

CAN POSTERIOR LUMBAR INTERBODY FUSION WITH CARBON SPACERS RESTORE LORDOSIS AND DISC HEIGHT?

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Introduction

Posterior lumbar interbody fusion can theoretically allow neural decompression directly and by restoration of disc height and appropriate lumbar lordosis. The technique of insertion of a trapezoidal lordotic wedge spacer (ramp) into the disc space before rotating it into position theoretically will obtain both an increase in disc height and allow correction of lordosis. However observations suggest that incongruity between a flat implant and a curved end plate, and possible settling of the implant into the vertebral body may limit the ability of the technique to achieve its full theoretical potential. This paper attempts to establish the capacity of this technique to (1) restore disc height, and (2) alter segmental lordosis.

Methods

Pre- and post-operative lateral radiographs were obtained from 34 patients who had undergone posterior lumbar interbody fusion using carbon fibre spacers with a lordotic angle of five degrees. Supplemental pedicle screws were used in all cases. The procedure was performed at L2/3 in one case, at L3/4 in two cases, at L4/5 in 16 cases and L5/S1 in 15 cases. Measurements of pre- and post-operative lordosis, anterior and posterior disc height, slip percentage and anterior and posterior positioning of the prosthesis were made. To allow for comparison of length measurements the raw data were normalised by dividing by the inferior end plate length.

Results

Stepwise multiple linear regression showed the only variable to be related to final post-operative lordosis was pre-operative lordosis ($p = 0.026$). There was no relationship between final lordosis and implant placement or slip percentage. The regression line suggested that small pre-operative segmental angles (less than 7.5 degrees) were increased post-operatively while large pre-operative angles (greater than 7.5 degrees) were reduced. This suggests that the segment is attempting to accommodate to the five-degree implant. The regression equation only explains 14% of the total variance ($r^2 = 0.144$). The mean normalised posterior disc height increased significantly by 55% (0.1195 to 0.1844) (paired t test $p < 0.0001$) and the mean normalised anterior disc height increased by 18% (0.27151 to 0.32251) (paired t test $p < 0.007$). Changes in both anterior and posterior disc height were highly correlated with pre-operative disc height ($r = -0.6729$ $p < 0.0001$, $r = -0.7402$ $p < 0.0001$).

Discussion

Posterior lumbar interbody fusion using a five degree wedged spacer can lead to significant improvements in anterior and posterior disc height when the disc space is narrowed and maintain disc height when the disc height is normal. The insertion of a wedged implant causes the segment to approximate the lordosis of the implant. The variation is however large. Possible causes for this variation are a mismatch between the flat implant and a curved end plate and end plate subsidence. Having a curved implant end plate and a selection of lordotic angles may possibly reduce the former effect.

RADIOLOGIC ASSESSMENT OF INTERBODY FUSION WITH CAGES

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Introduction

The radiographic criteria for successful lumbar arthrodesis remains controversial. Plain radiographs including flexion-extension views are commonly used to assess fusion, but there is disagreement on the degree of apparent motion that is significant. Helical CT assessment of bridging bone between vertebrae is considered to be the most accurate method currently available. This study compared the use of plain radiographs including flexion-extension views with helical CT scans in the assessment of lumbar interbody fusion.

Methods

Plain radiographs (including flexion-extension views) and helical CT scans were performed on 32 patients (47 levels) five years after ALIF using carbon fibre cages and autologous bone. A radiologist assessed fusion utilising the Hutter method to detect movement, whilst a spinal surgeon measured movement in degrees using the Simmons method. Helical CT scans (with sagittal and coronal reformatting) were assessed for the presence of bridging trabecular bone.

Results

The radiographic fusion rate was 85% based on the presence of bridging bone, and also 85% with the Hutter method. The fusion rate was 74% when movement of at least two degrees was considered significant, but was 98% with the five degrees cut-off adopted by the FDA. Fusion as determined by the presence of bridging trabeculae on helical CT Scans occurred in 67%. Concordance rates were as follows: between plain films and helical CT, 69.5%; between Hutter method and plain films, 76%; between Simmon's method (two degrees) and helical CT, 67%; and between Simmon's method with the FDA cut-off of five degrees and CT, 65%.

Discussion

The assessment of fusion with radiographs appears to be unreliable. The use of plain films and flexion-extension radiographs clearly overestimated the actual fusion rates. Furthermore, there was low concordance between these methods and the more reliable helical CT. This disparity between fusion rates from radiographs and with helical CT supports the view that plain radiographs, including flexion-extension films are of limited value in the assessment of spinal arthrodesis.

POSTERIOR LUMBAR INTERBODY FUSION – A REVIEW OF 362 PATIENTS

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Introduction

Since Briggs and Milligan¹ first described posterior lumbar interbody fusion (PLIF) in 1944, posterior lumbar interbody fusion has been a controversial fusion technique.

Reports regarding the safety, efficacy and fusion rates have varied greatly over the years. Modern pedicle screw instrumentation and the use of intervertebral spreaders/implants have provided a powerful technique for the restoration of spinal balance in degenerative deformity.

Since 1993, the author has performed over 400 posterior interbody fusions for a wide variety of degenerative, traumatic and neoplastic conditions. A review was undertaken of 362 consecutive patients who were managed with this technique between October 1993 and July 2001. The purpose of this review was to determine the efficacy and safety of the technique and, in particular, to attempt to identify those factors which have contributed to patient outcomes.

Methods

The first 86 patients underwent wide posterior decompression with resection of facet joints and interbody grafting using morcellised posterior elements and pedicle screw stabilisation. From February 1995, the interbody graft was supplemented with Carbon wedge shaped spacers bearing serrated upper and lower surfaces (Ramps). From July of 1996 (patient 170), the interbody graft was supplemented with posterior

grafting, and from December 2000 with Autologous Growth Factor (AGF) treated graft.

Patient pre-operative, operative and post-operative data and complications and follow-up Surgeon Subjective Outcome Assessments (SSOA's) were acquired prospectively. Questionnaires were administered seeking patient generated follow-up data, including Patient Subjective Outcome Assessment (PSOA).

