions:** Hyponatremia is frequent after SCI and is associated with injury severity. The extent of destruction of DRSPs is inversely correlated with post-SCI hyponatremia, and this likely reflects autonomic renal dysfunction.

Anterior corpectomy approach for removal of a cervical intradural schwannoma: technical case report and review of the literature. ***J. Cheng Xie, R.J. Hurlbert, S. Casha.*** **University of Calgary Spine Program, Calgary, Alta.**

Objective and importance: Intradural schwannomas of the cervical spinal cord are conventionally approached through posterior or postolateral surgical techniques. The anterior approach may offer more direct access to some tumours but may be disadvantageous due to a narrow operative corridor. **Case report:** An intradural-extramedullary schwannoma presented in a 31-year-old man with neck pain, progressive gait difficulties and bilateral arm weakness. The tumour spanned the C3 and C4 vertebral levels in the anterior midline, displacing the spinal cord posteriorly. The tumour was entirely resected through an anterior C3 and C4 corpectomy approach followed by C2 to C5 arthrodesis. The patient recovered full neurological function and had a stable union at 4 months postoperatively. **Discussion:** The anterior approach to midline intradural tumours is a very feasible alternative, particularly when the lesion is not accessible through a posterior approach. The operative corridor is adequate. This approach may be prone to significant blood loss from epidural veins.

Chylothorax following video-assisted thoracscopic surgery for anterior release and fusion: a case report. ***C.W. Reilly, R.L. Choit, E. Blain.*** **Department of Orthopaedics, University of British Columbia, Vancouver, BC; Faculty of Medicine, McGill University, Montréal, Que.**

We present a case of chylothrorax following video-assisted thoracoscopic surgery for anterior release and fusion. An 11-year-old girl with developmental regression and idiopathic scoliosis underwent VATS anterior release followed by posterior instrumentation and fusion from T3 to L4. There were no intraoperative complications. Chest tube drainage steadily decreased from 1100 cc the first 48 hours to 265 cc on POD 5, with a serosanguinous appearance. On POD 6, the drainage changed to thick yellow and milky and rose to a volume of 660 cc. That change in output coincided with the reintroduction of feeding. A fluid sample confirmed that the drainage was constituted of 95% of lymph and lipid-free TPN diet was instituted. On the following day, CT drainage was back under 300 cc, and the patient underwent debridement and repair of her wound due to wound dehiscence. On POD 13, output was 40 cc and the chylothorax was considered to be resolved. A chylothorax is an accumulation of lymph in the pleural cavity, usually after disruption of the thoracic duct. Although rare, chylothorax following VATS of the spine is a serious complication that needs to be kept in mind when operating on pediatric patients using such a novel technique. There is only one other case report in the literature of chylothorax in the pediatric population as a complication of thoracoscopic spine surgery.

Management of cervical posterior element instability with anterior decompression and fusion. ***D. Serletis, S. Casha, M Alhejji, R. Cho, R.J. Hurlbert.*** **University of Calgary Spine Program, Calgary, Alta.**

Background: Anterior discectomy and fusion is an alternative to posterior instrumented fusion for traumatic posterior element disruption in the cervical spine. **Methods:** We retrospectively reviewed 72 patients treated by anterior cervical decompression and fusion (65 single-level, 7 multilevel) for posterior cervical spine instability due to unilateral or bilateral fracture, dislocation or ligamentous disruption. Mean follow-up was 16 months. **Results:** Fusion was achieved in 96.8%. Asymptomatic spinal deformity occurred in 4 patients (2 kyphosis, 1 anterolisthesis, 1 retrolisthesis). There were 4 patients with complications (2 with transient dysphagia, 1 with esophageal fistula and 1 with iliac fracture). Hardware failure occurred in 3 patients (plate fracture, graft extrusion, screw

back-out). Two patients underwent reoperation (for non-union resulting from hardware failure, and for iliac fracture). Sixty-four percent of patients presented with neurological injury (29 radiculopathy, 17 spinal cord injury). Neck pain was seen in 61%. Seven patients with spinal cord injury improved neurologically; 4 were unchanged. Twenty-two radiculopathic patients improved, and 3 were unchanged. At last follow-up, 31 patients denied pain, 24 had mild pain and 6 had moderate or severe pain. Four patients were independent but restricting activities; 4 patients required assistance for daily living. **Conclusions:** Anterior decompression and fusion is safe and effective for management of traumatic posterior element disruption in the cervical spine.

