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LOW BACK PAIN IN AUSTRALIAN ADULTS. THE ECONOMIC BURDEN

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INTRODUCTION: Low back pain (LBP) is a common symptom in Australian adults. In any six months period approximately 10% of Australian adults suffer some significant disability from low back pain[1]. One way of assessing the impact of LBP on a population is to estimate the economic costs associated with the disorder. This method is usually known as a "Cost-of-Illness" or an "Economic Burden" study[2]. The economic burden of disease is often divided into direct and indirect costs and is most often calculated using the Human Capital Method[2]. According to this method the direct costs are represented by the dollar value of the interventions required for diagnosis, treatment and rehabilitation of the disease and the indirect costs by valuing the loss of productivity due to morbidity and mortality[2,3]. We estimated the economic burden of LBP in Australian adults.

METHODS: Data sources used in this study were the 2001 Australian adult low back pain prevalence survey[1] and a multiplicity of Commonwealth, State and Private Health instrumentalities. Using the Human Capital Method direct costs were estimated on the basis of market prices (charges) and the indirect costs by valuing the loss of productivity due to morbidity. The conservative Friction Cost Method for calculating indirect costs was also used as a comparison[4]. A sensitivity analysis was undertaken where unit prices and volume for a range of services were varied over a feasible range (10%) to review the consequent change in overall costs.

RESULTS: We estimated the direct cost of low back pain in 2001 to be AUD$1.02 Billion. Approximately 71% of this amount is for treatment by chiropractors, general practitioners, massage therapists, physiotherapists and acupuncture. However, the direct costs are minor compared to the indirect costs of AUD$8.15 Billion giving a total cost of AUD$9.17 Billion. The sensitivity analysis showed very little change in results.

DISCUSSION: The economic burden of low back pain in Australian adults represents a massive health problem. This burden is so great that it has compelling and urgent ramifications for health policy, planning and research. This study identifies that research should concentrate on the reduction of indirect costs. This is not to suggest excluding direct cost research, as it is likely that early, efficient and evidence-based management of low back pain in the first instance may lessen the indirect costs that often follow. These startling results advocate urgent Government attention to LBP as a disorder.

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LOW BACK PAIN IN AUSTRALIAN ADULTS. HEALTH PROVIDER UTILISATION AND CARE-SEEKING

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INTRODUCTION: There is no shortage of treatments for low back pain (LBP), including medication, injections, bed rest, physiotherapy, chiropractic, osteopathy, acupuncture, massage therapy, and surgery. In addition to this are a plethora of home and folk remedies. However, there is still doubt about the efficacy or effectiveness of even the most common forms of therapy[1]. Also, little is known about the proportion of persons who seek care for LBP, why they sought care, the type of care sought and indeed what differentiates them from those who do not seek care at all. The objective of this study was to determine the characteristics of Australian adults who seek care for LBP, including the type of care they choose and any factors associated with making those choices.

METHODS: An age, gender and State stratified random sample of 2768 Australian adults was selected from the

Electoral Roll. This sample were mailed a fully structured questionnaire that included a series of questions relating to care-seeking for LBP, choice of provider and types of treatment received. In addition a series of questions were asked relating to demographic characteristics, socioeconomic variables, and severity of LBP. Also asked was cigarette smoking status, anthropometric variables, perceived cause of low back pain, emotional distress, job satisfaction, physical fitness, past five year health status, and whether the subject feared LBP could impair their work capacity or life in the future.
RESULTS: The survey response rate was 69.1%. The sample proved to be similar to the Australian adult population. The majority of respondents with LBP in the past six months did not seek care for it (55.5%). Factors that increased care seeking were higher grades of pain and disability, fear of the impact of pain on future work and life and female sex. Factors decreasing the likelihood for seeking care were identified as the cause of pain being an accident at home and also never being married. General medical practitioners and chiropractors are the most popular providers of care.
DISCUSSION: High levels of pain and disability equating with higher levels of care-seeking would not surprise, however fear as a motivator for care-seeking has implications for clinical practice. Another important issue is the type of care selected for LBP. Using the best evidence available for the management of LBP is now seen as a responsibility for all practitioners. It would be useful to compare care-seeking with the evidence of the efficacy and effectiveness of the various therapies utilised.
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THE INNERVATION OF THE INTERVERTEBRAL DISC : A QUANTITATIVE ANALYSIS

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INTRODUCTION: Although it is well recognised that the outer annulus is innervated, the relative densities of innervation of different regions of the disc have not been quantitated. We present here the first comparative analysis of the innervation of the innervation of different regions of the lumbar intervertebral disc.
METHODS: A sheep model was used allowing evaluation of the whole motion segment. Four sheep spines were used. One was processed for PGP 9.5 immuno-fluorescence and three were processed for PGP 9.5 immuno-peroxidase histochemistry. Serial sagittal sections were obtained and a count was made of the densities of innervation of different regions of the endplate and annulus. These were compared to identify which areas of the disc and endplate are most innervated.
RESULTS: The endplate innervation is concentrated centrally adjoining the nucleus. The mean density of innervation of the central endplate was 0.44 (SEM 0.07) nerves/mm^2 while the mean density of the peripheral endplate was 0.10 (SEM 0.03) nerves/ mm^2 ($p= 0.0001$). There was no significant difference between the overall endplate and annulus innervation densities 0.52 (SEM 0.1) v 0.37 (SEM 0.07) $p=0.2$. But the peri-annular connective tissue, external to the outer annulus contained the densest innervation of any region in the motion segment 1.05 (SEM 0.16).
DISCUSSION: The lumbar intervertebral disc has a meagre innervation. This is concentrated in the peri-annular connective tissue and the central endplate. While receptor threshold is more closely related to nociceptive function than innervation density, these findings have important implications for any treatment of discogenic pain.

AN EVALUATION OF THE POTENTIAL FOR INTRADISCAL ELECTROTHERMAL THERAPY TO REPAIR AND DENERVATE PERIPHERAL ANNULAR TEARS IN AN ANIMAL MODEL

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INTRODUCTION: Intradiscal electrothermal therapy (IDET) is being used increasingly as a minimally-invasive treatment for chronic discogenic low back pain, with success reported in up to 70% of cases. The mechanism of action however is poorly understood. Proposed mechanisms include the contraction of collagen and the coagulation of annular nociceptors. An ovine model was used to assess the innervation of peripheral posterolateral annular lesions and the potential for IDET to denervate this region.
METHODS: Posterolateral annular incisions were made in 36 lumbar discs of 18 sheep. After twelve weeks the sheep underwent IDET at one level and a sham treatment at the other level. IDET was performed using a modified intradiscal catheter (SpineCATH^{TM}, Oratec Interventions Inc., Menlo Park, CA). Temperatures were recorded in the nucleus and the posterior annulus. The spines were harvested at intervals of up to eighteen months. Histological sections of the discs were stained with haematoxylin and eosin and an antibody to the general neuronal marker PGP 9.5.
RESULTS: The target temperature of 90°C at the catheter tip was reached in all cases. The mean maximum T_{Pa} was 63.6°C and the mean maximum T_N was 67.8°C. Vascular granulation tissue consistent with a healing response was observed in the region of the posterior annulus tear of all incised discs from 12 weeks. PGP 9.5 positive nerve fibres were clearly identified in the adjacent periannular tissue, but were scarce within the outer few lamellae of the annulus. There were no fewer nerve fibres identified in those specimens that had undergone IDET. From six weeks after IDET there was evidence of thermal necrosis in the inner annulus, sparing the periphery of the disc.
DISCUSSION: IDET delivered at 90°C in the sheep consistently heats the posterior annulus and the nucleus to a temperature associated with coagulation of nociceptors and collagen contraction. Thermal necrosis was observed within the inner annulus from six weeks after IDET. In this model IDET did not appear to produce denervation of the posterior annular lesion.

A RANDOMISED DOUBLE-BLIND CONTROLLED EFFICACY STUDY : INTRADISCAL ELECTROTHERMAL THERAPY (IDET) VERSUS PLACEBO

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INTRODUCTION: Intra-Discal Electrothermal Therapy (IDET) has been proposed as a treatment for chronic discogenic low back pain. Reports from prospective outcome studies demonstrate statistically significant improvements, but to date there are no published randomised controlled trials assessing efficacy versus a placebo group.
METHODS: Ethical committee approval was obtained prior to the study. Patients with chronic low back pain who failed to improve with conservative therapy were considered for the study. Inclusion criteria included the presence of one or two level symptomatic disc degeneration with posterior or postero-lateral annular tears as determined by provocative CT/discography. Patients were excluded if there was >50% loss of disc height or previous back surgery. Fifty-seven patients were randomised with a 2:1 (IDET: Placebo) ratio, 38 to the active IDET arm and 19 to the sham procedure (placebo). In all cases the IDET catheter was positioned under sedation to cover at least 70% of the annular tear defined by the CT/ discogram. An independent technician connected the catheter to the generator and either delivered electrothermal energy (active group) or did not (sham group). Both surgeon and patient were blinded to the treatment. Patients followed a standard post-procedural rehabilitation programme.
OUTCOME MEASURES: Low Back Outcome Score (LBOS), Oswestry Disability Index (ODI), SF-36 questionnaire, Zung Depression Index (ZDI) and Modified Somatic Perceptions Questionnaire (MSPQ) were measured at baseline and six months. Successful outcome was defined as: No neurological deficit resulting from the procedure, improvement in LBOS of >7 points, improvements in SF-36 subsets (pain/disability, physical functioning and bodily pain)
RESULTS: Two subjects withdrew from the study (both IDET). Baseline demographic data, employment and worker's compensation status, sitting tolerance, initial LBOS, ODI, SF-36, ZDI and MSPQ were similar for both groups.

No neurological deficits occurred as a result of either procedure. No subject in either treatment arm showed improvement of >7 points in LBOS or specified domains of the SF-36. Mean ODI was 41.4 at baseline and 39.7 at six months for the IDET group compared to 40.7 at baseline and 41.5 at six months for the Placebo group. There was no significant change in ZDI or MSPQ scores for either group.
DISCUSSION: No subject in either treatment arm met criteria for successful outcome. Further analysis showed no significant change in outcome measures in either group at six months. This study demonstrates no significant benefit from IDET over placebo.

RANDOMISED, PLACEBO-CONTROLLED TRIAL OF INTRADISCAL ELECTROTHERMAL THERAPY FOR CHRONIC LOW BACK PAIN

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INTRODUCTION: Intradiscal electrothermal therapy (IDET) is a controversial, new treatment for low back pain, whose efficacy has not been tested in randomised trials. The present study was undertaken to compare the efficacy of IDET with that of a placebo treatment.
METHODS: Patients were recruited by referral and by advertising in the media. Of 4,530 individuals who enquired, 1,360 were prepared to submit to randomisation. Of these, 260 were found potentially eligible after clinical examination, and 64 became eligible after discography. All had discogenic low back pain lasting longer than six months, with no co-morbidity. Thirty-seven were allocated to IDET, and 27 to sham therapy. Both groups were satisfactorily matched for demographic and clinical features. IDET was performed using a standard protocol, in which the posterior annulus of the painful disc was heated to 90^{o}C. Sham therapy consisted of introducing a needle on to the disc and exposing the patient to the same visual and auditory environment as for a real procedure. Follow-up at six months was achieved in over 85% of patients. Pain and disability were assessed using a visual analog scale for pain, the SF-36, the Oswestry disability scale, and the Back Depression Inventory.
RESULTS: Patients in both groups exhibited improvements, but improvements in pain, disability, and depression, were significantly greater in the group treated with IDET. Pain scores improved by 24 points in the IDET group compared with 11 in the sham group. Oswestry scores improved by 11 in the IDET group, but only by four in the sham group. More patients deteriorated when subjected to sham treatment, whereas eight patients (25%) achieved greater than 75% relief of pain following IDET. Only one patient did so after sham treatment. The number needed to treat, to achieve 75% relief of pain, was five. No patient suffered any adverse effects.
DISCUSSION: IDET fails to provide relief in some 50% of patients. Consequently, its efficacy is difficult to demonstrate statistically. Nevertheless, IDET provides satisfying relief in a substantial proportion of patients. Non-specific factors account for a large proportion of the apparent efficacy of IDET, but its efficacy cannot be attributed wholly to a placebo effect. The efficacy of IDET may be related critically to patient selection and the technique used. Improvements in either of these areas may improve the effect-size of IDET. Meanwhile, IDET is a low risk procedure that constitutes a legitimate option for patients with discogenic low back pain whose only alternative is fusion.

LATERAL APPROACHES TO THE CRANIO-CERVICAL JUNCTION

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INTRODUCTION: Standard approaches to the craniocervical junction (CCJ) include the midline posterior approach and the transoral approach. Both of them are limited laterally because of the Vertebral Artery (VA). Lateral approaches in which the VA is controlled and sometimes mobilised or transposed have been developed to reach the lateral corner of the CCJ. The surgical technique and personal experience are presented.
METHODS: From our experience in the VA surgical exposure, we developed since 1980 two lateral approaches directed towards the CCJ: the posterolateral and the anterolateral approach.

The posterolateral approach is a lateral extension of the midline posterior approach with control of the VA above the arch of atlas and opening of the CCJ up to the VA. Minimal drilling of the arch of atlas and occipital condyle is realised. It is mostly applied on intradural tumours but also in some extradural posterolateral lesions.