Results

Follow-up data (SSOA \pm PSOA) were available on 327 or 91% of patients. The data were for periods greater than six months in 64% of patients. PSOA data were available on 31% - mean follow-up time for these patients was 27.7 months (\pm 25.8). Average age at surgery was 56 years (\pm 16). Average number of levels operated was 1.5 (\pm 0.9). Average number of previous surgeries was 0.7 (\pm 1.0). 286 patients were private and 76 were compensation. 88 patients had no deformity while the remainder had some form of deformity, the most common of which were spondylolisthesis - 156 and scoliosis - 94.

Overall, private patients did much better (very good or excellent outcomes) than compensation ones: 76% vs. 57% ($p < 0.002$). Patients who underwent surgery for conditions associated with deformity did significantly better than those without: 80% vs. 57% ($p < 0.01$). The outcomes since the introduction of interbody serrated spacers and additional posterior grafting have been significantly improved: for private patients, 86% now vs. 62% ($p < 0.002$).

The introduction of ramps improved the non-union rate from 16.3% in the first 86 patients to 8.3% in the next 84. The addition of posterior grafting improved the non-union rate to 1.0% in the next 198 patients. There have been no non-unions since the introduction of AGF.

Serious complications included three deaths, five deep infections, eight early returns to theatre for radiculopathy, four partial and one complete foot drop, four CSF leaks and one pulmonary embolus. Of the patients surveyed, 123/131 or 94% considered the surgery worthwhile and 88% said that they would have it again, if necessary.

Discussion

Refinements in technique and improved patient selection have resulted in a significant improvement in clinical outcomes over the last eight years. While technically demanding, this PLIF technique now yields a high fusion rate, the ability to fully correct sagittal and coronal deformity and a high rate of good or excellent clinical outcomes: 86% in private patients.

ARTIFICIAL INTERVERTEBRAL DISCS AND BEYOND

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Introduction

This is a prospective study to determine the effectiveness of artificial disc replacements in the treatment of discogenic low back pain. There has been increasing interest in the possibility of preserving the motion of a diseased vertebral motion segment by various biomechanical designs. Preserving the motion of the segment, rather than opting for arthrodesis seems intuitively to be a more favourable treatment for several spine disorders.

Up until now most spine surgery has been salvage (correcting the effects of trauma, stabilising correcting deformity, fusing degenerative segments) not restoration of normal function. As new alternatives to fusion come to fruition, we now have the ability to truly restore the spine to normal function. Spinal arthroplasty is a new concept and includes total disc replacement, nuclear replacement and there

are efforts by investigators looking at posterior element reconstruction or facet replacement.

Methods

The data have been collected from the surgical experience of one surgeon since commencement of this procedure in 1996. Data were collected from pre-operative, post-operative clinical and patient questionnaires (both pre- and post-operative) and radiological assessment. Patient questionnaires include Roland-Morris Questionnaire, Oswestry Questionnaire, Visual Analogue Scores, and SF36 Data.

Results

86 Patients have had implantation of the Charite artificial disc prosthesis "*Link*"; 113 levels have been instrumented; 42 males, 44 females; follow-up two months to five years, average follow-up 20 months.

The results so far indicate good to excellent in 84% of cases. Complications have the potential to be catastrophic but attention to surgical detail results in minimal complications which will be discussed in the body of the presentation.

Discussion

This paper is a prospective study. It also represents a personal surgical evolution and understanding of the role disc replacement plays in the treatment of discogenic low back pain. Disc replacement should be used as part of the armamentarium a spine surgeon can utilise in his practice. There are strict guidelines and criteria that need to be adhered to if optimal results are to be obtained. The artificial disc which has been most extensively used in the world is the *Link SB Intervertebral Prosthesis*. To date, over 2000 cases have been performed world-wide. The study is not intended to suggest that routine or indiscriminate use of the artificial disc replacement is warranted, but rather serves to provide a framework for further investigation to the utility of spinal arthroplasty with function intervertebral replacements.

PRELIMINARY RESULTS OF A PROSPECTIVE STUDY USING THE SB CHARITÉ III DISC PROSTHESIS

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Introduction

There is a great deal of interest in intervertebral disc arthroplasty. These devices have been used in Europe for more than 10 years. There have been several reports published on the European results when using the SB Charité III (link) prosthesis and good results have been reported in 63% to 79% of patients^{1,2,3}. The purpose of this prospective study was to evaluate surgical outcome following implantation of an artificial disc.

Methods

The SB Charité III device has two cobalt chromium plates with a polyethylene core between them. Motion occurs through articulation between the concave/convex surfaces of the plates and core. The disc prosthesis is implanted using the same approach as used for anterior lumbar interbody fusion procedures. It comes in multiple sizes to accommodate variations in individual patient size.

The disc has been implanted in 39 patients in our clinic. This group includes 19 males and 20 females (mean age 39.8 years, range 26 to 54 years). The primary study inclusion criteria were single-level symptomatic disc degeneration, failure of at least six months of non-operative treatment, and no previous surgery at the operated segment. Outcome measures included neurological examination, radiographic assessment, Oswestry Low Back Pain Disability Questionnaire, visual analog scale (VAS) assessing pain, SF-36, and work status. Data were collected pre-operatively, and at six weeks, three, six, and 12 months post-operatively. To date, 22 patients have reached the 12 months follow-up point.

Results

Overall, patients demonstrated improvement in the self-reported outcome measures. The mean VAS score improved approximately 50% at the six weeks follow-up and this improvement was maintained during subsequent follow-up. The Oswestry scores improved 37% at six weeks follow-up and had improved by 50% at subsequent follow-ups. Radiographic assessment revealed no cases of device displacement or migration. Complications were comparable to those reported for anterior lumbar interbody fusion. There have been no cases of device failure.

Discussion

The results of this prospective study, using patient self-report questionnaires, demonstrated good clinical outcome. There was a significant improvement noted six weeks post-operatively that was maintained during the follow-up visits. The disc prosthesis can be implanted safely, with complications similar to those encountered with anterior lumbar interbody fusion. As with any surgical procedure, long-term prospective follow-up is needed and data will be collected as these patients reach 24 months follow-up.