The long-term efficacy of cervical laminoplasty in the treatment of cervical spondylotic myelopathy. ***N.R Berrington*. Section of Neurosurgery and Winnipeg Spine Program, University of Manitoba, Winnipeg, Man.**

The author presents his experience with 16 patients presenting with cervical spondylotic myelopathy, treated by open door cervical laminoplasty. Average follow-up is 28 months (range 22–36 mo).

Males and females are equally represented. The age range is 41–85 years of age. All patients presented with myelopathy due to cervical spondylosis. The change in JOA score postoperatively varied from 0 to 4. The average change in JOA score was 2.06. In spite of the modest change in JOA score, a dramatic effect on ambulation ability was noted.

Four cases failed to show any improvement of myelopathic features, and 1 case demonstrated ongoing deterioration.

Complications included profuse venous bleeding (1 case), wound sepsis (1 case) and reclosure of lamina requiring a "rescue" procedure 2 years later (1 case).

The author concludes that the efficacy of laminoplasty is sustained with long-term follow-up, and the procedure can be performed with relative safety. Even patients unable to ambulate preoperatively may benefit from this procedure.

The efficacy of spinal injections in the management of low back pain and radicular pain. A critical appraisal of an academic practice. ***J. Dusik-Sharpe, N.R. Berrington*. Section of Neurosurgery and Winnipeg Spine Program, University of Manitoba, Winnipeg, Man.**

The efficacy of spinal injections remains a controversial topic.

The authors present their experience of invasive injection therapy in the management of patients with a variety of spinal disorders over a 9-month period. A total of 109 procedures were done in 95 patients. The age of patients varied from 16 to 87 years (mean 55.2 yr). Duration of symptoms varied from 2 months to 50 years (mean 75.9 mo). All procedures were performed by a single operator in a fluoroscopy suite.

Procedures included 20 facet blocks, 59 perineural blocks, 3 facet rhizotomies and 3 pars blocks and 7 sacroiliac joint injections. Miscellaneous cervical procedures and denervations are included in the study.

Preoperative VAS and SF 36 scores were compared with results at 1 week, 6 weeks and 3 months. Despite initial improvement in almost half of the patients, the difference in the SF36 score at 3 months is not statistically significant.

The authors analyze the efficacy of each procedure and the predictors of poor outcome. Outcomes varied by procedure, but analysis of SF36 would, in general, not support these injections as long-term patient management strategies.

Unconventional applications for minimal access spinal fixation. Preliminary outcomes. ***O.R.T. Williams, N.R. Berrington*. Section of Neurosurgery and Winnipeg Spine Program, University of Manitoba, Winnipeg, Man.**

Minimal access spinal fusion is currently gaining wide acceptance among spine surgeons. The authors present their preliminary experience of unconventional applications for this technology.

Minimal access decompression and spinal fixation may provide a less morbid treatment option to patients with spinal metastasis. The authors present their preliminary experience with 6 cases treated with this approach. The technique provided excellent neural decompression and pain relief with a minimum of morbidity and is characterized by significantly shorter hospital stay. Very short, paramedian, trans-muscular approaches also minimize surgical dissection and allow consideration for early radiation therapy.

Additional cases of vertebral fractures and discitis are also presented.

We conclude that minimal exposure and reconstruction techniques do not inherently limit the volume of spinal tissue subject to surgical management, nor do narrow, well-chosen surgical corridors preclude complex surgical tasks.

