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1

THE GROSS AND HISTOLOGIC BEHAVIOR OF POLYMETHYLMETHACRYLATE IN THE PRIMATE VERTEBRAL COLUMN AFTER KYPHOPLASTY AND VERTEBROPLASTY

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Introduction: There is little data on the effect of polymethylmethacrylate (PMMA) on surrounding vertebral cancellous bone during the kypholpasty and vertebroplasty procedures. The purpose of this study was to compare the gross and histologic behavior of PMMA after both kyphoplasty and vertebroplasty. Special attention was paid to cement extravasation, osteonecrosis, and foreign body reactions.
Materials and Methods: Six elderly female baboons were identified. The study was approved by the Institutional Animal Care and Use Committee. Seven vertebrae from T12 to L6 were used. DEXA scans were utilized to document osteoporosis. A fluoroscopically-guided, unilateral levels served as unoperated controls. The seven levels were randomized to the various treatments within each animal. Three animals were sacrificed at 24 hours and three at 26 weeks post-operatively. Immediately after sacrifice, study levels were harvested, labeled, and preserved per protocol. First they were examined macroscopically for evidence of cement migration. Then, both decalcified and undecalcified sections were prepared and examined for evidence of osteonecrosis, foreign body reaction, and cement extravasation.
Results: Nine out of twelve vertebroplasty specimens had evidence of intravascular cement extravasation as opposed to two out of twelve kyphoplasty specimens (p=0.002). Histologic analysis revealed cement particles within vascular spaces in multiple specimens. Five vertebrae in each group revealed gross evidence of cement leak into the spinal canal via the foramen for the basivertebral vein. There was evidence for foreign body reaction in some specimens in the 26 week group. No specimen demonstrated evidence of osteonecrosis as a result of the interventions.
Discussion: Our results support the notion that by creating a void in which to place PMMA, one can decrease the amount of cement extravasation that occurs. Furthermore, neither intervention appears to induce osteonecrosis (thermal, chemical, or mechanical). Cement migration is a potential complication of both procedures. The presence of cement particles induces local foreign body reactions.
Conclusion: In the baboon vertebral augmentation model we noted subtle differences between the kyphoplasty and vertebroplasty techniques.

2

CONTINUING SIGNIFICANT IMPROVEMENT IN PHYSICAL AND EMOTIONAL HEALTH FOLLOWING KYPHOPLASTY FOR PAINFUL PATHOLOGICAL VERTEBRAL BODY COMPRESSION FRACTURES (VCFs): ONE YEAR OUTCOMES FROM AN IRB-APPROVED, PROSPECTIVE, SINGLE ARM, MULTI-CENTER, PROSPECTIVE STUDY

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Introduction: More than 250,000 painful pathological VCFs occur in the US each year. These impact function and health, and increase mortality, with a correlation to deformity that is independent of pain. Kyphoplasty minimally-invasively reduces and internally fixes VCFs.
Methods: Patients age ≥40 with 1-3 VCF's secondary to osteoporosis, multiple myeloma, or osteolytic metastatic lesions, with pain or progressive deformity refractory to medical care, were eligible. Patients consented to kyphoplasty, longitudinal outcome studies and reporting. Contraindications included solid tumors (primary or osteoblastic metastases), retropulsed bone, neurologic deficit, back pain secondary to other causes, Class III or IV CHF, pulmonary hypertension or unstable angina. SF-36 was administered pre-op and at 1, 3 and 12 months. Scores are expressed as percent age- and sex-matched normals. Mid-vertebral height was measured from lateral radiographs and expressed as percent 676 lost height restored.
Results: 155 subjects with 214 pathological VCFs were enrolled at 18 centers. There were 125 females (81%) and 30 males (19%); mean age 77, mean duration of pain 128 days. 125 of these subjects remain in the trial and have been followed for at least 12 months (range, 12-24 months). There were no device-related or peri-operative procedure-related adverse events. Minor, asymptomatic cement extravasation occurred in 9% of treated VCFs. The average mid-vertebral body height restored was 40%. The table below lists the mean score of statistically significant changes from baseline (p<0.01) in SF-36 categories. Higher scores reflect improvement.