The anterolateral approach is a superior extension of the lateral approach used to control the VA from the C6 to C2 levels. The field is opened between the sternomastoïd muscle and the internal jugular vein. Then the VA is exposed between C1 and C2 transverse processes and above C1. It is essentially applied on extradural and bony lesions around the CCJ.

EXPERIENCE: Posterolateral approach was applied on 109 tumours, mostly meningiomas (N=78) and neurinomas (N=22) and four bony malformations compressing the VA or the neuraxis. Excellent results were obtained with complete tumoural resection (Simpson grade I or II for meningioma) with only one case of worsening of the neurological condition and two cases with stabilisation.

Anterolateral approach was used on 139 patients with different types of tumours including neuromeningeal tumours N=36, primary bone tumours N=51, sarcoma N=16 and others types N=21, and on three cases of VA compression by bone malformations. Satisfying tumoural resection could be achieved in almost all cases. Sacrifice of the VA was deliberately realised in five patients to ensure as radical a resection as possible in case of malignant tumours or chordomas.

There was no mortality in this series. Morbidity is very limited; injury of the VA was observed in two cases in which repair of the vessel could be done successfully. Stretching of the XI nerve was the cause of pain along the trapezius muscle in five patients.

CONCLUSION: Lateral approach to the CCJ can be realised through two different axis of work; the posterolateral and the anterolateral approach. These approaches give very nice and safe access to the lateral aspect of the CCJ. They complete the other approaches to the CCJ and may be used in association with them.

A MULTICENTER, PROSPECTIVE, RANDOMISED, STUDY OF AN ARTIFICIAL CERVICAL DISC VERSUS FUSION FOR PRIMARY CERVICAL DISC SURGERY

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INTRODUCTION: A prospective, randomised, controlled study has been conducted to compare the clinical outcomes of patients treated with an Artificial Cervical Disc to patients who receive fusion after cervical discectomy for the treatment of primary cervical disc disease. It is hypothesised that maintenance of motion after anterior cervical discectomy will prevent the high rate of adjacent level premature degeneration. The primary purpose of the study is to prove equivalence (non inferiority) of outcome of the disc prosthesis in the short term compared with fusion.

METHODS: In four centres, 60 patients with primary, single level cervical disc disease producing radiculopathy and/or myelopathy are randomised prospectively to receive anterior cervical discectomy with either fusion or artificial cervical disc placement. The patients are evaluated with pre- and post-operative serial flexion-extension cervical X-rays at six weeks, three, six, 12, and 24 months. At the same intervals, the patients have pre- and post-operative neck disability indexes, visual pain analogue scales, European myelopathy scores, SF-36 general health scores, and neurological status examinations assessing the patient's reflex, motor and sensory function.

RESULTS: Data are presented for the first 47 patients. At six weeks the neck disability index reduced by 36.1 for the investigational group compared to 34.8 for the fusion group. The pain score had reduced by 8.2 for the investigational group and by 9.9 for the control group. This improvement appeared to be maintained until the 12 month follow-up. In general there appeared to be a slightly better outcome for the investigational group. Both pain score and disability scores improved statistically significantly compared to the pre-operative scores ($p<0.001$ all comparisons). Analysis of non inferiority of outcome for the investigational group using ANCOVA with the pre-operative score as the covariate and a non inferiority margin of five points showed statistical significance at six and 12 weeks for Neck disability index. Operative time appeared slightly less (2.3 hours) for the investigational group compared to the fusion group (2.5 hours). Blood loss also appeared higher in the fusion group (165 mls compared to 91 mls). Hospital stay was equivalent (2.8 days and 2.9 days).

DISCUSSION: Anterior cervical discectomy and fusion has a good short term outcome though there is a high incidence of failure at adjacent levels over time. It is hypothesised that the maintenance of motion of a segment will prevent adjacent premature degeneration. It will take long term follow-up studies however to prove this. In the meantime, the justification to insert artificial cervical prostheses rests on being able to prove equivalence of outcome between fusion and prosthesis in the short term. This paper shows that the outcomes appear to be equivalent. Early statistical evidence is available for some of the outcome measures at early post-operative follow-up. Further statistical power will be available when the full 60 cases are available for study and this may give further weight to the hypothesis of equivalence of outcome.

ELECTRICALLY STIMULATED SPINAL FUSION DEVICES IN PRIMATES

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INTRODUCTION: The use of adjunctive techniques such as electrical stimulation may improve the rate of successful anterior lumbar interbody fusion. The purpose of this study was to determine if supplemental direct current electrical stimulation of a titanium anterior spinal fusion device increases the incidence and extent of bony fusion in a nonhuman primate model.
METHODS: Anterior lumbar interbody fusion was performed at the L_5-L_6 level in 35 adult pigtail macaque monkeys with iliac crest graft and either a titanium fusion device or a femoral allograft ring. The fusion devices of some animals received either high current (100 μA) or low current (28 μA) electrical stimulation using an implanted generator for the duration of the 12- or 26-week evaluation period. All animals were studied using AP and lateral radiographs, CT imaging, nondestructive mechanical testing, and qualitative and quantitative histology. Specimens were scored for presence of fusion according to a semi-quantitative scale (0 = No healing, 1 = Minimal consolidation, 2 = Consolidation, 3 = Bridging callus, 4 = Bridging callus with trabeculations, 5= Evidence of bony remodeling of callus). A similar scale was used to score the extent of fusion.
RESULTS: As shown in Table 1, both low and high current stimulation groups had generally increased incidence of bony fusion compared to the non-stimulated and femoral allograft ring groups. At 26 weeks, the extent of bony fusion increased with the devices from 43% to 75% in a dose-dependent fashion, compared to 25% with the femoral rings. Mechanical testing also demonstrated similar increases in mechanical stiffness in a dose-dependent fashion.
DISCUSSION: Adjunctive electrical stimulation of an anterior titanium spinal fusion device improved success rate and overall fusion quality compared to non-stimulated devices and femoral allograft rings. Stimulated devices may be particularly beneficial in patients with known risk factors for nonunion.

INSTRUMENTED STABILISATION OF THORACOLUMBAR BURST FRACTURES WITH MINIMAL OR NO NEUROLOGIC DEFICIT

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INTRODUCTION*:* The optimal treatment for acute thoracolumbar burst fractures remains controversial, particularly in the patient with minimal or no neurologic deficit. While this group could be treated conservatively, at Burwood we prefer to utilise short segment instrumented stabilisation.

We wished to review the indications for surgical intervention and the outcomes in this group with emphasis on safety, rate of rehabilitation, function, and pain levels.
METHODS: The clinical notes and X-rays were reviewed for 34 consecutive patients with thoracolumbar burst fractures with minimal or no neurologic deficit, and treated by Dick fixator between August 1995 and September 2001. A questionnaire was mailed to all patients.

RESULTS: At presentation this group had a mean age of 30.7 years (range 16-59), mean kyphotic deformity (Cobb method) of 16.1°, decrease in vertebral body anterior height of 40.9%, and decrease in canal area of 41.2%. Operative fixation was successful in greatly improving both height and kyphosis. No major complication such as metalware breakage, thromboembolism, deep infection, or neurologic deterioration was encountered. Average operating time was 71 minutes, time to discharge was 8.4 days, except where an associated injury limited mobility (17.1 days).

Questionnaires were returned by 29 of 34 patients at a mean of three years post-injury. All of these had returned to work or usual level of activity at 14.3 weeks (4-36 weeks). Pain was experienced never or occasionally by 18 (62%), in relation to activity by 9 (31%), and on most days by 2 (7%). The average visual analog pain score was 2.1/10. No patient required regular or opioid analgesia.

DISCUSSION: This form of operative fixation appeared to benefit this group of patients by allowing rapid rehabilitation with early mobilisation, discharge, and return to work. Pain frequency and severity were both low at medium term follow-up and no major complication was encountered.

CHARACTERISTICS AND OUTCOMES OF PATIENTS WITH SPINAL CANAL STENOSIS AND HYPEREXTENSION INJURIES OF THE CERVICAL SPINE

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STUDY DESIGN: Retrospective, descriptive study.

OBJECTIVES: To describe the characteristics and outcomes of patients with spinal canal stenosis who suffer significant spinal cord injury (SCI) due to hyperextension injury of the cervical spine. To compare their characteristics and outcomes with all patients suffering traumatic cervical SCI and with the total cohort of patients admitted to a Spinal Injuries Unit for rehabilitation.

SETTING: Spinal Injuries Unit (SIU), Princess Alexandra Hospital, Brisbane.

METHODS: Demographic, injury and outcome data were obtained from an existing database and by review of the medical records of 575 patients admitted to and discharged from the SIU between July 1st, 1995 and July 1st 2002. Main outcome measures were: change in American Spinal Injury Association (ASIA) scale category, change in ASIA motor score, discharge Functional Independence Measure (FIM) score and change in FIM score, length of stay (LOS), primary means of mobility at discharge and discharge destination. Standard statistical methods were used to compare groups.

RESULTS: A total of 18 (3%) of the 575 patients were found to have cervical canal stenosis and hyperextension injury (the CCS/HI group). This represents 8% of the total group suffering traumatic injury to the cervical spinal cord (the total cervical trauma: TCT group, n = 225). This CCS/HI group was found to have a mean age at injury of 55.1 years compared to 37.1 and 37.8 years respectively for the TCT and total groups. Ninety-four percent of patients were found to have a neurological level at admission at C1-3 or C4-5 compared to 75.6% of the TCT group and only 5.6% of patients had an ASIA Impairment Category A lesion at admission compared to 38.7% of the TCT group. Falls (55.6%) was the most common cause of injury in the CCS/HI group with motor vehicle accidents (33.8%) most common in the TCT group.

The mean change in ASIA motor score between admission and discharge was 34.7 compared to 20.4 for the TCT group. Degree of impairment (measured by a change in ASIA Category) improved in 28% of patients and mean change in total FIM score was 41.3. There was no difference seen with the TCT group. LOS was shorter for these patients (111.1 days vs. 161.6 days). The primary means of mobility at discharge was "walking" for 50% of this group (compared to 28.4% for the TCT group) while the next most common means of mobility was "power wheelchair" at 28% (17% of TCT group). Most patients (55.4%) were discharged to their previous home following rehabilitation and 22.3% were discharged to another rehabilitation unit or acute hospital.

CONCLUSIONS: Patients with cervical spinal canal stenosis who suffer hyperextension injury constitute a distinct subgroup with the total group of traumatic cervical spinal cord injuries. This study suggests that they are older at the time of injury, have more rostral cervical injuries, are more likely to have incomplete injuries and that falls is the most common cause of injury. They have greater improvement in motor function but this does not appear to result in greater function at discharge as measured by the FIM. There appears to be a dichotomy with results for mobility at discharge with patients either being able to walk or requiring a power wheelchair. LOS in the SIU is shorter but a higher percentage are discharged to another hospital or rehabilitation unit.

INVESTIGATIONS OF CEREBROSPINAL FLUID DYNAMICS IN A SHEEP MODEL OF POST-TRAUMATIC SYRINGOMYELIA

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INTRODUCTION: Modern imaging techniques have demonstrated that up to 28% of patients with spinal cord injury develop syringomyelia. Cyst formation and enlargement are thought to be related to abnormalities of cerebrospinal fluid hydrodynamics, however the exact mechanism and route of entry into the spinal cord remain incompletely understood. Previous work in rats has demonstrated that experimental post-traumatic syrinxes occur more reliably and are larger when the excitotoxic injury is combined with arachnoiditis produced by subarachnoid kaolin injection. A sheep model of post-traumatic syringomyelia (P.T.S.) has been characterised and studies of cerebrospinal fluid dynamics are currently being undertaken. The aim of this study was to assess the effect of focal subarachnoid space blockage on spinal fluid pressures and flow.
METHODS: Arachnoiditis was induced in five sheep by injection of 1.5 mls of kaolin in the subarachnoid space (SAS) of upper thoracic spinal cord. The animals were left for 6-8 weeks before C.S.F. studies were undertaken. In another five sheep, a ligature was passed around the spinal cord to simulate an acute blockage of the subarachnoid space. Fluid-coupled monitors were used to measure blood pressure, central venous pressure and subarachnoid pressure (1 cm rostral and 1 cm caudal to the arachnoiditis or ligature). Fiberoptic monitors were used to measure intracranial pressure. In the ligature group, subarachnoid pressures were also measured prior to tying the ligature to obliterate the SAS and served as baseline control pressures. The effects of Valsalva and Queckenstedt manoeuvres on SAS pressures were examined in both groups.

CSF flow was studied at 0 and 10 minutes after injection of the CSF tracer horseradish peroxidase (HRP). Vibratome sections of the spinal cord were processed using tetramethylbenzidine and sections examined under light microscopy.
RESULTS: The mean SAS pressure rostral to the arachnoiditis was found to be greater than the mean caudal SAS pressure by 1.7 mmHg. In the ligature group, the difference was 0.9 mmHg, being higher in the caudal SAS. Queckenstedt manoeuvre exaggerated this difference to 3 mmHg in the Kaolin group and 4 mmHg in the ligature group. The effect of Valsalva was much less marked in both groups.