Comparing in vivo functional cervical spine motion following single level anterior cervical discectomy and fusion versus implantation of an artificial cervical disc. ***D. Rabin, G. Pickett, N. Duggal*. University of Western Ontario, London Health Sciences Centre, London, Ont.**

Purpose: Anterior cervical discectomy and fusion (ACDF) for management of cervical spondylosis may promote further degenerative changes secondary to abnormal spinal motion. Insertion of an artificial cervical disc (AD) may prevent this accelerated degeneration. This case–control retrospective cohort study compares in vivo functional cervical motion in ACDF and AD patients. **Methods:** Ten patients with single-level ADs were matched to 10 single-level ACDF patients based on age, sex and operated level. Lateral neutral, flexion and extension cervical radiographs were obtained preoperatively and up to 24 months postoperatively. Kinematic parameters including range of motion (ROM), translation, disc height and centre of rotation (COR) were measured for all cervical levels using motion analysis software. Changes in these parameters were compared between matched patients. **Results:** ROM differed significantly between ACDF and AD patients at the operated level in both early (mean 1.00 v. 6.70, $p = 0.003$, paired t test) and late (mean 0.90 v. 8.60, $p < 0.001$) follow-up. Late follow-up showed a trend toward increased change in ROM at the superiorly adjacent level in ACDF patients, which was not seen in AD patients (mean 7.430 v. –2.210, $p = 0.06$, unpaired t test). Global cervical ROM, translation, disc height

and COR were not significantly altered at any level in the AD patients. Full analysis of the ACDF group is pending. **Conclusion:** ACDF significantly reduces sagittal ROM at the operated level, while an AD maintains it. Preliminary data suggests a trend toward postoperative increase in ROM at the superior level in ACDF in comparison to AD. Complete comparative analysis of kinematics will be presented.

Laboratory tests of a new injection cannula for vertebroplasty. *G. Baroud.* Laboratoire de Biomécanique, Université de Sherbrooke, Sherbrooke, Que.

Study design: An analytical model and a laboratory experiment are used to evaluate a new cannula design. **Objective:** To determine whether the new cannula geometry significantly reduces the delivery pressure and eases cement injection during vertebroplasty. **Summary of background data:** One of the main limitations of vertebroplasty is the excessive pressure required to inject sufficient amounts of cement into a vertebral body. Based on previous work that shows that approximately 95% of the injection pressure is required to deliver the cement through the cannula, we proposed a new cannula design with a larger internal diameter in the proximal section. **Methods:** Two different methods were employed to examine the delivery pressure in a conventional and 2 redesigned cannulae. (a) Analytical model: Hagen–Poiseuille flow through a tube was used to predict the pressure drop in the cannulae. (b) Experiment: First a Newtonian silicone oil and then an acrylic bone cement was injected through the cannulae at a constant rate of 4 cc/min, and the delivery pressure was recorded. **Results:** Both the experimental and analytical findings confirmed that the redesigned cannula reduces the delivery pressure significantly. More specifically, when the internal diameter of the proximal section was increased by a factor of 2, which is clinically feasible, the delivery pressure dropped by about 63%. **Conclusion:** The redesigned cannula appears to have the potential to improve vertebroplasty. The key benefits are: (1) it eases cement injection; (2) it can be easily integrated into the existing procedure; and (3) it is cost effective.

Ex-vivo measurements of intra-vertebral pressure in vertebroplasty. *G. Baroud.* Laboratoire de Biomécanique, Université de Sherbrooke, Sherbrooke, Que.