SF-36 Outcome	Pre-op	1 Month	3 Months	1 Year
Physical Composite	56.5%	70.2%	78.0%	76.7%
Mental Composite	84.4%	99.0%	104.1%	106.5%
Physical Functioning	35.3%	56.6%	65.9%	68.7%
Role Physical	7.3%	35.6%	58.5%	67.2%
Bodily Pain	26.0%	67.7%	77.5%	75.5%
Social Functioning	41.9%	77.0%	85.0%	91.5%
Vitality	53.3%	78.3%	87.1%	89.2%
Role Emotional	52.2%	75.6%	82.2%	102.0%

Discussion: Pre-op SF-36 scores highlight the significant impact of painful VCFs on function in elderly patients. Post-op SF-36 scores demonstrate that kyphoplasty dramatically improves patients' lives quickly, with improvements maintained (or in some cases increased) at one year. Importantly, kyphoplasty is a safe procedure, with no device- or procedure-related complications and a low rate of asymptomatic cement leakage.

3

PERCUTANEOUS VERTEBROPLASTY FOR OSTEOPOROTIC COMPRESSION FRACTURES: QUANTITATIVE PROSPECTIVE EVALUATION COMPARED WITH A CONTROL GROUP

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Objectives: The purpose of this study is to assess the functional outcome of patients treated with percutaneous vertebroplasty (PV) and to compare them with a group of patients treated by conventional conservative therapy.
Methods: Eighty-two patients with an osteoporotic vertebral fracture confirmed by MRI were included in this prospective study. Fourteen patients declined to have a PV performed, and were studied as a control group. PV was performed in 114 symptomatic levels of 68 patients. Perioperative variables and complications were recorded and analyzed. The Spanish Spine Society (GEER) spinal intervention questionnaire, which includes a visual analogue scale (VAS), the Oswestry test and the SF-36, were administered to all patients before intervention and 3 months and 1 year after the procedure. Post procedural VAS and patient satisfaction at the end of the treatment were also assessed.
Results: The VAS showed significant improvement after treatment (p<0,001). VAS initial score was 8.8 mean, and decreased to 4 after the procedure, 3.3 at third month and 2,86 at one year. In the control group, initial score was 7,3 and decreased to 6,6 and 3,9 at third month and 1 year follow-up respectively. Oswestry score showed a significant improvement after treatment (p<0.001) in the group treated, while did not show any significant improvement in the control group until the first year follow-up. SF-36 scores showed significant improvement after the procedure in all parameters (p<0,01). Preprocedural scores were worse than in the control group. However, during follow-up scores were similar and even better for pain and general health for the group treated. Eighty six percent of the patients were satisfied with the results of the procedure. Two patients had a radicular neuritis after the procedure. One patient had cord compression from a cement leakage that required a surgical decompression.
Conclusions: PV is associated with early clinical improvement of pain and function. The rapid analgesic effect is persistent. In patients where conservative treatment has failed after six weeks, the functional results with PV are better than with continuing conservative treatment.

4

TWO-YEAR RADIOGRAPHIC AND CLINICAL RESULTS FROM KYPHOPLASTY: A MINIMALLY INVASIVE TREATMENT FOR PAINFUL VERTEBRAL COMPRESSION FRACTURES

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If untreated, the progressive deterioration of the spinal column, that is often associated with osteoporosis, multiple myeloma or osteolytic tumors, may lead to impaired function, decreased quality of life, gastrointestinal disorders, pulmonary complications and death. While medical care for vertebral compression fractures (VCFs) typically entails palliative measures, kyphoplasty addresses pain and often fracture reduction. In brief, an inflatable bone tamp (IBT) is percutaneously inserted into the fractured vertebral body. The IBT is expanded to restore the vertebral body endplates. Bone filler is deposited into the cavity created after the IBT is removed. This prospective, consecutive cohort study includes 119 kyphoplasty patients (71% women, 29% men) treated between May 2000 and December 2001. These patients underwent 128 procedures to treat 165 VCFs. Average patient age was 76 years (range 51-93 years). Average fracture age was 2.6 months (range 2 days-14 months). There were no complications related to the procedure or cement. Patients were monitored for pain reduction, improved mobility and fracture reduction. Some patients were lost to follow-up (20%) or have not reached the designated time points since surgery. Patients rated their back pain on a visual analog scale (1 = no pain and 10 = severe pain). Patients reported their ambulatory status as either fully ambulatory (independent mobility), assisted ambulation (cane or walker needed), or not ambulatory (wheelchair bound or bed ridden).