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ANTERIOR LUMBAR INTERBODY FUSION USING THREADED CORTICAL BONE DOWELS : EVOLUTION OF SURGICAL TECHNIQUE AND ANALYSIS OF COMPLICATIONS

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Introduction

Anterior lumbar interbody fusion has become a frequently utilised procedure. The trend has been towards less invasive techniques including laparoscopic and mini-open techniques. This report examines the results of one procedure and suggests appropriate tools to decrease the learning curve.

Methods

Twenty-two patients with a mean age of 41 (17-78) underwent mini-open ALIF with threaded cortical bone dowels. The same senior surgeon performed all procedures (RFD). Indication for the procedure was discogenic pain verified by concordant discography after a failure of a minimum of six months non-operative treatment. Patients were followed at standard intervals. Complications as well as the evolution of surgical technique were recorded prospectively for all patients.

Results

Twenty-one of 22 patients had the successful implantation of two dowels at each level. Intraoperative fluoroscopy and auditory EMG monitoring was used in all cases. Thirty-two levels were fused from L2-S1 (Average =1.39 levels). Average length of stay was 2.96 days (1-14). Follow-up averaged 24.93 months (2-36). Fusion was achieved in 15/16 (93%) of the one level cases but only 3/6 (50%) of the two level cases. Posterior re-operation with posterolateral fusion and pedicle screws was performed in 2/3 of these patients. Use of a dedicated pin-based anterior lumbar retractor enabled a 45% reduction in incision length with a 40% decrease in operative time. Complications included: massive bleeding (1), post-operative dysesthetic leg pain (2), postoperative kyphosis (2), lateral graft displacement (1).

Discussion and Conclusion

ALIF remains a formidable surgical procedure. Precise identification of the midline and use of fluoroscopy assures good placement of the devices. Preoperative osteopenia should be recognised and treated with posterior stabilisation. Posterior stenosis should be a relative contraindication. We have abandoned multilevel standalone procedures given the poor fusion rate. A pin-based retractor allows a smaller incision with less operative time. Attention to myriad technical details remains paramount.

MICROMOTION OF VERTEBRAL INTERBODY IMPLANTS SUBJECTED TO AN ANTERIOR SHEAR FORCE : AN *IN VITRO* PORCINE STUDY

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Introduction

The lordosis of the lumbar spine, flexion angle and body weight result in significant shear forces through the lumbar and lumbosacral disc spaces. These shear forces result in translational motion across the disc space, which is resisted but not completely abolished by pedicle screw stabilisation. Failure of lumbar interbody fusions through non-union may be related to translational micromotion at the vertebral endplate/bone graft interface. A porcine *in vitro* model was established to test whether variations in the design of interbody implants and, in particular, the presence of surface serrations would assist in resisting shear forces - especially those causing anterior translation.

Methods

Measurements of anterior vertebral translation were recorded on porcine cervical spine segments, subjected to 25 N antero-posterior shear load while under a 300 N compressive pre-load. Baseline testing was firstly performed on the intact specimens and following removal of the facet joints. The annulus, disc nucleus and cartilaginous endplates were then removed and the specimens were divided into two groups for testing using interbody implants. Four stainless steel blocks measuring 15 mm (length) x 5 mm (height) x 4 mm (width) were manufactured to act as intervertebral disc spacers. Two were made with smooth surfaces and two were made with 1 mm deep serrations on the upper and lower surfaces. One group was tested with two smooth and one with two serrated implants.

Results

Under 25 N shear load, the specimens tested with the serrated implants showed anterior vertebral translation of 0.046 ± 0.013 mm while those tested with the smooth surfaced implants measured 0.152 ± 0.075 mm ($p < 0.01$). A significant difference was also found between the stiffness of the specimens implanted with smooth surfaced (432.8 N/mm) and serrated (1088.4 N/mm) implants ($p < 0.01$). The value for peak load at failure for the specimens with smooth surfaced implants (150.43N) was less than those implanted with serrated implants (175.48 N), but not significantly different.

Discussion

The presence of surface serrations on the interbody implants significantly increased the resistance to shear forces in this model. In the clinical setting, we postulate that the degree of micromotion generated by anterior shear forces at interbody fusion sites should be substantially less when serrated implants are used and reduce the incidence of non-union. This may explain the improved fusion rates reported by contemporary authors when using some interbody implants. Further research is needed to clarify the combined effects of pedicle screw stabilisation and interbody implants upon shear displacement and variations in implant design.

TWO-YEAR FOLLOW-UP OF A CONTROLLED TRIAL OF INTRADISCAL ELECTROTHERMAL ANULOPLASTY FOR CHRONIC LOW BACK PAIN DUE TO INTERNAL DISC DISRUPTION

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Introduction

On the basis of observational data, intradiscal electrothermal anuloplasty (IDETA) has been implemented as a treatment for back pain due to internal disc disruption. In order to assess the efficacy of IDETA, a prospective cohort study with comparison group was commenced in 1998. The present study provides the two-year results of that study.

Methods

Of 53 patients who satisfied the diagnostic criteria for internal disc disruption 36 were allocated to a treatment group and 17 to a comparison group, according to whether or not their insurer approved treatment with IDETA. Outcomes were assessed in terms of relief of pain, return to work, and use of opioids to treat persisting pain, at three months, twelve months, and two years after treatment.

Results

As a group, the comparison patients exhibited no significant improvement in their pain at any time. One was partially relieved, but no patient was completely relieved at either 12 or 24 months. The patients treated with IDETA exhibited significant improvements in their median pain scores, which were sustained at 12 and 24 months. At 24 months, 54% of these patients had achieved at least 50% relief of their pain, no longer used opioids, and were at work. Seven patients (20%) were totally free of pain and at work at 24 months.

Discussion

Despite the small sample size, the study had 90% power to detect the differences encountered at three months, 78% power at two years. The long-term results of IDETA are stable and enduring. It is not universally successful, but 54% of patients can reduce their pain by half, and one in five patients can expect to achieve complete relief of their pain. The results encountered in the present study are better than those reported in the literature, but may be attributed to more stringent selection of patients and closer attention to the accuracy of operative technique. Given the benchmark established by this study, consumers should beware of observational and controlled studies that achieve lesser results, lest these be used to impugn the procedure rather than the operator.