Perivascular spaces were enlarged in most cases of arachnoiditis and HRP was seen to stain these spaces and the central canal within 10 minutes.
DISCUSSION: Post-traumatic syrinxes are usually juxtaposed to the injury site with 80% occurring rostral, 4% caudal and 15% in both directions. The finding of a higher subarachnoid pressure rostral to the injury site may help explain this phenomenon. We hypothesise that a reduction of compliance in subarachnoid space increases the pulse pressure and hence increases perivascular flow of C.S.F. contributing to the formation and enlargement of PTS. We are currently investigating this hypothesis by measuring subarachnoid space compliance directly in the sheep model of arachnoiditis described above.

RADIOGRAPHICALLY DEMONSTRABLE INSTABILITY IN SPONDYLOLYTIC SPONDYLOLISTHESIS

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INTRODUCTION: Contrary to the prevailing conviction that lumbar segments affected by lytic spondylolisthesis are unstable, multiple studies have failed to find evidence of increased or abnormal motion at these segments. Affected segments do not exhibit excessive anterior translation: the so-called slip. Previous studies, however, did not use techniques that might reveal abnormalities in the quality of motion, as opposed to its magnitude.
METHODS: To determine if features of instability could be detected in the radiographs of patients with spondylolisthesis, a retrospective, cohort study was conducted of the kinematics of the lumbar spine of patients with spondylolisthesis compared with asymptomatic normal subjects. The flexion-extension radiographs of 15 patients with spondylolytic spondylolisthesis were analysed to determine the location of their instantaneous centres of rotation, and their magnitudes of translation and sagittal rotation. Normative data were obtained by applying the same techniques to the radiographs of 20 asymptomatic subjects.

RESULTS: All but one of the 15 patients exhibited at least one segment with abnormal motion. Only one patient had excessive translation at the lytic segment. Four had minor abnormalities affecting either the lytic segment or ones above. Nine patients exhibited major abnormalities. Seven had paradoxical motion at the lytic segment, in which the centre of rotation was located above L5, instead of below, and in which L5 translated backwards, instead of forwards, during flexion. Two patients exhibited axial dropping of L4, instead of horizontal translation, during extension.
DISCUSSION: Not all patients with spondylolisthesis show features of instability. However, a proportion of patients exhibit highly abnormal movements that are consistent with instability. The abnormalities involve movements within normal range but in abnormal directions. Visual inspection of radiographs will not reveal these abnormalities but they can be detected by plotting the instantaneous axes of rotation.

RISK FACTORS PREDICTIVE OF PROLONGED DISABILITY FOLLOWING WHIPLASH. A PROSPECTIVE STUDY

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STUDY DESIGN: A prospective study of 135 subjects with whiplash injury.
OBJECTIVES: To identify factors predictive of prolonged disability following whiplash injury.
SUMMARY OF BACKGROUND DATA: Although subjects with whiplash associated disorders lack demonstrable physical injury, many exhibit prolonged disability. Disability appears unrelated to the severity of the collision.
METHODS: 147 subjects with recent whiplash injury were interviewed for putative risk factors for disability. 135 were re-interviewed 12 months later to assess degree of duration of disability. Bi-variate and multi-variate analyses were undertaken to measure the association between putative risk factors and measures of outcome.
RESULTS: The bodily pain score and role emotional scores of the SF-36 health questionnaire showed a consistent significant positive association with better outcomes. After adjustment for bodily pain score and role emotional scores, consulting a lawyer was associated with less improvement in NPOS ($p<0.01$) after one year, but there was no significant association with rate of return to work. The degree of damage to the vehicle was not a predictor of outcome.
CONCLUSIONS: SF-36 scores for bodily pain and role emotional are useful means of identifying subjects at risk of prolonged disability. The findings support the implementation of an insurance system designed to minimise litigation.
KEY WORDS: Whiplash – disability – litigation

ALTERED COMPLIANCE AND FLUID FLOW IN A MODEL OF POST-TRAUMATIC SYRINGOMYELIA

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INTRODUCTION: It has been suggested that arachnoiditis predisposes to post-traumatic syringomyelia formation by obstructing subarachnoid cerebrospinal fluid flow and enhancing perivascular flow into the cord. In an animal model of post-traumatic syringomyelia (PTS), fluid flow in spinal cord perivascular spaces (PVS) is greater at the level of arachnoiditis and syrinx than at other levels and fluid enters the syrinx via the PVS. This study was performed to determine the effects of cerebrospinal fluid (CSF) diversion from the subarachnoid space on perivascular flow and syrinx formation in PTS.
METHODS: Twenty six male Sprague-Dawley rats were investigated using the CSF tracer horseradish peroxidase (HRP), the excitotoxic and arachnoiditis model of PTS, and lumboperitoneal shunt insertion. Four experimental groups consisted of syrinx only and shunt only controls, and shunt insertion before or after syrinx formation. CSF flow studies were performed six weeks following the final intervention. Grading scales were used to quantify HRP staining.
RESULTS: Syrinxes formed in all animals. Perivascular flow was greatest at the level of the syrinx. Cerebral cortex perivascular flow was significantly reduced following shunt insertion in animals with a syrinx ($p<0.05$). Shunt insertion did not alter syrinx length or size, but did reduce the number of animals with evidence of sensory disturbances. There were no significant differences between shunt and syrinx first groups.

DISCUSSION: Increasing distal subarachnoid space compliance does not affect local CSF flow into the spinal cord and syrinx. These results suggest that localised alterations in compliance, as opposed to obstruction from traumatic arachnoiditis, act as an important factor in syrinx pathogenesis.

THE LEARNING CURVE ASSOCIATED WITH LUMBAR MICRO-ENDOSCOPIC DISCECTOMY

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INTRODUCTION: Repetitive undertaking of a physical task results in an innate memory for that task. Development of this memory is an important component of surgical training and the ease and safety with which these changes are incorporated into a smoothly flowing procedure is represented by the so-called "learning curve".

Changes in equipment and technology may radically alter the paradigm used by surgeons for completing the task of an operation. An example of this is the integration of endoscopy. The hand-eye orientation, field of view, angle of approach, binocularity of vision and skew of the visual field are all altered in lumbar micro-endoscopic discectomy (MED), when compared to open microdiscectomy.

METHODS: This is a prospective observational study of the initial twenty-five cases of lumbar MED in the hands of a single surgeon. The twenty-five cases of open microdiscectomy immediately predating the current series are used as a cohort for comparison.

RESULTS: A definite alteration in the ability of the surgeon to undertake a new method of discectomy occurred.

Three of the first seven cases of MED were converted to an open discectomy. None of the ensuing 18 cases was converted. The major learning outcomes to account for the change were familiarity with the radiological and videoscopic anatomy, and recognition of the importance of angles of approach.

The average time for surgery in the first ten cases was significantly longer than the second fifteen. The time for surgery in the latter group was not significantly altered from the open cohort group. The facets of surgery responsible for the increased time in the first group were techniques of exposing the nerve root, comfort of the extent of decompression of the nerve root and excision of the disc and comfort with the orientation and cleaning of the camera. The quality of illumination and visualisation of the operative field improved over the study although the significance of this could not be quantified.

Subjectively, surgeon "comfort" with the procedure developed relatively early in the "learning curve".

There was no significant difference in clinical outcome and complications between the two groups.

DISCUSSION: Minimal access techniques have been widely integrated into other fields of surgical endeavour. Open microdiscectomy is well accepted as a treatment for acute lumbar disc prolapse. The decision whether or not to change a surgeon's operative technique should be based on the final anticipated clinical benefit of such a change compared to the cost and risk of changing. This study shows that there is a learning curve associated with lumbar MED, but that it can be integrated relatively easily into a surgical armamentarium.

A HUMAN STUDY OF APOPTOSIS IN ACUTE AND CHRONIC COMPRESSIVE MYELOPATHY

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INTRODUCTION: Apoptosis, or secondary cell death, has been demonstrated in a number of neurological conditions, including Alzheimer's disease, Parkinson's disease, amyotrophic lateral sclerosis and brain ischaemia. It is well established from studies of acute spinal cord injury that apoptosis seems an important factor in secondary cell death and irreversible neurological deficit. It is only recently that studies have emerged analysing secondary cell death in chronic injury to the cord. In this study, the spatial and temporal expression of apoptotic cells was analysed in acute traumatic spinal cord injury (SCI) (n=6) and chronic myelopathies due to metastatic tumour (n=5), degenerative spondylosis (n=6) and syringomyelia (n=4). The study aimed to demonstrate apoptosis in compressive spinal cord injury and to analyse the spatial and temporal distribution of apoptosis in acute and chronic myelopathy.

METHOD: Archival material from 21 spinal cords of patients with documented myelopathy during life and definitive evidence on post mortem examination were available for study. The spatial and temporal expression of apoptotic cells was analysed in acute traumatic spinal cord injury (SCI) (n=6) and chronic myelopathy due to metastatic tumour (n=5), degenerative spondylosis (n=6) and syringomyelia (n=4).

Immunohistochemical analysis of each specimen was conducted using markers of apoptosis, as well as the biochemical apoptotic marker TUNEL. A total of 1800 histopathological slides were analysed. Specimens were also analysed using confocal microscopy to identify the immunopositive cell type. A combination of morphological, immunohistochemical and in situ end-labelling techniques were used to investigate the mechanism of cell death in this experiment. The analytical techniques employed were aimed at showing firstly the presence of apoptosis and secondly the size and position of the damaged regions.

RESULTS: Positivity for active Caspase-3, DNA-PKCS, PARP, TUNEL and active Caspase-9 was found in glia (oligodendrocytes and microglia) axons and neurons in both acute and chronic compression above, below and at the site of compression. In chronic compression, the severity of positivity for apoptotic immunological markers was positively correlated with the severity of white matter damage, as measured by APP immunostaining for axonal injury, and Wallerian degeneration. There was no correlation between the duration of chronic compression and immunopositivity for apoptotic markers. In acute SCI, axonal swellings were consistently positive for Caspases –9 and -3, suggesting mitochondrial activation of apoptotic pathways.

CONCLUSION: Apoptosis occurs in both acute and chronic spinal cord injury. In acute compression, axonal injury is associated with apoptotic immunopositivity of glia and neurons. In chronic compression, apoptosis of oligodendrocytes and microglia correlates with demyelination of axons within the white matter.

AUTOLOGOUS CHONDROCYTE IMPLANTATION IN AN OVINE MODEL OF DISC DEGENERATION

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INTRODUCTION: The development of laboratory techniques in the last ten years has enabled the successful harvest, in vitro selection, culture and transplant of chondrocytes. The study proposes that transplantation of autologous chondrocytes prevents degeneration of the intervertebral disc following outer annular injury in an ovine model.

METHODS: Eight sheep were anaesthetised and five contiguous lumbar discs were exposed via a left-sided posterolateral approach. Four of the animals were given full thickness annular incisions in three alternate discs. No annular incisions were made in the other four sheep. Costal cartilage was harvested from the left twelfth rib of all animals. Tissue was cultured and the chondrocytes were labelled in vitro with CFSE for verification following transplantation. Six weeks later autologous cultured chondrocytes were injected into the lower two alternate discs of all animals, leaving the uppermost discs and those untouched in between as internal controls. Animals were sacrificed after three, six, twelve and twenty-four weeks. Results were based on X-rays, histological, and immunocytochemical assessments.

RESULTS: Preliminary histological results up to three months showed viability of cultured chondrocytes and matrix production post transplantation. Serial X-rays suggested that progressive disc degeneration was arrested in the treated discs.

DISCUSSION: In this pilot study we have shown that cultured autologous chondrocytes can remain viable long term in vivo. These preliminary results suggest that these transplanted chondrocytes have the ability to retard and possibly prevent disc degeneration following annular incision. Previous similar studies have reported the use of chondrocytes cultured from disc, whilst this study showed that chondrocytes from a source foreign to the disc can exert positive effects. The encouraging result from this pilot study needs to be further validated to realise its potential as a treatment for degenerative disc disease.

COMPUTATIONAL MODEL OF THE LUMBAR SPINE MUSCULATURE : IMPLICATIONS OF SPINAL SURGERY

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INTRODUCTION: The complexity of the spine has made a complete understanding of its mechanical function difficult. As a consequence, biomechanical models have been used to describe the behaviour of the spine and its various components. A comprehensive mathematical model of the muscles of the lumbar spine and trunk is presented to enable computation of the forces and moments experienced by the lumbar intervertebral joints during physiological activities.
METHODS: The model includes the nine major muscles crossing the region and concentrates on improving the estimated line of action for the muscles. The muscles are considered to consist of numerous fascicles, each with its own force producing potential based on size and line of action. The model respects the physical constraints imposed by the skeletal structure by ensuring that muscles maintain their anatomical position in various spinal postures. Validation was performed by comparing model predictions of maximum moments to published data from maximum isometric exertions in male volunteers. To highlight the potential novel uses of the model, three examples of muscle injury caused by surgical procedures were investigated; posterior lumbar surgery, impairment of abdominal muscles from anterior surgery and removal of the psoas major unilaterally during total hip replacement.
RESULTS: The validation indicated that the model predicted forces similar to those measured in normal volunteers. The biomechanical changes resulting from the muscle injuries during the surgical procedures share several common features: decreased spinal compression and production of asymmetric moments during symmetric tasks.
DISCUSSION: The results suggest that interference with muscles crossing or attaching to the lumbar spine can have a significant impact on its function.