Study design: An experimental study conducted on osteoporotic cadaveric vertebrae. **Objectives:** (1) To measure the intra-vertebral pressure and injection pressure. (2) To determine the effect of the vertebral shell on the intra-vertebral pressure and on the injection pressure. **Background data:** Biomechanical forces that govern cement flow are an essential component of the cement injection process in vertebroplasty. The vertebral shell may play a significant role in confining the flow of cement in the vertebra, thereby affecting the intra-vertebral and injection pressure. **Methods:** A small fenestration was created in the left lateral vertebral shell of 14 vertebrae. A valve to open and close the fenestration and a sensor to measure the intra-vertebral pressure were attached to the opening. A closed fenestration simulated an intact shell, whereas an open fenestration represented a vented shell. Injection pressure and intra-vertebral pressure were recorded during a controlled injection. **Results:** The intact vertebra showed a significant increase in the intravertebral pressure. During the injection, it increased on average to approximately 3.54 ± 2.91 kPa. Conversely, an open fenestration resulted in an instant relaxation of the shell pressure to the ambient pressure of 0 kPa. More importantly, the injection pressure was almost 97 times higher than the intra-vertebral pressure. **Conclusion:** The intra-vertebral pressure adds little to the injection pressure. Methods such as venting or creating a cavity may have a minor impact on the injection pressure. Alternative means such as a redesigned cannula may be required to ease cement delivery.

Biomechanics of the cement injection of cement augmentation procedures. *G. Baroud.* Laboratoire de Biomécanique, Université de Sherbrooke, Sherbrooke, Que.

The incidence of osteoporotic bone fractures is growing exponentially as the western population ages and as life expectancy increases. Vertebroplasty, where acrylic or calcium phosphate cement is injected into the weakened vertebrae to augment them, is an emerging procedure for treating spinal fragility fractures. However, cement injection is currently limited due to a lack of clear standards for a safe, reproducible and predictable procedure. The purpose of this paper is to examine the role that bone cements play in the underlying bio-mechanisms that affect the outcomes of cement injection. Our most important finding after combining clinical, laboratory and theoretical research is that the process of cement injection poses conflicting demands on bone cements. The cements are required to be more viscous and less viscous at the same time. The challenge therefore is to develop biomaterials, techniques and/or devices that can overcome or manage the conflicting demands on cement viscosity.

Biomechanical study of adjacent fractures following vertebroplasty. *G. Baroud.* Laboratoire de Biomécanique, Université de Sherbrooke, Sherbrooke, Que.

Introduction: Vertebroplasty, where bone cement is pressure-injected into an osteoporotic vertebra at fracture risk, is an emerging procedure for managing and possibly preventing these fractures. Cement injection provides immediate and remarkable pain relief to patients. Currently, the predominant paradigm is maximum filling of the vertebra of interest. Using theoretical and experimental models, this paper will point out that the maximum filling may not be necessary or beneficial for an effective vertebroplasty. **Methods:** Changes in the material properties of spinal cancellous bone due to cement filling was experimentally examined using uniform compression tests (in vitro). A finite-element model of lumbar-motion segment incorporating these material changes was developed to examine static loading of the intervertebral (IV) joint adjacent to the augmented vertebra. **Results:** Cement-filled bone is 36 times stronger and 12 times stiffer than cancellous bone. FE analysis illustrated that cement in the augmented vertebra acts as an upright pillar that reduces the physiological inward bulging of the endplates of the augmented vertebra. As a result, IV pressure increases by 19%, and the loading adjacent to the augmented one increases by 17%. **Discussion:** The FE

results were confirmed by an elaborate experimental study conducted by Berlemann (2002), who reported a 19% decrease in the strength of vertebrae adjacent to the augmented one. Also, emerging long-term clinical studies are increasingly reporting on the phenomenon of adjacent fractures following a vertebroplasty. Clinicians may therefore need to shift their paradigm from maximum filling to sufficient filling.

Assessment of a hybrid cardiovascular and trunk stabilization exercise program for lumbar disc herniated patients. ***M. Johnson, M. Goytan, D. Kriellaars.*** **Department of Surgery, University of Manitoba, Winnipeg, Man.**