THE JIGSAW SIGN - A RELIABLE INDICATOR OF CONGENITAL AETIOLOGY IN OS ODONTOIDEUM

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Introduction

This is a prospective study of a series of consecutive cases of Os Odontoideum focussing on CT and MRI data. Both congenital and post-traumatic aetiologies have been proposed in the literature. This can lead to confusion in a medico-legal and clinical setting.

Methods

Radiological, CT and MRI data from 26 consecutive cases of cranio-cervical anomalies were collected prospectively. Demographic details, the presence of any recent or remote traumatic aetiology and the clinical presentation were obtained from the medical record. A reconstructed mid-sagittal CT was examined for the thickness

of the arch of C1, the size and location of the Os and the morphology of the atlanto-dens joint. The presence of any cord impression or signal change was obtained from the MRI.

Results

18 cases of Os Odontoideum were identified. Only one had a history of significant trauma remote from presentation. All adults had an abnormal arch-dens joint configuration (the 'Jigsaw' sign) with one exception. The atlanto-dens ratio was significantly greater in all cases of Os odontoideum indicating a relatively thickened anterior arch of the atlas. One case of non-union of a dens fracture presenting five or more years after the injury was identified in this series. Neither in this case nor two cases of transverse ligament rupture and two cases of Ossiculum terminale, was a thickened arch or an abnormal atlanto-dens joint observed. 12 of the cases presented after traumatic injury to the neck. In only three of these was there any abnormal neurological signs.

Conclusions

Os Odontoideum has a characteristic appearance of the anterior C1 arch and the atlanto-dens joint as viewed on CT. These radiological signs are not observed after dens fractures. They may be taken to indicate a congenital aetiology for the condition. Patients with Os odontoideum are able to tolerate moderate to severe levels of injury without sustaining significant acute cord damage.

DEFINING THE NEUTRAL ZONE OF INTERVERTEBRAL JOINTS USING A ROBOTIC TESTING FACILITY

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Introduction

The neutral zone is defined as a region of no or little resistance to motion in the middle of an intervertebral joint's range of movement. Previous studies have used quasi-static loading regimes that do not model physiological activity¹. The aim of the present study was to assess experimentally the existence of the neutral zone of intervertebral joints during spinal motion in flexion/extension, lateral bending and axial rotation during physiological movements simulated using a robotic testing facility. Sheep intervertebral joints were used as they have been shown to exhibit similar mechanical behaviour to human joints².

Methods

Five spines from mature sheep were used. Three specimens were tested from each spine to simulate human I1/2, I3/4 and I4/5 intervertebral joints. The robotic facility enabled the testing regime to be defined for each individual joint based on its geometry. The joints were tested by cycling through the full range of physiological movement in flexion/extension, lateral bending and axial rotation.

Results

A neutral zone was found to exist during dynamic movements only in flexion/extension. The results were equivocal for lateral bending and suggested that a neutral zone does not exist in axial rotation. The zygapophysial joints were shown to be significant in determining the mechanics of the intervertebral joints as their removal increased the neutral zone in all cases. A criterion for defining the size of the neutral zone was proposed.

Conclusions

A neutral zone exists in flexion/extension during dynamic movements of intervertebral joints. This has important implications for the muscular control of the spine consisting of several intrinsically lax joints stacked on one another.

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PAIN MANAGEMENT IN THE TRENCHES - A DAY IN THE LIFE

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Pain management has remained a challenge for surgeons since the dawn of organised medicine. A massive influx of unproven techniques and alternative therapies has descended upon us with little regard to true efficacy and even safety. It is incumbent upon us as practitioners of medicine to finally begin to pay more attention to the tenets of evidenced based medicine while making therapeutic choices.

Johns Hopkins has had a long history of dealing with pain in many of its chameleon forms ranging from the management of acute post-operative pain to the more difficult management of chronic pain. To effectively manage pain in a surgical practice requires attention to first establishing the type of pain (ie. nociceptive or neuropathic). Once the type of pain is clear, specific algorithms can be worked out based on the principles of evidenced based medicine which can be carried out by a variety of paramedical personnel (ie. Physician Assistants or Nurses) without specific surgeon input. This maximises benefit to the patient and minimises problems for the surgeon. Specific algorithms for the management of acute LBP, chronic LBP, acute postoperative pain, chronic postoperative pain, cancer pain and sociopathic pain will be discussed.

ANTERIOR CERVICAL DISCECTOMY AND INTERBODY FUSION (ACDF)

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Introduction

Anterior cervical discectomy and interbody fusion (ACDF) is recognised as an effective surgical treatment for cervical degenerative disc disease. The goals of anterior discectomy, interbody graft placement, and subsequent fusion, are to improve and maintain intervertebral height, establish and maintain physiological cervical lordosis, and achieve arthrodesis so as to eliminate pathological motion. Establishing the most clinically effective and cost effective operative approach to achieve these goals while, at the same time, minimising post-operative complications, is currently an evolving process. One view is that the use of anterior cervical plates reduces graft-related complications, maintains the cervical alignment, and leads to a higher incidence of fusion. In addition, there is evidence to suggest that there is a direct cost benefit of earlier return to pre-operative function and employment.

Bone Graft

Iliac crest autograft would be regarded as the gold standard source of bone for ACDF. However, donor site complications (due to harvesting autograft) are not insignificant and range from 1% to a sizeable 29%. These complications include iliac crest fracture, infection, persisting pain, neural injury, bowel injury, etc. With the advent of bone banks, allograft has become available and eliminates the problem of graft-harvest related complications. There is a theoretical risk of disease transmission and a corresponding difficulty with patients accepting donated tissue. To date, no HIV cases transmission has occurred from ACDF allograft. There are

several studies that demonstrate a significant difference in fusion rates when comparing allograft and autograft. The preponderance of data from the literature supports the conclusion that the use of allograft in ACDF can lead to a higher incidence of graft collapse, pseudarthrosis, and possible subsequent revision surgery. Bishop et al., (*Spine* (1991) 16:726-9) have documented a higher increase in pseudarthrosis rate, graft collapse, and interspace angulation in the allograft group compared to the autograft group. Therefore, the dilemma of allograft being preferred as a basis of eliminating graft harvesting complications, while at the same time being associated with a higher incidence of fusion failure and deformity, have led some surgeons to trial the combination of allograft with anterior plate fixation. Shapiro (*J Neurosurg* (1966) 84:161-5) has reported no incidences of fusion failure, graft collapse, progressive kyphosis, or plate-related complications in 82 consecutive single and multiple level ACDFs using allograft and anterior plating.