SINGLE LEVEL FIXATION OF FLEXION DISTRACTION INJURIES

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INTRODUCTION: Flexion distraction injuries (FDI) of the thoracic and lumbar spine can be stabilised with a short construct spanning one motion-segment. This fracture is functionally defined by failure of the posterior and middle columns in tension and the anterior column in compression or tension. Treatment of a predominantly bony injury with minimal deformity (Chance type) is usually non-operative. Intra-abdominal pathology, and ligamentous spinal instability are relative indications for surgery. Deformity of greater than 17 degrees of kyphosis has a poor prognosis when treated conservatively, and represents true instability in vitro. Surgical treatment is mainly through a posterior approach with instrumentation. Which construct to use and the number of motion segments to include is controversial. Multi-level instrumentation techniques both in distraction and compression have been used as well as shorter constructs, particularly in the lumbar spine. We addressed the efficacy of single motion-segment fixation by evaluating the radiographic and functional results of this treatment technique.
METHODS: All patients diagnosed with a FDI were prospectively identified over a 48 months period. Non-operatively treated fractures were excluded. Other spine fractures were excluded. Demographics, co-morbidity, neurological status, operative details and complications were recorded. Radiographic reviewers were blinded to the functional outcome of the patient and the time of follow-up. The Oswestry Functional Assessment Questionnaire was administered by mail.
RESULTS: Twenty-one eligible patients were identified. A significant ($p<0.0001$) correction of deformity was achieved, from a mean pre-operative kyphosis of 10.1 degrees to a mean post-operative lordosis of 0.9 degrees. No loss of correction occurred. The mean Oswestry score was 11.5, with 88% of patients having minimal disability. One patient died from unrelated morbidity.

CONCLUSIONS: Hoshikawa et al showed in vitro how compression forces alone can create FDI. Compression without flexion causes burst fractures. With moderate flexion there is FDI with anterior body compression. With increasing flexion FDI becomes entirely distractive. As the forces are concentrated at a single point, reconstruction only requires that this location be addressed. As all FDI are created by the same mechanism, regardless of structures injured only short segment fixation is required.

We have demonstrated in FDI, single level fixation is biomechanically sound. Multilevel instrumentation creates loss of adjacent level motion segments. This is not necessary. The absence of a control group precludes absolute conclusions. Nonetheless most patients reported minimal disability related to their back and had excellent radiological outcomes. This study demonstrates that posterior reduction and stabilisation of a single motion-segment for FDI can adequately stabilise the spine and lead to excellent functional outcomes.

ONE YEAR FOLLOW-UP ON PATIENTS IN A PILOT SAFETY AND EFFICACY STUDY OF OP-1 (RHBMP-7) IN POSTEROLATERAL LUMBAR FUSION AS A REPLACEMENT FOR ILIAC CREST AUTOGRAFT

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INTRODUCTION: Posterolateral intertransverse lumbar fusion is a commonly performed procedure for stabilisation of the degenerated lumbar spine. A typical clinical scenario for which such fusions are used is the stabilisation of a degenerative spondylolisthesis after decompression. In a recent large series reported in the literature, this type of fusion was noted to have a pseudarthrosis rate of up to 45% (Fischgrund, *Spine* 1997).
METHODS: A pilot study was designed to evaluate the safety and efficacy of osteoinductive protein-1 (OP-1, also known as recombinant human BMP-7) in lumbar posterolateral fusion. Thirty-six patients with the diagnosis of symptomatic spinal stenosis and single level degenerative spondylolisthesis in the lower lumbar spine (L3-S1) were enrolled. The patients were randomised to either the OP-1 group or the control group. The OP-1 group received 3.5 mg of OP-1 per side in a putty carrier. The control group received iliac crest autograft alone. Outcomes were measured clinically using the Oswestry score and radiographically using dynamic radiographs evaluated independently by two blinded radiologists using digital calipers. Patients were deemed a clinical success if they showed a >20% improvement in Oswestry score and were deemed a radiographic success if they showed bridging bone and spinal stability on flexion/extension films.
RESULTS: At twelve months, 18/21 (85.7%) patients in the OP-1 group and 8/11 (72.7%) patients in the autograft group were considered clinical successes, while 13/18 (72.2%) of patients in the OP-1 group and 6/10 (60%) patients in the autograft group were considered radiographic successes. No adverse events related to the use of OP-1 were noted.
DISCUSSION: Despite the non-statistical number of patients enrolled in this pilot study, these preliminary results suggest that OP-1 appears to be a safe and effective replacement for iliac crest autograft in human posterolateral lumbar fusion. The OP-1 group had a higher radiographic fusion rate than the autograft group. This correlated well with the greater clinical success experienced by the OP-1 group, as measured by improvement in the Oswestry score. None of the previously reported device related complications related to the use of BMPs in animal studies, such as exuberant bone growth with subsequent neural impingement, ectopic ossification, or spinal stenosis, was seen in the treatment group.
CONCLUSION: OP-1 appears to be a safe and effective replacement for iliac crest autograft in human posterolateral lumbar fusion. The dose, 3.5 mg per side, and the carrier, a biodegradable putty, appear to provide a safe and effective means of delivering the bone morphogenetic protein OP-1 to the human lumbar spine.

THE MECHANICAL EFFECTS OF INTERVERTEBRAL DISC LESIONS

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INTRODUCTION: Structural changes to the intervertebral disc (IVD) in the form of anular lesions are a feature of IVD degeneration. Degeneration has been related to changes in the mechanical function of the IVD. This study determined the mechanical effect of individual concentric tears, radial tears and rim lesions of the anulus in an in vitro experiment.
METHODS: The lumbar spines from five sheep were taken post mortem and divided into three motion segments. The disc body units were tested on a robotic testing facility, using position control, in flexion/extension, lateral bending and axial rotation. Concentric tears, radial tears and rim lesions were experimentally introduced and the motions repeated after the introduction of each lesion. The mechanical response after the lesion creation was compared to the undamaged response to assess the mechanical effect of each lesion.
RESULTS: It was found that an anterior rim lesion reduced the peak moment resisted by the disc in extension, lateral bending and axial rotation. Concentric tears and radial tears did not affect the peak moment resisted, however, radial tears reduced the hysteresis of response in flexion/extension and lateral bending. The neutral zone was not affected by the presence of IVD lesions.
DISCUSSION: These results show that rim lesions reduce the disc's ability to resist motion. Radial tears change the hysteresis of response indicating an altered stress distribution in the disc. These changes may lead to overloading of the spinal ligaments, muscles and zygapophysial joints, possibly damaging these structures. This suggests a mechanism for a cycle of degeneration that is instigated by small changes in the mechanical integrity of the IVD.

OBLIQUE CORPORECTOMY FOR CERVICAL SPONDYLOTIC MYELOPATHY AND TUMOURS

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INTRODUCTION: Oblique corpectomy is a surgical technique of spinal cord decompression through a limited bone resection of the posterolateral corner of the vertebral bodies. In this study the results of this technique applied in cases of spondylotic myelopathy and tumours are presented.
METHODS: The oblique corpectomy is achieved through a lateral approach with control and sometimes transposition of the VA. It can be used at any level from C2 to T1 and on as many levels as required from 1 to 5. It was mostly applied on cervical spondylotic myelopathy (N=157) or radiculopathy (N=89) but also on hourglass tumours (neurinomas N=67, meningiomas N=7, hemangioblastoma N=1, paraganglioma N=1) and different tumours N=49 involving the lateral part of the vertebral body such as osteoid osteomas N=8, chordomas N=11, aneurysmal cyst N=3, sarcomas N=4. The total series includes 126 tumours. In most cases preservation of the main part of the vertebral bodies permitted to avoid bone grafting and plating. However stabilisation procedure is still necessary when more than one disc is resected and when the discs are soft and not collapsed.
RESULTS: Excellent decompression was obtained in every case of spondylotic myelopathy and radiculopathy. Clinical results are similar to those obtained by any other techniques of decompression through anterior approach but without the complications related to grafting and plating. Improvement of the pre-operative score was noted in 79% of patients with myelopathy stabilisation in 13% and worsening in 8%. In patients with radiculopathy, good and excellent results were obtained in 85%. A better decompression of the intervertebral foramen is achieved through the oblique corpectomy since the whole length of the cervical nerve root from the dural sac to the vertebral artery can be decompressed. Instability requiring further stabilisation procedure was observed only in three cases which in fact were pre-operatively unstable.

Complete tumour resection was achieved in every case especially for the lateral part located into the intervertebral foramen and around the vertebral artery. Even tumours extending from the outside of the spine to the intradural space could be entirely removed through the same approach. Grafting and plating were realised in 13 out of the 126 cases of tumour.
CONCLUSION: Oblique corpectomy technique is a safe technique which permits to decompress the spinal cord and cervical nerve roots from spondylotic elements and tumours.
As compared to other techniques, it achieves a better decompression on the lateral part of the spinal canal and on the intervertebral foramen up to the vertebral artery. In many cases it does not require any complementary stabilisation technique and avoids the use of instrumentation.

PROSPECTIVE OUTCOME EVALUATION OF A TOTAL DISC REPLACEMENT

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INTRODUCTION: Two total disc replacement devices have been used in Europe for more than 10 years. However, there are few, if any, prospective studies evaluating their results. The purpose of this prospective study using standardised outcome evaluations was to evaluate surgical outcome following implantation of an artificial disc.

METHODS: This study is based on the consecutive series of the first 57 patients undergoing total disc replacement using the SB Charité (Link) disc prosthesis. Indications included single-level symptomatic disc degeneration, failure of at least six months of non-operative treatment including active rehabilitation, and no previous surgery at the operated segment. Data were collected prospectively pre-operatively and at six weeks, three, six, and 12 months post-operatively (24 month follow-up data collection is continuing). Primary outcome measures included visual analog scales (VAS) assessing pain and the Oswestry Low Back Pain Disability Questionnaire.

RESULTS: The mean operative time was 78.5 minutes and the mean estimated operative blood loss was 134.3 cc. Estimated blood loss and operating time were both significantly less for disc replacements at the L5-S1 level than at L4-5 ($p<0.05$; t-test). As seen in Figures 1 and 2, there was a significant improvement in the VAS and Oswestry scores ($p<0.05$) at the six week follow-up visit, and the improvements were maintained during subsequent follow-up visits.

There were no cases of device failure, displacement, or migration. Complications were comparable to those encountered with anterior interbody fusion.

DISCUSSION: The results of this prospective study, using patient self-report questionnaires, demonstrated significant improvement at six weeks and the improvement was maintained during the 12 months follow-up period (24-months data is being collected). The disc prosthesis can be implanted safely, with complications similar to those encountered with anterior lumbar interbody fusion.

ANTERIOR LUMBAR INTERBODY FUSION – TWENTY YEAR MRI FOLLOW-UP

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INTRODUCTION: Numerous in-vitro studies demonstrating increased stress at levels adjacent to a lumbar fusion have raised concerns of accelerated degeneration. However, the significance of this increased stress in the in-vivo setting remains unclear, especially with long-term follow-up. The objective of this study is to assess the level of degeneration on MRI in this same cohort of patients at a minimum of twenty years follow-up.

METHODS: Twenty-five patients undergoing one or two level anterior lumbar interbody fusion at the L5-S1 or L4-5 levels with a minimum of twenty-years follow-up were identified. Only patients with normal pre-operative discograms at the level adjacent to the fusion were considered in this study. MRI scans were performed and evaluated for any evidence of degeneration by an independent radiologist. Advanced degeneration was defined as either: (1) absence of T2 signal intensity in the disk, (2) disk herniation, or (3) spinal canal stenosis.

RESULTS: Advanced degeneration was identified in five (20%) patients, with three (12%) being isolated to the adjacent level. Fourteen (56%) other patients had evidence of early degeneration in their lumbar spine. Overall, eight (32%) patients had some evidence of degeneration isolated to the level adjacent to the disk whereas seven (28%) patients had multilevel degeneration and four patients (16%) had degeneration in their lumbar spine but preservation of the adjacent level.

DISCUSSION AND CONCLUSION: Without a control group, it is difficult to make firm conclusions on whether the changes seen on MRI represent the natural history of spinal deterioration or represent accelerated degeneration. However, after twenty years, only a handful of patients developed advanced adjacent level degeneration. Furthermore, the majority of degenerative changes seen occurred over multiple levels or at levels not adjacent to the fusion, suggesting that changes seen may be more likely related to constitutional factors inherent within the individual as opposed to the increased biomechanical stresses at the adjacent levels.