Examine the outcomes of a novel, hybrid exercise program on lumbar spine disc herniated patients. Three groups (n = 25); EX-exercise (6–8 weeks, 2×/w, 6 multi-stage trunk stabilization exercises and walking program); NEX-no exercise; NORM-subjects without back pathology. The EX and NEX groups had radiographically verified posterolateral lumbar disc herniation with low back and unilateral extremity pain. EX and NEX assessed at baseline and at 6–8 weeks for pain (VAS for intensity, capacity and provocation), Oswestry Disability Index (ODI) and Disability of Arm, Shoulder and Hand (DASH). Objective measures of physical activity (PA) and cardiovascular function (CV) were employed. The NORM group was assessed once using these measures. PA measured for 7 days (RT3 triaxial accelerometer). CV was assessed using the 1-mile walk test (Rockport, treadmill based). Exercise volume (repetitions, stage level) was computed for the EX group at each treatment. EX group improved in CV, ODI, DASH and pain ($p < 0.05$) but not PA. NEX and EX were significantly lower in CV and PA in comparison with NORM ($p < 0.05$). After completion of the program, the EX group was still significantly lower than NORM in CV and PA. Important lifestyle modifications through enhanced physical activity (at work or leisure) were not adopted even though disability was substantially reduced at discharge. Continued behaviour modification would be required to attain the enhanced PA.

Driving with a cervical collar: vehicle kinematics. head movement and driver stress. ***M. Johnson, M. Thiessen, S. McFayden, D. Kriellaars.*** **Department of Surgery, University of Manitoba, Winnipeg, Man.**

The impact of a cervical collar on driving has not been determined. This study was a preliminary investigation of vehicle and driver assessment methodology. Five subjects drove an automatic vehicle on a basic closed circuit. Subjects wore a heart rate monitor (Polar S810i, RR data collection) and a triaxial accelerometer (RT3, 1-second sampling) mounted to the occiput. The vehicle dynamics were monitored by GPS (Garmin III using a 1-Hz sampling rate). The UTM positional data was downloaded, and the velocity and acceleration of the vehicle were computed. The drivers drove the course in 4 conditions: normal (N), aggressive (A), cautious (C) and with an Aspen cervical collar (CC). GPS derived dynamics clearly delineated between the driving styles (mean velocity and mean absolute acceleration, $p < 0.05$). The highest HR was observed for aggressive driving. HR variability was highest (lowest stress) in the normal driving condition. Collared, aggressive and cautious driving showed lower HRV (higher driver stress, $p < 0.05$). Unexpectedly, head accelerometry showed that collared driving had the greatest number of left/right head checks. These methodologies were capable of classification of driver and driving characteristics supporting the use of these tools in safety and rehabilitation studies of cervical injured patients. Collared driving was similar to the cautious driving state but with high frequency of low amplitude head checks.

Canadian orthopedic curriculum: the spine. ***V. Wadey, E. Tang, J. Bouchard, P. Dev, J. Halpern, R. Olshen, D. Walker.***

Purpose: The purpose of this research was to determine the opinions of orthopedic surgeons regarding the spine curricula targeted to meet the needs of residency training in Canada. **Study design and setting:** Cross-sectional survey of orthopedic surgeons in Canada whose primary affiliation is non-academic. **Methods and analysis:** A 281-item questionnaire was developed based on the musculoskeletal core curriculum recommendations outlined by the Bone and Joint Decade Undergraduate Curriculum Group (BJDUCG) and previous research involving the program directors and educators from 16 accredited orthopedic residency training programs across Canada. Structured "elite" one-to-one interviews with a random selection of orthopedic surgeons were completed. The choices of response in the questionnaire were 0, unable to assess; 1, not important; 2, probably not important; 3, probably important; and 4, important. The 24 items that pertained to spine were identified and analyzed. The data were analyzed descriptively and quantitatively. **Results:** 131/156 (84%) respondents participated in this study. 12/24 received an average ranking of ≥ 3.8/4.0 (important); 2/24 items were ranked to be ≥ 3.0/4.0 (probably important); and 10/24 items that pertained specifically to spine procedures were ranked < 2.5/4.0 (probably not important). A multiple comparison analysis of each question was significant at the $p < 0.05$ level. **Conclusions:** This study demonstrated with reliable statistical evidence agreement among orthopedic surgeons in Canada regarding topics to be included in a spine curriculum for educating residents. Differences that do exist appear to relate to procedures performed during residency.