Treatment failure

The incidence of the following complications have been reported in the literature. (Graham JJ. *Spine* (1989) 14:1046-50).

- Pseudarthrosis – 3% - 36%
- Graft collapse – 3% - 14%
- Graft extrusion – 0.5% - 4%

These figures are regardless of the graft source and are significant. Recent studies show that the combination of graft and anterior plate fixation virtually eliminates the complication of graft extrusion, and also decreases the risk of graft collapse and development of pseudarthrosis. There are also studies that contend that plate fixation can maintain proper lordotic alignment of the spine more effectively than can ACDF without plating. I contend that the use of contemporary cervical plates significantly decreases the rate of fusion failure and graft-related complications without imparting significant implant-related complications. (Abstract truncated at one page).

As a result, there is decreased overall risk to the patient.

The current type of plates which are available are unicortical with locking systems that substantially decrease the risk of screw loosening or hardware migration. (Abstract truncated at one page).

SURGICAL MANAGEMENT OF CERVICAL SPINE FRACTURES IN THE ELDERLY

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Introduction

The management of cervical spine fracture, subluxation or dislocation in the elderly may present difficulties in decision-making. Frequently, the elderly suffer from medical co-morbidity and a limited physiological reserve, which need to be considered in deciding on surgical versus conservative management of fractures and dislocations.. Debate exists regarding the merits of surgical versus nonsurgical management of these injuries^{1,2,4}.

Methods

Retrospective analysis of 16 patients with traumatic cervical spine fractures with or without dislocation or subluxation in patients greater than 65 years of age, spanning 1994 to the present were carried out. Success of spine stabilisation, time in hospital, ability to return to pre-injury function and medical or surgical complications were measured.

Results

The average age of the patients was 76 years with a range of 67-86 years of age. A variety of cervical injuries and fixation methods were identified, the most common

injury being odontoid fracture requiring transarticular screw fixation. One patient died eight days post-operatively of cardiac arrest and a second patient died of pneumonia. One other complication of wound hematoma while the patient was taking anticoagulation therapy occurred. All other patients were discharged independent in activities of daily living. There were no cases of failure of surgery to restore stability. No post-operative neurological deterioration in any of the patients occurred.

Discussion

This study shows that surgical fixation of cervical fractures in the elderly can be performed as a safe and efficient form of management. Surgery decreases the period of both immobility and hospitalisation with subsequent decrease in the risk of complications such as deep vein thrombosis, pulmonary embolism and pneumonia³. Complications from immobilisation devices such as the halo-thoracic brace may also be avoided.

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ANTERIOR CERVICAL DISCECTOMY AND FUSION WITH ALLOGRAFT AND ANTERIOR PLATING:

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Introduction

Although anterior cervical discectomy and fusion is a well-established technique for arthrodesis of the cervical spine, there are limited data on the use of allograft with plate in large series. There are even fewer such studies that incorporate three and four level fusions. We report our experience with 252 patients (530 levels).

Methods

252 patients underwent anterior cervical discectomy and fusion (ACDF) with plate and allograft (91-one level, 74-two levels, 57-three levels, 30-four levels; 530 total levels) via a modified Smith-Robinson technique. Radiographic fusion was determined with plain X-rays at predetermined intervals. Fusion was defined as no lucent line and no hardware failure. Average follow-up was 22.5 months. Average age was 50 years (M 26, F 19). Co-morbidities included 58 smokers and 16 diabetics. Patients wore an external orthosis for six weeks.

Results

There were six re-operations for junctional disease outside the original fusion construct. 16 patient developed junctional disease. 28 levels had residual radiographic lucent lines and/or hardware failure at most recent follow-up for a fusion rate of 94.7% (502/530). Complications occurred in 32 patients (6.0%). There included 16 instances of hardware failure and/or pseudoarthrosis, nine of which occurred in the three and four level group, dysphagia (9), vocal cord dysfunction (2), respiratory distress (2), wound hematoma (2), wound infection (1).

Conclusion/Discussion

Extremely high fusion rates were recorded in this series, including three and four level constructs, with an acceptable complication rate. We believe that outstanding results are obtainable with allograft and plate, even at three or four levels. The principles of precise fit and fill of the interspace with a contoured graft and fixation with compression and instrumentation must be employed.

POSTERIOR DECOMPRESSION AND VERTEBRAL RECONSTRUCTION FOR THORACO-LUMBAR BURST FRACTURES

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Introduction

The management of patients with thoraco-lumbar burst fractures has evolved over the last 60 years from the days of conservative management through to the current era of anterior decompression combined with either anterior or posterior stabilisation. There is no doubt that surgical outcomes have improved markedly with the more modern techniques. Nevertheless, there are still technical and other difficulties, which the surgeon may encounter. Based upon his experience with posterior vertebrectomy and reconstruction for thoraco-lumbar tumours, the author has used this technique for the management of acute burst fractures in this region.

This paper presents a review of 10 patients with severe thoraco-lumbar burst fracture or fracture dislocation managed since 1997, using a single stage posterior decompression, realignment and stabilisation/interbody fusion.

Methods

Data were acquired prospectively on consecutive patients between June 1997 and October 2000. All patients underwent single stage posterior decompression via laminectomy and then a subtotal eggshell vertebrectomy with removal of any herniated bone fragment(s) or partial vertebrectomy/pedicle subtraction osteotomy. Pedicle screw stabilisation was performed to include one or two vertebrae above and below the involved vertebra(e). The intervertebral discs adjacent to the fractured vertebra were removed prior to realigning the vertebral column and performing interbody fusion using carbon fibre spacers and autograft (four patients) or vertebral body reconstruction with Titanium mesh cages and autograft (six patients).