POSTERIOR LUMBAR INTERBODY FUSION (PLIF) AS A PRIMARY TREATMENT FOR PAN-ANNULAR FAILURE PRESENTING AS A CENTRAL DISC HERNIATION : MEDIUM TERM (2 TO 5 YEAR) FOLLOW-UP

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INTRODUCTION: Discectomy for herniation of the nucleus pulposus is an effective procedure when conservative treatment has failed. However, a number of patients rapidly progress to symptomatic instability after discectomy**.** Those most likely to develop instability have central and multi-regional herniations. Therefore, primary posterior lumbar interbody fusion (PLIF) may be a better option than discectomy alone in this group. This paper presents the clinical and radiological outcome of a consecutive group of such patients treated in one centre by PLIF, but recognises that newer technologies may make such destructive spinal surgery unnecessary in the future.
METHODS: Between June 1997 and December 2000, PLIF for central disc herniation presenting with acute, sub-acute and chronic back and leg pain, with or without neurological loss, using Diapason pedicle screw instrumentation and Ogival PEEK (Poly-ether-ether-ketone) Interbody Fusion cages was performed on 41 patients. Eight patients presented acutely with cauda equina symptoms and 33 patients had sub-acute or chronic symptoms. Formal clinic follow-up was continued for at least two years post-surgery and the final outcome at two to five years after operation was assessed using the Low Back Outcome Score (LBOS). Two independent orthopaedic surgeons assessed the radiological evidence of fusion on X-rays taken at least two years after surgery.
RESULTS: 39 of the 41 patients completed the LBOS questionnaire (95%). One patient had died from an unrelated cause and the other could not be contacted having moved away. 34 (87%) of these had an excellent or good outcome according to the LBOS criteria. However, every patient who returned the questionnaire stated that they would undergo the operation again if guaranteed the same surgical result and all would recommend it to a friend for similar trouble. Four patients (9.7%) were dissatisfied with the process of care they experienced. Analysis of radiographs taken between two and four years post-operatively revealed that spinal fusion (as defined by the Brantigan and Steffee criteria) was present in 38 cases (92.7%). None of the patients with a non-union radiologically had a poor outcome.
CONCLUSIONS: Post-discectomy instability causing disabling low back and leg pain is more likely to occur in patients with an incompetent annulus than those with a largely intact annulus. The patients in this series all had good evidence on MRI of complete (pan-annular) failure. The decision to perform an acute single level PLIF was taken after discussion with the patients, presenting them with the option of having only a central discectomy and a later fusion if needed or of dealing with the problem at one operation. The outcomes described in this study show that this condition is a good indication for PLIF. However, newer technologies such as disc arthroplasty may be a better option for this group of patients in the future.

A COMPARISON OF TWO POSTERIOR FIXATION TECHNIQUES IN COMBINED ANTERIOR AND POSTERIOR LUMBAR SPINE FUSION

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INTRODUCTION: 360 degree combined anterior and posterior fusion is an accepted surgical treatment for the management of discogenic back pain. Controversy exists to the optimal technique of posterior fixation. Proponents of translaminar screw fixation cite lower morbidity as a result of less dissection. Despite reports of high fusion rates with this technique, there are concerns over the biomechanical inferiority of this construct compared to pedicle screw fixation. Previous studies on translaminar screws have used only plain radiographs to assess fusion. The objective of this paper is to compare radiographic outcomes, using high definition CT scans, and clinical outcomes between these two methods of posterior fixation.
METHODS: During 2001, 31 patients underwent combined anterior and posterior fusion by the two senior surgeons for the management of back pain. Anterior interbody fusion was performed using the Syncage in all patients. 16 patients underwent translaminar screw posterior fixation and 15 underwent pedicle screw posterior fixation. Fusion was assessed by high definition CT scan at one year post-operatively. Function was assessed with pre- and post-operative Low Back Outcome Score and visual analogue scores.

RESULTS: Minimum follow-up was 12 months. The incidence of pseudarthrosis in the translaminar group was over 75% which was five times greater than that seen in the pedicle screw group ($p = 0.01$). There were trends towards greater improvements in the LBOS and VAS scores in the pedicle screw group and amongst those patients who achieved a successful fusion. There were two surgical complications in the translaminar screw group and one in the pedicle screw group.
DISCUSSION: With the numbers that are available, there are no clinical differences between the two methods of fixation, although there were trends towards improved function and reduced pain in the pedicle screw group. Furthermore there does not appear to be any difference in regard to complications. However, translaminar screws are associated with a significantly higher rate of pseudarthrosis compared to pedicle screws.

POSTERIOR LUMBAR INTERBODY FUSION USING INSERT AND ROTATE INTERBODY IMPLANTS AND PEDICLE SCREWS - A PROSPECTIVE FOLLOW-UP STUDY

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INTRODUCTION: Posterior interbody fusion (PLIF) can be performed for a variety of indications and by a variety of methods. This paper presents a prospective observational study of the outcome for PLIF using an insert and rotate lordotic implant with pedicle screws for the indication of neurological compression caused by segmental deformity.
METHODS: Prospective data were collected pre-operatively and at regular intervals during the post-operative period. Self assessed outcome measures of visual analog pain score (VAS), Low Back Outcome Score (LBOS) and SF12 general health data were obtained at intervals after the surgery. This paper presents the results of a consecutive series who have a minimum of six months follow-up. All surgery was performed by the two authors. Implants used were a carbon fibre composite ramp (DePuy AcroMed), a titanium mesh lordotic cage (Medtronic Sofamor Danek) or a lordotic PEEK spacer (R90, Medtronic Sofamor Danek).
RESULTS: One hundred and twenty eight cases were performed. The mean age was 61.5 years (sd 15.1), 63 (49%) were female and 65 (51%) were male. Thirteen cases (10%) were workers compensation. Eighty seven (69%) had a single level fused, thirty three (26%) had two levels fused. Six cases had three or more levels fused. Forty cases had had one or more previous decompressive procedures at the target level. All cases had leg pain due to neurological compression associated with some form of deformity. Fifty three percent had a spondylolisthesis, 20% had degenerative scoliosis with collapse of the disc space being the most common other deformity. The mean pre-operative VAS pain score dropped from 6.95 (sd 2.0) to 3.2 (sd 2.4). ($p<0.0001$ paired t test). The mean percentage VAS improvement was 49.7% (95% ci 42.4% to 57.1%). Twenty seven percent achieved greater than 80% pain improvement with 47% achieving greater than 60% pain improvement. The mean LBOS score rose from 21.8 (95% ci 19.6 to 24.0) to 37.9 (95% ci 35.1 to 40.6) ($p<0.001$ paired t test). The mean percentage improvement in LBOS was 120.7% (95% ci 94.6% to 146%).

Complications consisted of three cases of minor wound drainage that settled, a possible deep infection that settled with antibiotics. There were four cases of transient leg weakness that recovered and one case of post-operative extradural haematoma requiring evacuation for partial cauda equina lesion (near full recovery). Unexplained persistence of leg pain or new leg pain was present in eight cases. Three cases resolved spontaneously, two cases were due to screw malposition and required revision and three cases required re-exploration for further foraminal decompression. Other medical problems included pulmonary embolus (1), chest infection/atelectasis (2), confusional state (2), paralytic ileus (3), atrial fibrillation (2), myocardial infarction (1).
DISCUSSION: Posterior lumbar interbody fusion with insert and rotate implants for neural compression gives reasonable pain relief and reduction in disability with a low complication rate for the target (elderly) population.

CERVICAL AND SUBOCCIPITAL CHORDOMAS : THERAPEUTIC STRATEGY AND RESULTS

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INTRODUCTION: Results on surgical treatment of chordomas from series published in the literature are disappointing with survival rate of 50% and 35% respectively at five and 10 years. In most reports, surgical resection is limited to a palliative decompression or at best to a subtotal resection. The purpose of this study is to evaluate the results of patients treated aggressively by several surgeries and radiotherapy from 1989 to 2000.
METHODS: From a series of 36 patients presenting with cervical (N=8) or suboccipital (N=28) chordomas, 22 were referred primarily while 14 were sent to us for a recurrence after a previous partial surgical resection. In both groups of patients, we proposed as radical a surgical resection as possible realised in one to four surgical stages followed by radiotherapy (and protontherapy for the more recent cases).
RESULTS: Patients seen at first presentation (group A) underwent 1,9 surgeries in average and 10 of them could have a protontherapy while in group B patients referred after recurrence, 1,4 surgeries were carried out and three could have a protontherapy. Follow-up extends from one to 11 years (mean 4 years).

Actuarial survival rate was 80 and 65% respectively at five and 10 years in group A as compared to 50 and 0% in group B. Actuarial recurrence free rate was 70 and 35% at five and 10 years in group A and 0% at three years in group B. Disease related mortality was 15% in group A and 63% in group B. The rate of recurrence per year was 0,15 in group A and 0,62 in group B. The mean delay before the first recurrence was 43 months in group A and 15 months in group B.

Factors such as sex, age, duration of symptoms, severity of symptoms, extent of tumour, histological type or grading have no influence on the survival rate and the recurrence free rate. Even the comparison between patients having received or not radiotherapy and patients treated or not by protontherapy failed to show any difference. However these groups of patients are very small and include group A and group B patients.
CONCLUSION: Aggressive surgical treatment at first presentation of patients with chordomas seems to provide better results in terms of survival and recurrence. However it requires several surgical stages (up to four) followed by radio and protontherapy. No other factors have proven to influence the prognosis. In case of patients already presenting a recurrence this aggressiveness does not seem to be justified. Therefore after this study, aggressive surgical treatment was only proposed to primary patients (N=12) and not on patients with recurrence (N=7).

PAEDIATRIC SPINAL OUTREACH SERVICES : THE NSW EXPERIENCE

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Recent years have seen a decided swing from the longstanding inpatient model of rehabilitation to an outpatient model for all branches of medicine in Australia. This swing has been largely cost-driven and is unlikely to change. This paper reports on the development of a paediatric spinal outreach team (ORT) in NSW. The ORT was formed in 1993 and consists of a nurse, physiotherapist, occupational therapist and a social worker. It functions in close collaboration with the two children's hospitals in Sydney. Approximately 10-11 new cases of paraplegia/quadriplegia occur in children/adolescents (up to 18 years of age) in NSW each year. Their therapeutic needs change with growth, development and maturation. Families in regional NSW have special requirements and website information services (distance education) will play an important role for them in the future. Integration with an organisation which provides ancillary services is essential for a comprehensive, state-wide program.

It is suggested that a comparable service would play an equally important role in other states. Case studies to demonstrate savings to be made with this type of service need to be done to secure recurrent government funding.

THORASCOPIC ANTERIOR RELEASE – A NEW TECHNIQUE

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INTRODUCTION: Thorascopic techniques are an accepted and useful technique for spinal surgery. For certain clinical indications (ie thoracic kyphosis), an anterior spinal release followed by a posterior instrumentation may be indicated. The standard technique for a thorascopic anterior release is with the patient in the lateral decubitus position and intubated with a double lumen endotracheal tube (ETT), allowing one lung to be deflated for access to the spine. Placing a double lumen ETT and repositioning the patient before the posterior surgery both add to the duration of surgery. We report our initial experience using standard ETT ventilation, low pressure CO_2 insufflation into the thorax to push the lung away from the operative field, and prone positioning, for thorascopic anterior spinal release, followed by posterior instrumentation. Although previously described for thoracic surgery [1,2], this technique has not been reported for spinal procedures.

METHODS: Five male patients, mean age 15.4 years (13-17 years) have undergone thorascopic anterior release and posterior instrumentation as described above. CO_2 insufflation pressure was maintained at 6 mm Hg or less. There were three cases of Scheuermanns disease and two progressive kyphosis post laminectomy for intradural tumours. Clinical, operative (including intraoperative physiological measurements) and radiological data have been collected by a retrospective chart review.

RESULTS: In all cases the anterior release was performed successfully followed by posterior instrumentation. Three portals were used in each and three to five levels released. Mean time from start of anaesthesia to completion of anterior release was 140 minutes. Intraoperative physiological measurements ($EtCO_2$, SaO_2, pulse, BP) remained stable in all cases during the endoscopic procedure. All patients were extubated post-operatively, spent 24 hours in ICU, and remained in hospital for a mean of nine days (7 – 13 days). There were no significant complications. Mean kyphosis angle improved from 82 degrees pre-operatively to 50 degrees post-operatively.

DISCUSSION: Our initial experience with this new technique has been encouraging. There have been concerns regarding the physiological effects of inducing a tension pneumothorax[3], although our results are similar to others who have found low pressure CO_2 insufflation to be safe[2]. The prone positioning is especially suited for anterior release of a kyphotic spine as it allows the lung to fall away from the spine. Overall we feel this is a useful technique for anterior release of a kyphotic spine.

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TREATMENT OF DEEP INFECTION IN INSTRUMENTED POSTERIOR SPINE SURGERY

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INTRODUCTION: The principles of treatment of deep wound infection around bony implants involve appropriate antibiotics, drainage, repeat debridements, and secondary closure. This type of wound management can be difficult for nursing staff and uncomfortable for the patient. This paper discusses the results of debridement and immediate closure over drain tubes in eight cases from one surgeon's practice in two tertiary hospitals.

METHODS: This is a retrospective review of patients from a personal database. Over a five year period, 178 instrumented posterior spine surgeries, in all regions of the spine, were performed. The indications for surgery included trauma, scoliosis, degenerative conditions, tumour, and other deformities in decreasing order of frequency. In this group, there were eight deep wound infections requiring debridement. All were in the thoracic and/or lumbar region. In two patients with non-fusion rods, the implants were removed. In six patients the implants were retained. All wounds were closed immediately over 16 Fr drain tubes. Follow-up times range from four years to three months.