Follow-up period	Preop	1 week	6 months	1 year	2 years
Average pain score	8.8	2.7	1.4	1.4	1.3
Fully ambulatory	38%	77%	90%	92%	95%
Assisted ambulation	31%	18%	8%	8%	5%
Not ambulatory	30%	4%	2%	0%	0%

Normal vertebral height for a fractured vertebra was estimated as the average height of the normal vertebrae immediately above and below the fracture. Average anterior vertebral height changed significantly from 63% preoperatively to 82% at 1 week (paired t-tests, p-value<.0001) and remained at 82-83% between 6 months and 2 years postoperatively.
While technically demanding, kyphoplasty is proving to be an effective treatment for VCFs. Few long-term kyphoplasty studies have been published. These patients will be followed further to examine long-term outcomes and effects of this relatively new technique.

5

CLINICAL OUTCOME OF VERTEBRAL AUGMENTATION FOR OSTEOLYTIC COLLPASE

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Purpose: To assess the clinical outcome of methylmethacrylate vertebral augmentation in a prospective group of patients debilitated by osteolytic vertebral collapse.
Method: A consecutive prospective series of patients who presented with painful progressive osteolytic vertebral body collapse in the absence of neurological symptoms or signs were treated with percutaneous vertebral body reduction and cavity creation using an inflatable bone tamp followed by methylmethacrylate augmentation to the vertebral body defect. Symptomatic levels were identified by correlating the clinical data with MRI findings. Peri-operative variables and complications or issues were recorded and analyzed. Pre-operative and post-operative X-rays and CT scans were compared. Outcome data was obtained by comparing pre and latest post-operative Oswestry Disability Index (ODI), Visual Analogue Pain (VAS) and SF-36 Generic Health Questionnaire (SF-36) outcome scores.
Results: A total of 264 vertebral bodies in 63 consecutive patients presented for treatment. Fifty-two had multiple myeloma, 11 presented with other lytic metastases. The mean duration of symp-

toms was 12 months. In this group there were no peri-operative complications associated with the technique or tools. Asymptomatic cement leaks were noted in less than 5% of the vertebral bodies treated. The patients reported statistically significant improvement in SF-36 scores for Bodily Pain: 28.33 to 47.56, (p= 0.0003) and Physical Function: 24.48 to 47.17, (p<0.0001), as well as improvements in VAS score: 6.18 to 2.84, (p<0.0001), and ODI score: 46.7 to 30.33, (p=0.0001). In this ongoing evaluation twelve patients sustained further vertebral collapse at other levels for a patient rate of 23%.
Discussion: With modern advances in Oncologic treatment patient survival has improved to the point where what was once life threatening could now be considered a chronic disease. Unfortunately the Oncologic treatment itself also contributes to the already present osteolytic bone loss. With the increased survival and ongoing bone loss osteolytic vertebral collapse is becoming much more of a clinical and functional problem for these patients. The indications for surgical intervention are reported as being progressive collapse, neurological deterioration and or intractable pain. However, surgical intervention in this patient group is typically regarded very difficult by virtue of the co-morbid conditions and the poor bone quality. To alleviate these issues, percutaneous minimally invasive vertebral augmentation techniques have evolved and show promising results for this debilitated group of patients.