Results

The mean age was 37 years (21 – 52 years). There were six males and four females. Three patients had no neurological deficit. Seven had incomplete paraplegia, three of which were severe with no or only a flicker of leg movement. The principal fracture involved L1 in six patients, L2 in two, L4 in one and L5 in one. Seven had herniated bone fragments occupying 90+% of the spinal canal. Of the seven patients with incomplete paraplegia, all recovered the ability to walk. Two with conus lesions still self catheterize. There were no serious early complications. A serious late complication was the development at three months of a severe deep wound infection, which required debridement and subsequent anterior/posterior revision surgery. One patient with severe polytrauma and an L4 burst fracture/dislocation has developed a chronic pain syndrome.

Discussion

The decompression, realignment, interbody reconstruction and stabilisation of thoraco-lumbar burst fractures/dislocations using a single stage posterior technique is technically demanding but the neurological outcome and restoration of spinal balance in these 10 patients was gratifying. The procedure appears to have two advantages over an anterior decompression and reconstruction combined with anterior or posterior stabilisation: first, it appears to provide easier access and improved visualisation for lumbar burst fractures where the psoas muscle may be swollen and contused, and second, it allows for easier realignment of any coronal or sagittal deformity.

RECONSTRUCTION FOR VERTEBRAL BODY RESECTION USING TITANIUM MESH CAGES IN THE THORACOLUMBAR SPINE

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Introduction

Large anterior column defects of the thoracolumbar spine, after fracture decompression, tumour or other pathological resection, or spinal osteotomy present significant difficulties in respect to autograft procurement, donor site morbidity, graft instability and residual spinal instability. Titanium Mesh Cages for reconstruction thoracolumbar vertebral body defects (after corpectomy) offer an alternative to structural iliac crest autograft or allograft. The use of TMCs for interbody reconstruction has been addressed yet the use of larger cages for corpectomy reconstruction has not. This study examines implant stability and deformity correction of TMCs following corpectomy reconstruction in the thoracolumbar spine.

Methods

Independent radiological review before, after and at follow-up (one year) was performed for 27 patients having implantation of TMCs. Measurement of thoracolumbar kyphosis was performed before surgery, immediately post operatively, and at one year follow-up. Correction of kyphosis was expressed both as angular improvement and percentage improvement. Cage settling into adjacent vertebral bodies, translational deformities and any evidence of implant failure was sought.

Results

Indications for reconstruction with TMC included burst fracture (13), post traumatic kyphosis (eight), primary tumour resection (three), debridement of infection (one), and stabilisation of severe kyphotic deformity in achondroplasia with associated spinal stenosis requiring decompression (two). Desired resection and decompression was achieved as indicated. Correction of kyphosis was a mean of 12 deg/61% (range 0 – 38 deg, 0 - 85%). No cage moved. One patient had kyphosis recurrence of >5 deg (12 deg). Five patients demonstrated some settling of the cage within adjacent vertebral bodies (1-8%, mean 3.4% of height loss over construct length – the vertebral body above to the body below). Translational malposition of three cages occurred. One of these cases demonstrated the maximum settling and another was associated with the only case of instrumentation failure. Clinically significant spinal canal intrusion did not occur. One cage demonstrated buckling of the wall without evidence of other problem and the clinical result was excellent.

Discussion

Use of TMCs is safe when managing vertebral body reconstruction. Significant kyphosis or translational deformity has not occurred, however minor cage settling within adjacent vertebra may occur. Fusion rate is unknown as the cage mesh obscures graft maturation. Construct failure has only occurred after pre-operative translational malalignment could not be corrected. This demanding procedure offers a reconstructive option with superior structural stability and reduced bone grafting morbidity.

REDUCTION OF SCOLIOSIS DURING POSTERIOR VERTEBRAL INSTRUMENTATION USING POLYAXIAL CLAWS

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Introduction

Some authors (Suk, Barr, Hamill ...) showed that lumbar and thoracic pedicle screws provided adequate reduction of scoliosis. Quality of reduction depends on primary stability of the vertebral anchors. If the anchor has a good primary stability, reduction forces are entirely transferred to the vertebra, which results in reduction of the deformity, whereas, if the anchor has a poor primary stability, it will move when subjected to reduction forces, and this will result in inadequate reduction. Lumbar screws which are advocated by many authors, are extensively used. Thoracic

screws are only used by a limited number of surgeons, as most surgeons favour hooks. Poly-axiality facilitates rod positioning; it eliminates the orthogonal stresses that are generated during tightening and which are known to be responsible for screw fracture. The drawback manoeuvre consists in applying forces directly to the vertebra via the anchor; the deformity is reduced by gently translating the vertebra towards the rod. The polyaxial vertebral claw that we are presenting here is a self-stabilising implant that provides the same primary stability as the screw and allows application of multidirectional drawback forces.

Materials and Methods

The system consists of self-stabilising vertebral anchors, either screws or claws. Each anchor is polyaxial and features a threaded extension that allows translation of the vertebra towards the rod. Connection of the screw or claw to the rod is provided by connecting clamps. The first operative step consists of inserting the vertebral anchors, favouring the apex of the deformity. The insertion technique is described in detail. The claw is locked independently, prior to securing the rod on to the claw. The second operative step consists of positioning the rods which are bent to the ideal sagittal curve. Poly-axiality and threaded extensions make rod positioning an easy step. Progressive tightening of the nuts results in correction of the deformity as it slowly moves the vertebrae towards the rods. The translation force is distributed over all the anchors, ensuring a gentle reduction manoeuvre with no risk of back out of the implants. Approaching vertebrae at the end of the reduction manoeuvre results in vertebral derotation. It is not necessary to use distraction which is considered hazardous.

Results

35 such instrumentations have been used in patients with idiopathic scoliosis over the previous 12 months. We have used an average of nine screws and four claws per patient, mainly thoracic pedicle/transverse claws. Main curve correction was 71% (average curve was 59° preoperatively and 17° postoperatively). Average correction of the uninstrumented lumbar curve was 73%. The upper curve improved from 34° to 15°. The slope of the first uninstrumented vertebra was 14° preoperatively and 6° postoperatively. In the sagittal plane, the average angle of thoracic kyphosis in hollow backs (kyphosis less than 15°) was 9°, increasing up to 27° postoperatively.