RESULTS: No wounds required repeat debridement or developed subsequent breakdown. No patient had any further significant septic episodes. The drain tubes remained in situ for a time ranging from five days to three weeks. Of the two patients who had their implants removed at debridement, one remained on antibiotics for six weeks and the other for three months. Four patients remained on antibiotics for one year. One patient had removal of the implants before ceasing the antibiotics but the other three have not had a recurrence of infection despite retaining their implants. Two patients remain on lifelong antibiotics.
DISCUSSION: Debridement and immediate wound closure, in concert with the appropriate antibiotic, after post-operative deep wound infection can be successful with the benefit of less discomfort for the patient and greater ease of nursing care.

LUMBOSACRAL DISLOCATION INJURIES AND THEIR MANAGEMENT : EXPERIENCE AND RECOMMENDATIONS

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PURPOSE: Lumbosacral dislocation injuries are rare. Severe trauma disrupts the mechanically stable lumbosacral junction, rendering the injuries particularly unstable. Aggressive surgical management has been recommended. We present a review of our experience with these uncommon injuries defining injury patterns, surgical strategies and outcomes.
METHODOLOGY: Six patients were treated at Auckland Hospital in the last decade. Thorough review and literature search were performed to revise recommendations for management.
RESULTS: All injuries were associated with high-energy trauma. In two cases there was evidence of previous spondylolysis, with dramatic progression after injury. All cases were surgically treated with decompression, reduction as indicated, and fusion with instrumentation. The only instrumentation failure occurred when reduction reconstituted disc height without attention to reconstruction of the severely mechanically compromised intervertebral disc. Satisfactory recovery of nerve root injury occurred in all but one case. Major cauda equina damage did not occur. Correlations with previously described classification systems for this injury were poor, and often showed injuries to span grades.
CONCLUSIONS: These highly unstable injuries require a high index of suspicion, and aggressive surgical management of these highly unstable injuries is warranted, yielding satisfactory outcomes. Existing classification systems are of little value prognostically, or in planning treatment, and it is better to classify and treat these injuries specifically relating to the anatomical injury patterns. The severe disruption to the intervertebral disc warrants special consideration with attention to a stable reduction position or three-column reconstruction. Spondylolysis may represent a predisposing factor.

TARLOV CYSTS – NOT ALWAYS AN INCIDENTAL FINDING

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INTRODUCTION: Tarlov first described the sacral perineural cyst in 1938 as an incidental finding at autopsy. There is very little data in the literature regarding the natural history of Tarlov cysts and consequently the recommendations for treatment are vague. Various operative treatments have been suggested including cyst aspiration, cyst decompression, micro-surgical cyst imbrication and cyst plication with cement filling of bony defects. We were first presented with the difficulty of managing a patient with a large symptomatic sacral cyst in 1997 and found little in the literature to help advise the patient. This paper presents the results of a prospective observational study and describes the clinical relevance of the different types of cyst, showing how a simple clinico-radiological classification can be used to help manage patients with cysts.
METHODS: Between February 1997 and December 2002, 3935 patients underwent standard three sequence MRI scanning (T1 and T2 sagittals and T2 axials) for lumbosacral symptoms in our hospitals. 62 patients had cysts in their sacral canals, an incidence of 1.6%. Additional contiguous axial and coronal scan sequences were carried out to fully characterise them. Once identified, the clinical picture was correlated with the findings on MRI.

RESULTS: Tarlov cysts can be classified according to whether or not their presence is related to clinical symptoms. Type 1 cysts (n=38; 61%) are small, often multiple and are found at the most distal sacral segments. They are entirely unrelated to the patient's symptoms and require no specific treatment. This has been confirmed when the primary pathology has been treated and the patient's symptoms have been alleviated. Type 2 cysts (n=13; 21%) are usually single, unilateral and occur at the same level as the main cause of the patient's symptoms, often a prolapsed intervertebral disc at L5/S1 with a Tarlov cyst in the S1 root canal. As such, the cyst itself will not require any treatment, which should be directed at the main pathology. Type 3 cysts (n=11; 18%) are the main cause of the patient's symptoms and may require specific treatment. We have found that more than half of the Type 3 cysts can be managed expectantly with serial clinical and MRI review. However, the majority of these cysts (9 of 11) are massive and can cause both erosion of bone and compression of the lower sacral nerve roots. Three have to date required decompression to treat cauda equina symptoms.
CONCLUSIONS: The majority of Tarlov cysts are incidental findings on MRI. They may, however, either contribute to, or be responsible for, a patient's symptoms. Our classification system addresses this and offers guidance on patient management.

SPINAL HYPEROSTOSIS : CONDITION OR ILLNESS?

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INTRODUCTION: The clinical condition was described as *Ankylosing Hyperostosis* of *the Spine* by Forestier (1950[1]), was expanded by Resnick (1975) with the *Extraspinal Manifestations*[2]. What is the nature of this unique formation, asymptomatic in 90% of cases? Several researchers questioned whether the hyperostosis was physiological or pathological. Initially, in 1985 B.M. Rotschild called it a phenomenon[3]. Schlapbach in 1989 found no associated pathological condition[4]. Hutton in his Editorial "Hyperostosis…a State not a Disease" was doubtful[5].

In recent personal observations, protection by ossification was recorded in a severe trauma case and in vertebrae weakened by malignant infiltration.
METHODS: A phylogenetic review of the animal world, followed by an ontogenetic study of mammals/humans, could assist in a decision regarding the nature (physio-or patho-logical) of the hyperostosis.
RESULTS: The phylogenetic lineage on one side showed the oldest record of hyperostosis in dinosaur (144 million years ago=mya). Ossifications were found in the anterior, lateral, posterior longitudinal ligaments, in C1-C2 transverse ligament. In the other phylogenetic, Hyperostosis was in historic and contemporary mammals.

The next step in this study is in the ontogenetic line of the Humans. The oldest skeleton (Ethiopia, 4.5 mya) showed "bridged vertebrae". The first definite hyperostosis was in the Shanidar skeleton (Iraq, 40-12,000 BCE) with "flowing osteophytes". In the historic Humans since 9500 BCE, hyperostosis was found in Europeans, Egyptians, Indians (Chile) and Incas. In the Christian era, hyperostosis was present in Roman-British/Celt populations, Franks, Saxons, British, Swiss and N. Americans. In the 20th C, it is pandemic.
DISCUSSION: (a) Impressions from the animal world: Paleo-pathology was established as a scientific branch in 1912 (Ruffer), and exemplified its value in understanding the nature of diseases. Moodie questioned the function of the long spinal "bony rods", considered them with a protective function. Others[6] suggested spinal hyperostosis as induced by "mechanical stress". Shore[7] (1936) described the *spondylitis ossificans* ligamentorum as due to mechanical strain.

(b Impressions from the Hominid world: The ontogenetic line shows a constant presence of hyperostosis in prehistoric and historic periods. Parallel to human migration from Africa, hyperostosis expanded globally.

(c) The theory of logical probability: It is postulated that hyperostosis is a condition, as no pathology (other than inflammatory) could have expanded and persisted in many species along millions of years, as it would have been removed by the rules of the Darwinian Selection. Possibly triggered by strain in younger age, functional in the past, it is today an atavistic older age "condition", with increased osteoblastic activity in connective tissues of ligaments and tendons. At times it is incidentally discovered and is occasionally excessive. Once presented with clinical manifestations, it becomes defined an illness and should be called the *Forestier-Resnick syndrome.*

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SCIENCE AND PAIN : RECONCILING THE OBJECTIVE AND SUBJECTIVE

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Science is an endeavour built on facts. Scientific methods discover facts, which have force because they are believed to be directly observable and exist independently of theory. Facts so discovered, constitute the solid and reliable foundations of scientific knowledge. Science is objective and rational because it predicts and explains outcomes that are valid and reliable. Applying scientific methods to medical practice is therefore thought to protect medical decision making from arbitrariness, bias, and error.

Pain presents a particular challenge to physicians seeking to base their practice on science. Pain is defined as an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage. It is defined as subjective, because it is an internal phenomenon, not directly observable. It represents a quality, not a fact.

Tensions arise when scientific methods attempt to include subjective experiences within its objective framework. These tensions however, must be resolved if subjective phenomena, such as pain, are to be treated in a reliable and rational manner.

This paper presents a philosophical exploration of the tensions inherent in the study of subjective phenomena, such as pain, within an objective framework, based on contemporary models of rationality.

EARLY RESULTS OF STABILIS – A NEW TWO-PART STAND-ALONE ANTERIOR INTERBODY FUSION (ALIF) DEVICE – AN ALTERNATIVE TO 360^0 FUSION

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INTRODUCTION: The initial promise of stand-alone threaded anterior interbody fusion cages to treat chronic low back pain has not been maintained. In an attempt to overcome some of the problems associated with threaded fusion devices (endplate subsidence, failure to re-establish lordosis and displacement) a two-part ALIF cage was devised. The device consists of a rectangular frame that accommodates a threaded, open-weave cylinder holding bone graft material. The device addresses the biomechanical issues required for successful ALIF whilst providing a large area for bone in-growth and is a less invasive solution than a formal 360^0 fusion.
METHODS: From August 2001 to December 2002, 41 patients who fulfilled selection criteria for a single or two-level 360^0 spinal fusion for low back and leg symptoms underwent ALIF using Stabilis. All patients had failed to improve with all non-invasive and minimally invasive treatments available to them. Prospective follow-up has continued for all cases using the Low Back Outcome Score and a Patient Satisfaction Score. Plain X-rays were taken at three, six and 12 months post-operatively and the 12-month series included flexion and extension films.

RESULTS: Ten patients (24.4%) have completed more than 12 months follow-up; 18 (43.9%) are between six and twelve months post surgery and the rest (31.7%) have less than six months follow-up. LBOS results for the first 10 showed nine (90%) as excellent or good. LBOS results for the second group of 18 were excellent or good in 15 (83.3%). All but two of the 28 patients, would be prepared to undergo the procedure again and all would recommend the operation to a friend with similar trouble. Radiographic assessment at six months showed 16 patients had at least a partial anterior or posterior sentinel sign. Using motion criteria, all 10 cases at one year were fused on flexion and extension lateral X-rays. No devices migrated anteriorly or posteriorly and no lucent lines have been seen around the implants. Three of the two-level procedures showed some subsidence of the L4/5 implant into the L5 vertebral body, but none was symptomatic. No clear reasons have emerged to explain the clinical failure of 14% of the patients given the radiological success. In only one was there a mismatch in the LBOS outcome measure and the satisfaction rating.
CONCLUSIONS: Stabilis is a useful stand-alone ALIF device that not only addresses the theoretical biomechanical failures of anterior threaded interbody fusion cages, but has been shown in this early clinical and radiological evaluation to be effective, objectively and subjectively. It is likely that in the medium term future, fewer patients will require fusion to treat back and leg pain as the results from lumbar spine arthroplasty become established and non-fusion technologies become accepted. Until that time, experience in the UK and USA suggests that Stabilis is a good alternative to 360^0 fusion.

AVASCULAR NECROSIS OF THE FEMORAL HEAD AFTER SURGERY FOR LUMBAR SPINAL STENOSIS

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INTRODUCTION: No previous cases of avascular necrosis (AVN) of the femoral head have been described in the World Literature, to our knowledge. This paper reports the catastrophic failure of the bony integrity of the hip in three patients (five hips) following prolonged hypotension during spinal surgery for spinal stenosis on a Montreal mattress and offers advice to prevent this complication of spinal surgery. A theory to explain this phenomenon is explored, but we recognise its limitations with such a small sample.
METHOD: The case notes of all patients undergoing decompressive spinal surgery in our hospitals between March 1997 and December 2001 were examined (168 cases). Three patients had been identified as suffering from AVN following prolonged hypotensive anaesthesia prospectively. No other cases were identified after the notes review. Clinical notes and pre- and post-operative radiographs were studied in an attempt to identify the factors that caused this complication in these three patients.
RESULTS: Between 1997 and 2001, 168 patients underwent surgery for multi-level symptomatic spinal stenosis in our hospitals. Forty percent of the patients had an instrumented fusion as well as a decompression. During this period, three patients had catastrophic AVN of the femoral head requiring total hip arthroplasty soon after their spinal operation. All had some clinical and radiological evidence of hip arthritis at their pre-surgery visit. All subsequently, presented with symptomatic hip AVN within six months of the index operation. In two, histology confirmed the diagnosis of AVN, and typical changes of AVN were well demonstrated on MRI in the third patient.
CONCLUSIONS: The development of avascular necrosis of the femoral heads following surgery for spinal stenosis may be due to a femoral head at risk being exposed to hypotensive anaesthesia, prone positioning on a Montreal mattress or a combination of the two. Careful intra-operative positioning may reduce the risk of this occurring after spinal surgery. However, close post-operative surveillance and a high index of suspicion of worsening hip pathology in patients who appear to mobilise poorly after lumbar spinal surgery may be the only method of early detection of this condition.