6

OCCULT OSTEOMALACIA AND MYELOMA IN PATIENTS WITH OSTEOPOROTIC COMPRESSION FRACTURES

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Introduction: The purpose of this study is to describe the nature of tissue obtained during kyphoplasty from osteoporotic vertebral compression fractures, with special reference to the presence of unmineralized bone (osteomalacia) or occult malignancy.
Methods: A hundred thirty five vertebrae of 103 patients with osteoporotic compression fractures underwent biopsies during 190 kyphoplasty procedures. Patients included 33 men and 70 women with an average age of 72 years (range, 44-88). The patients were informed, agreed with this procedure and received tetracycline (1g/day, in two doses separated by 6 days). Biopsies were taken using the trephine just before the kyphoplasty procedure and were embedded without decalcification, stained with toluidine blue, and viewed with transmitted and fluorescent light.
Results: The 135 biopsy levels included: T4 (2), T5 (2), T6 (4), T7 (12), T8 (11), T9 (6), T10 (9), T11 (11), T12 (23), L1 (19), L2 (10), L3 (10), L4 (11), and L5 (5). Twenty-seven biopsies obtained from 21 patients complied with the tetracycline administration. All specimens showed fragmented bone with variable amounts of unmineralized bone (osteoid), suggesting bone remodeling and/or fracture healing. Only rare areas of peritrabecular fibrosis, fibrocartilage and hyaline cartilage were present. Focal fragments of hematopoietic marrow were also identified. In a few cases foci of either acute or chronic inflammation were present, probably related to a recent compression fracture. Woven bone and cartilaginous tissue were often present, representing fracture callus formation. Twenty samples showed a significantly increased extent of osteoid. In most of these samples evaluation of an unstained section using flourecent light showed single or absent labels of tetracycline, suggesting either a mineralization defect (osteomalacia) or insufficient tetracycline ingestion prior to biopsies. The biopsies provided definite diagnosis of plasmacytoma in four cases (4%) in which previous studies had been inconclusive.
Conclusions: Most of the histologic findings in this series of cases are quite consistent with osteoporotic compression fractures in variable stages of healing, but in several cases the findings could reflect either mild osteomalacia, high bone remodeling, or an underlying neoplasm. Biopsy in these cases is justified as in our series it revealed 4 unsuspected cases of plasmacytoma.

7

COMPARISON OF SURGICAL AND NON-SURGICAL TREATMENT METHODS FOR BURST FRACTURES IN TERMS OF HEALTH RELATED QUALITY OF LIFE

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Introduction: Treatment of burst fractures without neurological compromise is controversial. Functional outcome comparable to surgical treatment has been reported with non-surgical management despite residual kyphosis. Analysis of functional outcome and the influence of kyphotic deformity were mainly based on condition specific questionnaires in previous studies. However, patients' perceptions of various aspects of their condition, and the result of its management can be more precisely analysed using health-related quality-of-life questionnaires (HRLQ). The purpose of this prospective study was to compare non-surgical treatment with surgical treatment in terms of radiological and functional outcomes by using SF-36 for the latter.
Materials and Methods: Twenty-five consecutive patients with thoracolumbar (T11-L2) burst fractures without neurological compromise were treated according to integrity of posterior ligamentous complex (PLC) detected by MRI. Group A included 15 patients with intact PLC (Magerl type A) treated by closed reduction, cast immobilization under conscious anesthesia, and the patients were mobilised the next day. Group B included 10 patients with disrupted PLC (Magerl type B), treated by posterior three level instrumentation (two above, one below) with supplemental hooks under the lamina of inferior pedicle screws. X-ray analyses included the measurement of preoperative, postoperative and follow-up (f/up) local kyphosis angles (LKA). All patients were given SF-36 questionnaires at the latest follow-up.
Results: All the patients had more than two years of f/up (average 33 months, range 24 to 66). The two groups were similar according to age, gender, etiology of trauma, site of fractures, duration of follow-up and severity of preoperative kyphosis (p<0.05). Mean pretreatment LKA of 16.5(±9) degrees was corrected to 5(±10) degrees in group A later deteriorated to 17(±7) degrees at the final f/up. Mean preoperative LKA was 18(±10) degrees in group B. It was corrected to -4(±7) degrees postoperatively and deteriorated to 1(±3) degrees at the final f/up. The difference between the groups in terms of residual kyphosis was significant (p=0.001). However, no significant difference was observed between the two groups considering physical functioning (70(±23) vs. 75(±17); p=0.727), role physical (79(±35) vs. 62(±46); p=0.432), role-emotional (50(±36) vs. 62(±33); p=0.401), vitality (57(±25) vs. 49(±22); p=0.368), social functioning (65(±21) vs. 71(±23);p= 0.505)pain index (65(±20) vs. 65(±17); p=0.907), general health perceptions (52.5(±15) vs. 57.5(±26); p=0.534) and mental health index (67(±19) vs. 61(±21); p=0459). There was no correlation between the magnitude of kyphosis and any of the parameters of SF-36 (p<0.05). The rate of complications and additional procedures were higher in group B (1 deep infection necessitating 3 additional surgical interventions, 1 screw close to aorta necessitating 1 surgical intervention, 1 donor site pain after graft harvesting) than group A (no complications). There was no significant difference between the two groups in terms of duration of return to work (mean 3.5 months vs. 3.3 months; p= 0.645).