Discussion

This instrumentation is characterised by stable implants which provide a quality of reduction similar to that achieved with pedicle screws. Vertebral claws are easy to insert and have a better primary stability than screws.

Poly-axiality is a common feature to all the implants of this system; it greatly facilitates placement of the implants and allows to apply traction simultaneously to all the anchors, which results in progressive, gentle reduction. Simultaneous traction application ensures adequate correction of the thoracic kyphosis (gain of 18°). As a matter of fact, severe kyphosis can be bent into the rods, and translation of the vertebrae towards the rods is very easy. Adequate reduction of the main curve results in correction of the underlying lumbar curve and shifting of the first uninstrumented vertebra into a more horizontal position.

Conclusion

This instrumentation based on stable polyaxial implants, should allow to improve the quality of reduction of scoliosis.

THORACOSCOPIC CORRECTION OF SCOLIOSIS : AN UPDATE

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Introduction

The purpose of this study is to present the current results of a series of 21 cases operated on over the past two years. This is the only series of this type in Australia to date. Although the technique was first reported four years ago, two year results have not been reported or published.

Methods

This study is a prospective single cohort study. The technique is applicable to approximately half of the adolescent idiopathic cases requiring surgery in a busy spinal deformity practice. Clinical radiological and patient derived outcome data are collected pre-operatively and at six weeks, three months, 12 months and 24 months post operatively.

Results

The series comprised 17 females and one male. Median age was 16 years (range 10-37). A median of four portals was used (range 3-5), six discs excised (range 4-8) and seven levels instrumented (range 5-9). Operating time was a median of six hours (range 4.5-7). Median blood loss was 300 ml (range 20-2000). Mean intra-operative x-ray time was 160 s (range 130-190). Rib hump was corrected from a mean of 17° to 7°. The Cobb angle was converted from a mean of 51° to a mean of 24°, a correction rate of 52%. There has been no loss of correction in any case to date. Further to the minor complications outlined last year there has been one case of persistent postoperative deltoid pain from the dependant shoulder that resolved after several days.

Discussion

The thoracoscopic technique has proven safe and effective. A more cosmetic wound is achieved and one or two levels in the thoraco-lumbar spine are spared from fusion.

FUNCTIONAL SCANOGRAM IN THE DIAGNOSIS OF POST-TRAUMATIC FIXED SAGITTAL IMBALANCE.

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Introduction

Flat Back Syndrome resulting from decreased lumbar lordosis or increased thoraco-lumbar kyphosis was initially described by Doherty¹ in post scoliotic surgery patients. This decompensation was later coined as fixed sagittal imbalance and was also detected in patients operated for ankylosing spondylitis or with fractured vertebrae. Various clinical symptoms were included in the syndrome such as stooped posture, knee/hip flexion compensation, fatigue of para-spinal muscles, neck pain and upper spinal deformities, imbalanced gait. Surgical corrections were described by Kostiuk², Lagrone³, Farcy⁴ and others. The "normal" assessments were varying, but accepted according to Propst-Proctor⁵ and Bernhardt & Bidwell Segmental measurements⁶. The clinical diagnosis was supported by radiological evaluation using the Cobb technique and a plumbline alignment from odontoid to promontorium. This evaluation required multiple sets of x-ray films.

Methods

Our preliminary study is aiming at describing in detail the clinical syndrome in patients with lower dorsal and upper lumbar vertebral compressions. Scanogram CT-imaging of the spine is suggested for diagnosis, a rapid technique reported to be with at least 40% reduced radiation^{7,8}. The scanogram is suggested to be functional as it is repeated in prone and in supine positions. The two films were superimposed and rigidity assessed, angles were measured (Cobb) at the T/L junction (two above and two levels below the fracture) and of the lumbar lordosis (from Inferior L1 to superior L5).

Results

This technique was applied to eight patients: the clinical syndrome is detailed with one additional, as yet unreported feature, namely the sleeping position. These were patients with two, three or four vertebral compressions, resulting in imbalance of the dorso-lumbar junction and deformity of the lumbar lordosis. All patients had increased T/L kyphosis of varying degrees, all but one had parallel loss of lordotic curvature.

Discussion

A different imaging technique, functional and less irradiating is suggested for the diagnosis of fixed sagittal imbalance of the dorsolumbar spine and is applied to deformities resulting from fractured vertebrae. The clinical syndrome is enlarged with one feature, namely sleeping in prone position. These early impressions need a larger prospective study for confirmation.

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FAR-LATERAL DISC HERNIATION AND IDIOPATHIC SPINAL EPIDURAL LIPOMATOSIS – A CASE REPORT

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Introduction

The purpose of this case report is to highlight an unusual presentation of a well-described but rare condition (idiopathic spinal epidural lipomatosis) in association with a commonly presenting problem (far-lateral disc herniation).

Methods

Retrospective case report and review of the literature.

Results

A 46-year-old Caucasian male presented with right L5 radiculopathy secondary to a far-lateral lumbosacral disc protrusion, confirmed on MRI scanning. Treatment consisted of a right L5 foraminal steroid injection with a 50% improvement in symptoms. This was soon followed by symptoms of spinal stenosis, and repeat MRI showed worsening of idiopathic spinal epidural lipomatosis seen on the initial scan. Over this period the patient had been unable to exercise regularly and had gained 10 kg of weight. Nonoperative treatment, including a supervised Xenical weight-reduction program (which was unsuccessful), failed to alleviate his symptoms so operative decompression was performed, with satisfactory resolution of the stenotic symptoms.

Discussion

Spinal epidural lipomatosis may be idiopathic or secondary to excess steroids (endogenous or exogenous). It affects either the thoracic or lumbar spine. Treatment options are withdrawal of exogenous steroids, weight reduction or decompressive surgery. In this case, disability associated with a far-lateral disc herniation resulted in weight gain, and subsequent stenotic symptoms from previously asymptomatic lumbar idiopathic spinal epidural lipomatosis.