SELECTION CRITERIA ARE THE MOST IMPORTANT PREDICTORS OF SUCCESS IN 360^0 FUSIONS USING THE BRANTIGAN ALIF CAGE AND DIAPASON PEDICLE SCREWS

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INTRODUCTION: Recent evidence from the Swedish Lumbar Spine Group has confirmed the anecdotal opinions of many spinal surgeons that fusion for persistent back pain can be a very effective treatment. However, it is clear that many more variables operate in determining clinical success than just radiological evidence of solid fusion. The very careful selection of patients for low back surgery is, in the opinion of the authors, the most important predictor of success. This paper addresses this issue and presents data to show why clinical failure can coexist with radiological success.
METHODS: Between October 1997 and January 2001, 360^0 spinal fusion using Diapason pedicle screw instrumentation and Brantigan anterior interbody fusion cages was performed on 25 patients. During this period 5,850 new outpatients with back pain were assessed in the low back clinic. Patients were selected by the following criteria: Low back pain of two years or more duration; Pain resistant to all non-operative and minimally invasive treatments; Normal psycho-social profile; Normal body mass index; Non-Smokers; Single or two level disease on MRI proven to be painful by provocative discography; No current insurance or workers-compensation claims. Postal follow-up was at a minimum of two years post-surgery (mean 47 months) using the Low Back Outcome Score (LBOS) and X-rays taken at the two-year clinic follow-up were independently assessed to determine fusion.
RESULTS: 24 patients returned the questionnaire (96%). Only 20 (83%) patients had 'good' or 'excellent' results, as defined by the LBOS. However, 92% of patients stated that they would opt to have a circumferential fusion again, if guaranteed the same post-operative result. The same number of patients stated they would recommend the treatment to friend or family member. Analysis of the post-operative radiographs revealed that spinal fusion (as defined by the Brantigan and Steffee criteria) was present in all 25 cases.
CONCLUSIONS: Our opinion that patient selection is the most important predictor of satisfactory outcome in spinal surgery is demonstrated in this study by the mismatch between the clinical and radiological results. We have identified the causes of clinical failure in this group of patients as: Multiple sites of musculo-skeletal pain confounding the LBOS; Neuropathic leg pain that cannot respond to surgical treatment; More than two previous spinal operations; Excessive pre-operative disability and functional loss that confounds the LBOS; Poor psychosocial profile. Stringent application of rigid selection criteria might improve outcomes in lumbar spinal fusion so that clinical and radiological results correlate more closely. However, even with adherence to such rigid criteria, the outcome tool (LBOS) may be confounded and a more holistic assessment of outcome, including a more sensitive subjective assessment of satisfaction, might be a better measure.

NITRIC OXIDE MODULATES RHBMP-2 INDUCED CORTICOCANCELLOUS AUTOGRAFT INCORPORATION IN RAT INTERTRANSVERSE FUSION

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Nitric oxide (NO) is a free radical labile gas which has important physiological functions and is synthesised by the action of a group of enzymes called nitric oxide synthases (NOS) on L- arginine. We have shown that nitric oxide modulates fracture healing[1]. Bone morphogenic proteins (BMP) are potent differentiating factors that augment the process of new bone formation. Recombinant human BMP-2 (rhBMP-2) enhances spinal fusion[2]. With progression of fusion there is a remodelling of the fusion mass bone accompanied with a decrease in the fusion mass size. It is not known whether nitric oxide has a role in spinal fusion or rhBMP-2 enhanced spinal fusion.

We studied this in a novel rat intertransverse fusion model using a defined volume of bone graft (7 caudal vertebrae) along with 157 mm^3 of absorbable Type-1 collagen sponge (Helistat®) carrier, which was compacted and delivered using a custom jig for achieving a similar graft density from sample to sample. The control groups consisted of a sham operated group (S, n=20), an autograft + carrier group (AC, n=28) and a group consisting of 43 μg of rhBMP-2 (Genetics Institute, Andover, MA) mixed with autograft + carrier (ACB, n=28). Two experimental groups received a nitric oxide synthase (NOS) inhibitor, N^G-nitro L-arginine methyl ester (L-NAME, Sigma Chemicals, St Louis, MO) in a dose of 1 mg/ml ad lib in the drinking water (ACL, n=28) and one of these experimental groups had rhBMP-2 added to the graft mixture at the time of surgery (ACLB, n=28). Rats were sacrificed at 22 days and 44 days, spinal columns dissected and subjected to high density radiology (faxitron) and decalcified histology. The faxitrons were subjected to image analysis (MetaMorph).

On a radiographic score (0-4) indicating progressive maturation of bone fusion mass, no difference was found between the AC and ACL groups, however, there was a significant enhancement of fusion when rhBMP-2 was added (ACB group, 3.3±0.2) when compared to the AC group (1±0) ($p<.001$). However, on day 44, the ACLB group (3.3±0.2) showed significantly less fusion progression when compared to the ACB group (4±0) ($p<0.01$). There was a 25% ($p<0.05$) more fusion-mass-area in day 44 of ACLB group (297±26 mm^3) when compared to day 44 of the ACB group (225±16 mm^3) indicating that NOS inhibition delayed the remodelling of the fusion mass. Undecalcified histology demonstrated that there was a delay in graft incorporation whenever NOS was inhibited (ACL and ACLB groups).

Our results show that the biology of autograft spinal fusion and rhBMP-2 enhanced spinal fusion can be potentially manipulated by nitric oxide pathways.

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CERVICAL SPINE INJURIES IN FOOTBALL

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INTRODUCTION: Regular review [1, 2] of cervical injuries occurring in rugby players is an important step toward maximising the safety of the players. It is hoped that the recognition of recurring patterns of injury would lead to appropriate rule modification by the regulatory bodies of the sport. Serious cervical injuries in rugby have been reported to occur by a range of mechanisms, including those involved with scrummaging, tackling, rucking and mauling.

Spinal flexion is the commonest mechanism of injury and has been associated with scrum engagement, scrum collapse, rucking or mauling, and mistimed tackling. The second most common mechanism of cervical spinal injury is hyper-extension. This commonly occurs during tackling, particularly the 'gang tackle' involving several participants simultaneously, where sudden deceleration of a player's head may lead to cervical hyperextension, focal spinal stenosis and potential damage to the spinal cord by a "pincer" mechanism.

The most commonly reported levels of injury are C5/6 and C4/5 [3].

METHODS: A retrospective review of neck injuries presenting to a major spinal injuries facility and resulting from all codes of football (rugby union, rugby league, soccer, indoor soccer and touch) was conducted and 38 cases identified.

RESULTS: Of the 38 patients, 14 were injured playing rugby union, 15 rugby league, three soccer, one indoor soccer, one touch football and four were playing an unidentified code. Six players were injured while scrummaging, five rugby union and one rugby league. 21 people were injured as tacklees, four as tacklers and two with unspecified involvement in a tackle. One person was injured whilst "heading" the ball, and three people were injured in a non-contact or unspecified action. At final follow-up, four people were found to be quadriplegic (ASIA A), 10 quadriparetic (ASIA B – 0 C –1 and D –9) and 24 recovered completely (ASIA E).

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RESPIRATORY FUNCTION AND ENDOSCOPIC SCOLIOSIS SURGERY

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INTRODUCTION: Endoscopic techniques are an established technique for anterior correction and instrumentation of thoracic scoliosis. Deterioration in respiratory function post thoracotomy has been cited as a disadvantage of anterior approaches and led certain authors to recommend posterior methods[1]. Endoscopic techniques may reduce respiratory complications and respiratory compromise in both the short and long term.
METHODS: Thirty eight patients, seven male 31 female, mean age 17.3 years (11- 37 years) have undergone endoscopic scoliosis surgery under the senior author. Indication for surgery was idiopathic scoliosis 36 and an underlying syrinx 2. All patients undergoing endoscopic scoliosis surgery have a standard pre-operative assessment including respiratory function tests (RFTs). All patients have been followed up prospectively (mean 15 months, range 3 – 33 months) and standard data recorded. As part of this study we are in the process of performing follow up RFTs on all patients.
RESULTS: Pre-operatively no significant respiratory function compromise attributable to the scoliosis has been detected**.** Mean duration of intercostal drain was two days, one patient requiring reinsertion for a recurrent pneumothorax. No other major respiratory complication occurred. On average patients were fully mobile by day five and mean hospital stay was six days (4-10 days). Provisional RFTs post-operatively have shown no significant change.
DISCUSSION: Our provisional results indicate that endoscopic scoliosis correction and instrumentation do not lead to early respiratory complications or to a significant deterioration in respiratory function of the patient.
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3D VISUALISATION OF MUSCLES FROM MR IMAGES

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INTRODUCTION: An estimated 80% of all adults will experience back pain at some time during their life. To aid in the understanding of how the spine functions as a mechanical system and assist clinicians in their diagnosis this study produced 3D models of the muscles in the lumbar spine region. The models show selected muscles at rest and during controlled activities.
METHODS: The images were acquired on a Siemens Sonata 1.5T System using breathhold FISP sequences. Twenty slices of thickness 5 mm and zero separation were acquired using an in-plane resolution of .68 mm and Fast-Fourier-Transformed to 512 x 512. Single acquisitions were acquired per slice. Imaging time per posture (rest, extension, left rotation and right rotation) was approximately 17-20 seconds. All image series conformed to the DICOM Standard.

The code developed for this study was written in Interactive Data Language (IDL) Version 5.5 from Research Systems Inc (RSI).

Each slice from an image series was displayed to an Operator, who roughly selected the muscle(s) boundary. The user-selected points were then compared with the 24-neighbouring pixels, and the vertices moved to the minimum value in the 5x5 area, which corresponds to the muscle boundary. The adjusted region of interest was then displayed to the user for verification. Once the Operator had completed selection of the regions of interest in all slices, spatial smoothing was performed on the data, and 3D models of the muscles constructed.
RESULTS: This analysis produces 3D images of the muscles in the lower back. The visualisation of the data enables different combinations of muscle and posture to be displayed. Typically, a muscle at rest is overlaid with one of the three controlled activities – extension, left or right extension. The 3D models can be displayed as either a meshed or solid object.

The 3D model is displayed in a window that enables an operator using a mouse to rotate, scale and/or translate the model.

To aid visualisation, the volume of each muscle of interest is calculated using the number of pixels within the region of interest, pixel spacing and slice thickness. The result, in mm^3, is displayed alongside the 3D model.

DISCUSSION: The refinement of MR Imaging techniques for subjects in a variety of postures, and the development of post processing techniques provides a useful tool for all in the understanding of the mechanics of the lumbar spine. It is envisaged that this tool with further analysis will assist in determining if there is a link between muscle volume during movement and lower back pain.

FUNDAMENTALS OF TOPICAL AUTOLOGOUS TISSUE GROWTH FACTOR THERAPEUTICS

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INTRODUCTION: Tissue growth factors have been extensively investigated as agents for acceleration of wound repair. Individual recombinant molecules have shown promise in animal models, but in humans both safety and efficacy remain questionable[1,2] and costs are substantial. Recently introduced technologies allow intraoperative collection of the full naturally occurring array of tissue growth factors contained in platelets and white cells.[3] These preparations rely on the normal healing cascade for their performance, and their activity is limited solely to the wound site without undesirable proliferative or inappropriate tissue formation and no systemic effects. Numerous methodologies have been proposed for intraoperative preparation of autologous tissue growth factors for topical application, and an ever widening variety of approaches and formulations are available to the practitioner.[3] Physicians trying to decide which technique to adopt can easily find themselves bewildered while attempting to sift through myriad proponent's claims.[4]
PURPOSE: This presentation will review the state of the art, including: a summary of the role of autologous growth factors in bone fusion; a discussion of the importance of dosage and carrier matrix effects; an outline of the mechanics of intraoperative preparation; a survey of the capabilities of various techniques, and; an overview of *in vitro*, experimental and clinical studies. Audience members will receive a detailed understanding of the physiology, mechanics and clinical range of applicability for this newly emerging technology. This information will aid clinicians in choosing the most appropriate methodology for their practice.
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USE OF SMALL DOSES OF RECOMBINANT FACTOR VIIA DURING SCOLIOSIS SURGERY

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INTRODUCTION: Further development of extensive spinal surgical techniques forced surgeons to find drugs helpful in reducing blood lose during surgery. These drugs are necessary in surgical treatment in patients with congenital or acquired bleeding disorders. Recombinant FVIIa appears to be an efficient haemostatic product for surgery in patients suffering from bleeding disorder. Recombinant activated factor VII (rFVIIa) has recently been introduced for improving haemostasis in non-haemophiliac patients during extensive surgical procedures.
AIM: The present study evaluates the use of low dose of recombinant factor VIIa during scoliosis surgery and its influence on blood coagulation tests and haemostasis.
MATERIAL AND METHODS: 22 patients from evaluated group were treated with Cotrell-Dubosset distraction method with posterior spondylodesis and gibectomy during the same surgical procedure with bone grafts taken from patients iliac crest received a single 10 micrograms/kg dose of recombinant FVIIa given as a i.v. bolus.

Control group consists of 30 patients treated with use of identical surgical technique but without any factors influencing blood coagulation. Fibrinogen value, prothrombine time, APTT and INR value altogether with thrombocytes count were measured day before operation and 15 minutes, two, four and 12 hours after administration of rFVII.

RESULTS: Authors report effective haemorrhage control, decrease in prothrombine time and INR value, reduced thrombocytes count and stabile patients haemodynamics parameters. Changes in these parameters occurred 15 minutes after intravenous administration of recombinant VIIa factor, remained unchanged up to four hours after dosage and its normalisation were observed 12 hours after single intravenous bolus of 10 micrograms/kg of body mass. APTT and fibrinogen value remained unchanged.
CONCLUSION: Authors conclude that use of small doses of recombinant VIIa factor causes short and fast thrombin activation by relived tissue factor (TF), what effectively reduces bone ant tissue bleeding during extensive surgical procedures.