Perioperative blood loss after posterior vertebral fusion for adolescent idiopathic scoliosis (AIS). ***G. Grimard, J. Joncas, H. Labelle, B. Poitras, C.H. Rivard.*** **Hôpital Ste-Justine, Montréal, Que.**

Purpose: To determine the predictive factors associated with perioperative blood loss after spinal fusion for AIS. **Conclusion:** Blood loss after posterior vertebral fusion for AIS is associated with the length of the procedure, number of fused levels, number of screws implanted and the utilisation of the cell saver. **Significance:** The identification of factors associated with blood loss after spinal fusion for AIS will allow us to develop better strategies to reduce blood transfusion. **Results:** The cohort included a total of 480 subjects (87% girls) with a mean age of 14.9 ± 2.1 years. The mean preoperative Cobb angle was 62° ± 15°. Most scolioses were right thoracic and left lumbar. The average number of level fused was 10.8 ± 2.2. The length of the

procedure was on average of 314 minutes. The mean perioperative blood loss was 1873 ± 1055 mL. Patients were transfused an average of 3.5 units of autologous blood. Almost all subjects participate in the blood donation program. The multivariate analysis showed that blood loss is mostly affected by the length of the procedure ($p < 0.01$), number of levels fused ($p < 0.01$), number of screws implanted ($p < 0.01$) and use of the blood saver ($p < 0.01$). **Material and methods:** This retrospective and prospective study was carried out at Shriners and Ste-Justine Hospitals between 1993 and 2004. All subjects who underwent a posterior vertebral fusion and instrumentation for AIS were included. The clinical and radiological charts for all patients were reviewed by an independent observer. More than 100 variables per subject were collected and analysed. A bivariate analysis of variance was used to identify the variables associated with blood loss, then a regression analysis was carried out.

Financial support: Ortho Biotech Company.

Recalled pre-injury health-related quality of life in patients who have sustained spine trauma.

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Objectives: To determine the relationship between recalled Health Related Quality of Life (HRQOL) and age-matched normative data in a sample of spine trauma patients. **Summary of background data:** There are situations in which baseline psychometric evaluation of patients is difficult or impossible. The acute spine trauma patient represents such an example. Without baseline data it is difficult to know how successful an intervention has been in trying to restore the patient's pre-event or pre-treatment HRQOL. **Methods:** A consecutive series of spine trauma patients, following appropriate medical or surgical treatment of their spine injury, were asked to complete 2 self-administered outcome instruments, the Medical Outcomes Study SF-36 and the NASS Cervical or Lumbar Questionnaire, as appropriate for their level of injury. Patients were asked to complete the outcome measures by recalling their health status during the 3 months prior to injury. The primary comparison was between recalled HRQOL and normative data, as measured using individual normalized scores. **Results:** Forty-nine patients completed outcome measures following treatment of their acute spine injury. Using the SF-36 and NASS instruments, we found that recalled HRQOL closely approximates normative data. The exception to this was the NASS Pain and Disability Score (PDS) which was 1 standard deviation lower than the age-matched normative scores. **Conclusions:** Recalled pre-injury HRQOL approximates normative data for the generic SF-36 and to a lesser extent for the disease-specific NASS instrument. This study was limited by its small sample size and the lack of a gold standard comparison group.

Acute postoperative pain following outpatient lumbar microdiscectomy: an assessment of 2 different microsurgical approaches.