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CLINICAL SYNDROMES OF THE "INNOCENT" FORRESTIER'S DISEASE

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Introduction

Described by Jacques Forrestier at the beginning of the 20th century, the disease was named ankylosing hyperostosis of the spine¹. Since that time various other names have been accorded to it, the most comprehensive being dish: diffuse, idiopathic, skeletal, hyperostosis². The disease is often misdiagnosed by radiologists, unrecognised by surgeons and considered a silent condition. To diffuse this myth of 'innocence' I am presenting syndromes collected from over 80 patients, during some 20 years.

Methods

The clinical syndromes were recorded, with emphasis on general health and family history. The physical examination recorded the rigidity of spinal movements and neurological changes. All patients were exposed to plain films and CT scan of the spine, to barium meal and/or laryngoscopy.

Results

Only clinical assessment and radiological illustrations were the aim of this review:

Cervical syndromes: - painful ankylosis; stenosis with myelopathy (3);
- Tracheal compression with laryngeal nerve palsy;
- Esophageal compression with endoscopic implications (4).

Dorsal syndromes: painful ankylosis, spinal stenosis & myelopathy (5,6,);

Lumbar syndromes: painful hyper-lordotic ankylosis, spinal stenosis (7);

Sacro-iliac fusion (8);
calcifications of ilio-sacral and ilio-lumbar ligaments.

Extra spinal calcifications: peri articular at elbow, hips and
in operative scars: Achilles' repair;
Post-laparotomy abdominal wall ossification (9).

Particular features: early onset (age 40); incidence in families with two brothers and another with three brothers.

Discussion

Presentation of multilevel spinal syndromes and extra-spinal symptomatic calcification/ossification is intended to dispel the "innocence" of this disease. Except the ankylosis, often asymptomatic, the approximate symptomatic disease was found to be of 10%.

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AUTOLOGOUS DISC CELL THERAPY IN THE SAND RAT

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Purpose/Introduction

80% of individuals experience low back pain in their lifetime. This is often due to disc injury or degeneration. Conservative treatment of discogenic pain is often unsuccessful whilst surgery with the use of spacers or fusion is non-physiological. The aim of this study was to develop an animal model to assess the viability of autologous disc cell therapy.

Method

The Fat Sand Rat (*Psammomys obesus obesus*) was chosen due to its predisposition to the early development of spondylosis. Using microsurgical techniques fragments of annulus and nucleus were harvested from a single disc in 52 sand rats. Vascular clips were placed on the adjacent psoas muscle to mark the harvested level. Disc material was initially cultured in monolayer then transferred into a three dimensional culture media of agarose. This technique yields greater cellular proliferation and the development of cell growth in colonies. Cells were labelled with Bromodeoxyuridine for later immunohistochemical identification. 20 000 cells in a carrier media were then re-implanted at a second operation at an adjacent disc level in the same animal. The rat was subsequently euthanised and the histology of the disc space reviewed.

Results

To date 52 primary disc harvests and 20 reimplantations have been performed. 15 rats have been euthanised and sectioned. Average age at primary surgery was 6.8 months reimplantation eight months and euthanasia 11.2 months. Cell colony viability was inversely related to rat age at harvest. Immunohistochemical analysis of colony extracellular matrix revealed production of type 1 and 2 collagen, chondroitin and keratin sulphate. Two rats died prior to reimplantation. All histological specimens confirm the presence of viable transplanted disc cells. Transplanted cells did not alter the progression of degenerative changes on x-ray.

Conclusion

Autologous disc cell transplantation can be performed in the rat. Further modification of these techniques may lead to the development of autologous disc cell therapy comparable to that currently successfully used in hyaline cartilage defects of synovial joints in humans.

THE PREVALENCE OF LOW BACK PAIN AND RELATED DISABILITY IN AUSTRALIAN ADULTS

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Introduction

Estimates of low back pain prevalence show that low back pain is a common problem particularly in western countries. But the extent to which low back pain causes true disability and not just nuisance pain casts doubt on the utility of these estimates. No studies have been performed in Australia to study both the prevalence and disability associated with low back pain in the population. Accordingly, the objectives of this study were to determine the prevalence ranges and retrospective one year incidence of low back pain together with any related disability in Australian adults.

Methods

survey was mailed to a stratified random sample of 3000 Australian adults selected from the Electoral Roll. There was a 69% response rate. Demographic variables of respondents were compared with those of the Australian population taken from Census data. Selective response bias was investigated using wave analysis. A range of prevalence data were derived as was a disability score using the Chronic Pain Grade Questionnaire¹ (CPG). The CPG has demonstrated reliability and validity in measuring pain and disability in postal surveys². Prevalence

and disability estimates were variously standardised using gender, age and marital status.

Results

There was little variation between the sample and the Australian adult population. There was no significant selective response bias found. The sample point prevalence was estimated at 25.5% (95% CI, 23.6-27.5), six-months prevalence was 64.6% (95% CI, 62.6-66.8) and lifetime prevalence was 79.2%, (95% CI, 77.3-80.9). The retrospective one year incidence was 8.0% (95% CI, 6.9-9.3). In the previous six months period 42.6% (95% CI, 40.4-44.8) of the adult population had experienced low intensity pain and low disability from it. Another 10.9% (95% CI, 9.6-12.3) had experienced high intensity pain, but still low disability from this pain. However, 10.5% (95% CI, 9.2-11.9) had experienced high disability low back pain. The mean time-off from usual activities in the past six months for this group was 1.6 months (95% CI, 1.3-1.9), the median was 18 days. There was no gender difference for a high disability rating or time-off.

Conclusion

Low back pain is a very common problem in the Australian adult population, yet most of this is low intensity and low disability pain. Nevertheless, over 10% had been disabled by low back pain in the past six months and it required significant time off from usual activities.

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THE OR OF THE FUTURE - A JOHNS HOPKINS IMPERATIVE

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Technology has grown at a logarithmic pace during the last century. The ability to accommodate these challenges in today's operating theatre has become problematic. A specific task force has been established at Johns Hopkins to deal with these issues proactively.

The operating room of the future must be able to integrate technology with continuous attention to modern day economics. Contributions from surgical staff must be combined with input from administrators, architects, and industry. Physician surgical administrators are perhaps the best compromise to spearhead such projects. I will introduce the concepts of interstitial space, imaging track systems and surgical workstations to stimulate thought and discussion.