The use of recombinant VIIa factor shortens operation time and reduces number of blood transfusions.

BIOMECHANICS OF SYRINGOMYELIA : A FLUID-STRUCTURE INTERACTION ANALYSIS

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INTRODUCTION: Post-traumatic syringomyelia typically occurs in the spinal cord adjacent to a region of arachnoiditis. This research tests the hypothesis that pressure pulses in the subarachnoid space (SAS) are higher adjacent to the arachnoiditis than in its absence. A fluid-structure interaction (FSI) analysis has been performed to study this behaviour under both normal physiological conditions and in the presence of arachnoiditis.
METHOD: A 2-dimensional axisymmetric cylindrical FSI model has been developed to represent the spinal cord and the SAS. CSF flow into the SAS is defined from MRI flow studies. Arachnoiditis is modelled as narrowing of the SAS. This model was based on a patient suffering from post-traumatic syringomyelia. Only the cervical region where arachnoiditis occurs has been modelled, that is from C1 to T1.
RESULTS: Pressures in the SAS adjacent to arachnoiditis are almost three times higher (7.2 Pa vs. 21.67 Pa) than without arachnoiditis, with peak pressure occurring at the time of peak fluid inflow from the foramen magnum.
DISCUSSION: The model supports the hypothesis that pressure pulses in the SAS are higher in the presence of the arachnoiditis than in normal unobstructed SAS. This elevated pressure may be implicated in syrinx formation.

DYNESYS STABILISATION FOR CHRONIC BACK PAIN

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INTRODUCTION**:** We report a series of 90 patients enrolled in a prospective study of Dynesys stabilisation reviewed at 12 to 30 months.

The procedure involves, at each segment, cephalad and caudad pedicle screws connected with a polycarbourethane spacer and polyethylene cord. It achieves load relief and controlled flexion. Since 1996, 7000 procedures have been undertaken globally.
METHOD: Indications are analogous to consideration for fusion. Entry criteria included (1) unresolved and unacceptable lumbar back pain despite protracted conservative management and (2) definite pathology where symptoms could be abolished by anaesthetising the target segments.

Where root compression was present, a midline approach and posterior screw placement was used in conjunction with open decompression. With back pain alone a bilateral Wiltse approach and posterolateral placement was used.

All patients were assessed pre- and post-surgery with SF36, Oswestry Disability Index and pain analogue scores and modified Zung. Standing radiographs were obtained post- surgery and at review. Follow-up was at six, 12, 24 and 52 weeks in addition to this review.
RESULTS: Follow-up was 100%. 89 patients survived. Mobilisation was achieved on day 1 and discharge usually by day 2. Based on the above outcome measures and patient satisfaction good to excellent results were achieved in 74% (66/89). Screw loosening or breakage occurred in 8%, and was associated with a poor result.
DISCUSSION: Dynesys flexible stabilisation offers a simple alternative to fusion with less potential for adjacent 'Domino' failure. It differs from tension ligament systems such as Graf. At this stage the results appear at least as good as a comparable cohort of fusion patients.

The present series is early, but gives grounds for encouragement. Screw loosening and failure are technical problems detracting from the result and require further development.
We are continuing to use the technique.

TREATMENT OF PYOGENIC DISCITIS WITH AN INTRA-DISCAL CATHETER

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INTRODUCTION: Treatment of discitis using conventional methods can be prolonged and unrewarding. Patients can have prolonged pain and persistently elevated Inflammatory markers. We propose a new method of treatment of severe cases, and present two cases where this method has successfully been used.
METHOD: Once discitis has been diagnosed clinically and radiologically, a percutaneous discectomy of the infected level is performed. Matter is sent for microbiological analysis. An epidural catheter is then left in the infected disc space cavity. This is then used to administer appropriate antibiotics directly into the infected cavity. After one week the patient is converted on to intravenous antibiotics, for a further two weeks, then a prolonged course of oral antibiotics.
DISCUSSION: Discitis can be a difficult and unrewarding condition to treat. This novel method appears to be a new and effective mode of treatment, for both acute and chronic infections, although it does require further evaluation.

SPONDYLOLISTHESIS - COMPLETE REDUCTION AND PLIF USING AN INSERT AND ROTATE TECHNIQUE : A REVIEW OF 35 PATIENTS

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INTRODUCTION: Since Briggs and Milligan first described posterior lumbar interbody fusion (PLIF) in 1944, it has been a controversial technique. However, modern pedicle screw instrumentation and the use of intervertebral spreaders and implants have provided a powerful technique for the restoration of spinal balance in degenerative deformity.

This study assesses the functional outcomes and safety in a series of patients undergoing complete reduction and posterior interbody fusion (PLIF) of lumbo-sacral spondylolisthesis with interbody fusion spacers implanted using an Insert and Rotate technique.
METHODS: A prospective, non-randomised, observational study of pre- and post-operative data, in a series of 35 patients with lumbo-sacral degenerative or isthmic spondylolisthesis, between April 2001 and June 2002.

All patients underwent decompressive laminectomy followed by complete reduction of the spondylolisthetic deformity with the aid of intervertebral disc space spreaders and pedicle screw instrumentation. Wedge shaped spacers made from Carbon Fiber, Titanium mesh or PEEK plastic were then inserted on their sides and rotated 90 degrees to support the vertebral end plates prior to placing bone graft beside them, within the disc space.

Outcomes were measured using the Low Back Outcome Score (LBOS), SF-12, visual analogue pain scores (VAS) and patient satisfaction survey.
RESULTS: Of the 35 patients, 24 had degenerative spondylolisthesis and 11 were isthmic in type. 26 were Meyerding Grade I; seven were Grade II; one was Grade III and one was Grade IV. The indications for surgery included relief of foraminal stenosis in 26 and likely post-operative instability in 24. Average time of last follow-up was 7.4 ± 3.0 months. Data are available on 34 of the 35 patients at three months and 29 at six to twelve months (83%). Mean pre-operative VAS and LBOS were 5.1 ± 2.5 and 26.5 ± 16.9, respectively. Mean scores at last follow-up were 2.2 ± 2.4 and 45.6 ± 14.6 ($p<0.01$ for both measures). At last follow-up, 30 of the 35 patients or 88.2% described their outcome as good or excellent. One patient considered himself worse. 91% said the procedure had been worthwhile but only 79% said they would have it again under similar circumstances.

There were no deaths. There were no interbody implant/PLIF related problems but five intraoperative problems related to pedicle screw placement with one screw loosening during slip reduction, requiring replacement. Post-operatively, three patients developed an ileus. One patient developed a probable wound infection with high fever which settled on antibiotics.

DISCUSSION: This series represents a recent subset of a much larger total series managed with this technique for symptoms associated with spondylolisthetic deformity (187 patients to date). The author has previously reported to the society on the clinical results of the technique but without the benefit of prospective pre-operative data. This smaller series appears to confirm the results of the earlier studies and suggests that PLIF using an Insert and Rotate technique can yield satisfactory clinical outcomes with high patient satisfaction and low levels of complications.

MECHANICAL DERANGEMENT OF THE MATRIX IN THE ANULUS FIBROSUS : AN HYPOTHESIS FOR THE MECHANICAL INITIATION OF DISC DEGENERATION

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INTRODUCTION: A computer model of the L4/5 human intervertebral disc is currently under development. An integral aspect of this model is the material properties assigned to its components. Detailed data on the material properties of the anulus fibrosus ground matrix are not available in the existing literature. To determine these properties, mechanical tests were carried out on specimens of anulus fibrosus harvested from sheep spines. The tests included unconfined uniaxial compression, simple shear and biaxial compression. Data on the strain required to cause permanent damage in the anulus ground matrix and data on the mechanical response of the anulus to repeated loading were obtained.
METHODS: Intervertebral discs were isolated from the lumbar spines of recently sacrificed sheep. These discs were sectioned into test specimens ensuring there were no continuous collagen fibres bearing load. The edge dimensions of the cubic specimens were 3 ± 0.2 mm. To ascertain the strain to initiate tissue damage, the specimens underwent successive loadings, which were carried out one hour apart to allow recovery. The maximum strain in each test was increased incrementally by 5% until a reduction in stiffness was observed in the following test. Separate tests were carried out to quantify and characterise the response of the anulus ground matrix in the three modes of loading and to strains greater than that which initiates damage.
RESULTS: The strains at which permanent tissue damage occurred were between 20 and 27% in uniaxial compression and between 25 and 35% in simple shear. Testing the specimen beyond these strains showed an obvious reduction in stiffness. The biaxial compression tests showed similar changes but did not result in such pronounced losses in stiffness. The material characteristics were reproducible up to 20% strain. Following deformation to higher strains the altered mechanics were also shown to be reproducible indicating that the matrix had been deranged but not failed.
DISCUSSION: Average physiological strains in the L4/5 intervertebral disc are in the order of 10-50% based on maximum deformations observed *in vivo*. The current results demonstrate that this strain will cause some permanent damage to the anulus ground matrix, however, the matrix will still be capable of carrying stress upon repeated loading. Thompson et. al[1] found that people over the age of 35 all exhibited signs of disc degeneration. We hypothesise that the regenerative ability of the anulus ceases to function effectively as we age and the continual damage caused to the anulus tissue by daily activities may lead to the degenerative changes seen in the anulus.

Knowledge of the material characteristics up to 20% strain and following exposure to higher strains will enable a more realistic model of the intervertebral disc and the effects of degeneration to be studied.
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A PILOT STUDY OF TREATING DISCITIS IN THE OVINE MODEL

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INTRODUCTION: Infection can occur after any spinal procedure that involves entry into the disc and although it is not common, the potential consequences are serious. Treatment usually requires identification of the bacteria followed by a course of antibiotics. This treatment remains controversial since it is not clear whether antibiotics actually penetrate the disc and if so, whether they are effective, or even if the outcome would be the same without antibiotics.

For an antibiotic to be effective against the infecting organism it must diffuse through the disc matrix. Blood vessels that surround the disc facilitate the diffusion process, but with age this vascularity decreases and may impede diffusion**.**

The aims of the pilot study were to assess the effectiveness of antibiotic in treating infection in both normal and degenerate sheep discs and to measure the concentration of antibiotic in non-operated discs at varying ages.
METHODS: In each of six Merino wethers aged 12 weeks (n=3) and 24 months (n=3), two lumbar discs were "degenerated" by incising the posterolateral annulus with a scalpel blade. After four weeks all animals had discography with radiographic contrast that contained Staphylococcus aureus at the incised levels and at two non-incised levels. Seven days after infection four animals began IV antibiotic treatment with cephazolin sodium (David Bull Laboratories, Australia) for 21 days at a dose of 50 mg/kg/day. The antibiotic was chosen for effectiveness against S. aureus. One control animal from each age group did not receive any antibiotics, to follow the natural progression of infection. Lateral radiographs of the lumbar spine were taken at two, six and 12 weeks. At 12 weeks all sheep were given a single intravenous dose of cephazolin sodium as either a 1, 2 or 3 g dose. The sheep were then killed after 30 minutes. The spines were removed and prepared for light microscopy to assess pathology of the discs and for biochemical analysis of antibiotic concentration. Success of treatment was judged using histologic and radiographic features.
RESULTS: Discitis was evident radiologically as early as two weeks after inoculation in all animals. Histology at 12 weeks confirmed discitis in all discs regardless of treatment. Biochemistry results confirmed that antibiotic diffused throughout the disc but was more concentrated in the annulus than the nucleus. At all doses disc concentration of antibiotic was higher in lambs than sheep.
DISCUSSION: Treatment with cephazolin sodium at a dose of 50 mg/kg/day for 21 days administered from seven days after inoculation, did not prevent discitis. This does not appear to be due to inability of antibiotic diffusion into the disc.

APOPTOSIS IN AN EXCITOTOXIC MODEL OF POST-TRAUMATIC SYRINGOMYELIA

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INTRODUCTION: Apoptosis has been observed following experimental contusive and transective spinal cord injury, but it is not known whether this is related to secondary excitotoxic injury or other factors. This study examines apoptosis after a purely excitotoxic injury and the relationship between apoptosis and syrinx formation.
METHODS: Twenty-four male Sprague-Dawley rats were divided into six groups. Twenty rats received four 0.5 μL injections of 24 mg/mL quisqualic acid and 1% Evans blue between the rostral C8 and caudal T1 level. Ten microliters of 250 mg/mL kaolin were then injected into the subarachnoid space. Animals were sacrificed at 1, 5, 10, 20 and 50 days following the injections. There were four control animals. Spinal cord tissue was frozen and sectioned, and damaged DNA was detected immunohistochemically by using anti-single-stranded DNA monoclonal antibody. The area and density of single strand DNA were semi-quantitated.
RESULTS: No significantly damaged DNA was found in the 1 day group. Light staining of single-stranded DNA was observed at C6, C7, T1 and T2 levels in 30% of the section area in the 5 and 10 day groups. Moderate staining of damaged DNA occurred at C7 and T1 levels in 25-30% of the section area at 20 day group. Syrinxes formed in this group. Heavy staining and larger syrinxes were noted in the 50 day group.
DISCUSSION: Apoptosis increased with time after excitotoxic injury. These findings suggest that apoptosis may play a pivotal role in syrinx pathogenesis.