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Objective: The primary objective of this retrospective study was to assess the effectiveness of a minimally invasive tubular retractor system (METRx™) in reducing acute perioperative pain and analgesic use. **Methods:** Patients undergoing outpatient microdiscectomy using a minimally invasive tubular retractor (METRx™; Group T, $n = 95$) were compared to a similar group where a conventional microdiscectomy retractor (McCullough; Group C, $n = 106$) was utilized. **Results:** Comparatively, the groups were equal with respect to age, sex, body mass index, surgical level, surgical side and type of preoperative analgesic use. A significant ($p < 0.05$) reduction in PACU-IV and total analgesic use as well as pain VAS (6.1 [C] v. 3.5 [T]) was found in the tubular retractor group. In addition, this group had shorter PACU (mean time = 84 min [C] v. 73 min [T]) and DSU (mean time = 224 min [C] v. 182 min [T]) stays. Logistic linear regression showed a significant ($p < 0.05$) reduction in PACU pain VAS and IV / total analgesic use as well total oral analgesic use in DSU. **Discussion and conclusion:** Infiltration of the paraspinal muscles with local anesthetic was utilized significantly less in the conventional group and is a confounding variable. However, the effect of local anesthetic infiltration on pain following lumbar microdiscectomy is unclear as reflected by conflicting results from 2 randomized blinded studies. Despite this and other inherent weakness of any retrospective study, the results of this retrospective review (with a good sample size and homogenous groups) do suggest that the use of a minimally invasive tubular retractor microdiscectomy reduces acute postoperative pain.

Surgical management of the adult tethered cord syndrome.

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Introduction: The adult tethered cord syndrome (TCS) is a complex clinical condition that continues to pose a management challenge. To date, relatively few studies have reported on the clinical outcomes of these patients following neurosurgical intervention. **Methods:** Patients who underwent de-tethering surgery between August 1993 and 2004 were identified. Their clinical charts, operative records, urodynamic studies, electrophysiological and follow-up data were reviewed. **Results:** De-tethering procedures were performed in 55 patients (age range 19–72 yr) for TCS of varying etiologies. Forty-five of these patients underwent surgery by the senior author (M.G.F.). The most common tethering lesions were tight filum terminale ($n = 35$), lipoma ($n = 9$), secondary adhesions ($n = 9$) and split cord malformation ($n = 2$). Fifty-five patients presented with progressive pain and/or neurological dysfunction. One patient underwent prophylactic sectioning of the filum terminale. Most patients had bladder dysfunction at presentation. Micro-surgical release of the tethered cord was performed in each case using intra-operative neurophysiological monitoring. The most common complication encountered was CSF leak, which was managed by reinforcement sutures ($n = 4$), temporary external drainage ($n = 2$) and lumbo-peritoneal shunting ($n = 2$), respectively. Infective

complications included superficial wound infection (n = 2) and meningitis (n = 1). One patient experienced worsened foot weakness postoperatively. At a mean follow-up period of 28.3 months, the majority of patients presenting with back (59%) and leg pain (72%) improved. Preoperative motor weakness (68%) was more likely to improve than sensory deficits (47%). Overall, the neurological status was improved or stabilized in 85% of patients. Subjective improvement in bladder function was noted in 60% of patients. **Conclusions:** Surgery for adult TCS is safe and effective for improving pain and neurological status in a majority of patients.

A comparison of functional outcomes in patients treated surgically by open and minimally invasive means for low-grade isthmic spondylolisthesis. ***F. Miyanji, W. Latham, Y. Raja Rampersaud, S.J. Lewis, S. Zhang.*** **Department of Orthopaedic and Neurosurgery; Spinal Program, Toronto Western Hospital, Toronto, Ont.**

Purpose: To compare the health-related quality of life (HRQoL) of patients treated surgically for low-grade isthmic spondylolisthesis by open and minimally invasive (MIS) interbody techniques. **Methods:** Outcome data for all patients were collected prospectively. A retrospective chart review was done to obtain baseline demographic and clinical variables. Cross-sectional outcome analysis was done using Oswestry and SF-36. **Summary of results:** Seventeen patients treated with MIS technique were age- and sex-matched with a cohort of 16 patients treated by open technique. For the open group, the average ODI/SF-36 PCS/SF-36 MCS scores were 21.2% /35/42.9 preoperatively and 8.4%/47.4/47.7 postoperatively (mean follow-up 18 mo). In the MIS group, the ODI/SF-36 PCS/SF-36 MCS scores were 24.9%/30.4/39.2 preoperatively and 12.5%/41.1/53.9 postoperatively (mean follow-up 6 mo). A statistically significant difference was not found when comparing the postoperative scores between these groups. **Discussion and conclusion:** There are few clinical outcome studies to support the potential benefits of MIS spinal procedures. This study found that the functional outcome of patients treated either by the open or MIS technique is favourable. Study limitations were characteristic of retrospective reviews; however, this study is strengthened by a comparison of matched homogenous cohorts and validated outcomes. No difference in the ODI, PCS and MCS was shown between the 2 groups. Postoperative pain, blood loss and hospital stay were reduced in the MIS group at the expense of operative time.

Surgical options for the treatment of metastatic lesions of the upper cervical spine. ***F. Miyanji, S.J. Lewis.*** **Division of Orthopaedic and Neurosurgery; Spinal Program, Toronto Western Hospital, Toronto, Ont.**

Purpose: To illustrate reconstructive techniques for metastatic lesions of the upper cervical spine. **Method and discussion:** Baseline variables were obtained by chart review. Healing and alignment were determined by radiographic analysis. Attention to the reconstruction of the anterior column deficits was achieved in all cases with stable constructs providing good pain relief. This series demonstrates good results with innovative reconstructive techniques of upper cervical lesions. **Summary of results:** Three patients underwent reconstruction with the C2 body being involved in 2 cases (breast carcinoma, plasmacytoma) and the C1 lateral mass in 1 case (metastatic thyroid papillary carcinoma). Both C2 body tumours were treated with curettage and open vertebroplasty with odontoid screws and a posterior C1–C2 fusion in 1 case. The C1 tumour was treated with a posterior occipito–cervical fusion, a posterior resection of the tumour and reconstruction using a Harms cage. All patients underwent postoperative radiation. Resolution of neck pain was achieved in all cases. Two patients died of disease progression at 7 and 10 months. The other patient was disease free at 18 months with an Oswestry score of 0, a SF-36 PCS of 57 and MCS of 60. **Conclusion:** Vertebral column metastases involving the upper cervical spine and craniocervical junction present a surgical challenge. Patients with a long life expectancy having extensive metastases of the upper cervical spine can benefit from surgical stabilization. We demonstrate several unique techniques as options for treatment. The functional outcome and radiographic analysis after these procedures is favourable.

Spinal stenosis CT parameters: an analysis of interobserver variability. ***A. Furey, V. Sahajpal, G. Hogan, C. Stone.***

Diagnosis of lumbar spinal stenosis is a common clinical problem, as it represents both an anatomic and clinical diagnosis. Although the gold standard is considered to be myelography, many new tests have developed that are less invasive and offer potentially more preoperative information. The purpose of this study was to assess the degree of reliability in using one of these modalities, namely CT scanning. Twenty-five CT scans reported as being stenotic were randomly chosen from the past 5 years in 2 tertiary care centres. The CTs were reviewed by 2 orthopedic surgeons, 1 senior orthopedic resident, 2 radiologists and 1 neurosurgeon who measured the AP and IP diameters of marked images representing L3–4, L4–5 and L5–S1. They were also asked to classify the spinal canal as normal, mild, moderate or severe stenosis. The results were first tabulated and analyzed using a weighted kappa test for the spinal canal as a whole. The weighted kappa achieved was 0.51 with a 95% confidence interval of 0.43–0.60. A second weighted kappa was performed assessing the agreement between orthopedic surgeons (0.58) and between radiologists (0.58). Weighted kappas were performed considering the Verbiest classification at all 3 levels L3–4, L4–5 and L5–S1 were 0.25, 0.22 and 0.26, respectively. A series of 4 ANOVA analyses were performed to determine the degree of agreement in the AP measurements when considering how the scans were originally classified as normal, mild, moderate or severe. It was concluded that the degree of agreement between observers in assessing the degree of stenosis for the spine overall was moderate while the agreement between measurements and assessing individual level was less reliable.