Discussion: We conclude that; despite the residual kyphosis, non-surgical management provides a similar outcome compared with surgical management in terms of HRLQ. Although adjacent segment degeneration is considered as a consequence of residual kyphosis, a similar condition may be observed adjacent to the fused segments after surgical treatment.

8

FACTORS AFFECTING SYRINX FORMATION AFTER SPINAL CORD INJURY

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Objective: Aim of this study was to analyse the factors affecting the formation of post-traumatic syrinx.
Design: Retrospective study of 295 patients with spinal cord injury with a minimum follow-up of two years since injury.
Subjects: The series included 252 men and 43 women. The injury was treated non-operatively in 172 (M 144, F 28) and surgically in 123 (M 108, F 15). Mean age at the time of injury was 28.2 years and mean follow-up 6.4 years (2-34).There were 98 cervical, 134 thoracic and 73 lumbar and thoracolumbar injuries.
Outcome measures: The incidence of post-traumatic syrinx and its realtionship with the level and type of skeletal injury, the severity of spinal cord injury and the sagittal angle at the injury level were assessed.
Results: Fifty-nine patients (20%)had post-traumatic syrinx. Of the 123 patients treated operatively 15 (12.2%)developed syrinx as did 44 (25.6%) of 172 petients treated non-operatively (p=0.001). Twenty-one (21.4%) crvical injuries, 29 (21.6%) thoracic injuries and nine (12.3%) lumbar injuries had syrinx (p=0.023). Complete cord injury was found in 27 (46%) with syrinx and in 130 (55%) without syrinx (p=0.112). Frcature dislocation was highly associated with syrinx. Of the 40 patients with fracture dislocation 16 (40%) developes syrinx. Eleven of the 18 patients with conservatively treated fracture dislocation developed syrinx as did five of the 22 operatively treated ones (p=0.0001). The mean kyphotic angle at the level of injury was 25.2 degress in those with syrinx, 20.4 degrees in non-operatively managed patients without syrinx and 15.32 degrees in the operatively treated patients without syrinx (p=0.016).
Conclusions: In this series of 295 patients post-traumamtic syrinx developed in 20%.Syrinx formation was significantly associated with non-operative treatment, especially if the original injury was a fracture dislocation. Syrinx formation was also significantly more common in cervical and thoracic cord injuries, but not associated with the completeness of cord injury. Patients with syrinx formation had significantly more kyphotic deformity at the level of injury.

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A FRACTURED VERTEBRA COULD BE REMODELLED BY GROWTH - AN UP TO 47 YEARS FOLLOW-UP

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Introduction: The purpose of this study was to evaluate the clinical and the radiological long-term outcome of vertebral fractures in children with special reference to any potential remodelling capacity.
Material and Methods: Malmo University Hospital, the only emergency hospital in a city of 230 000 inhabitants, saves radiographs since 100 years, leaving the opportunity to re-examine and classify old fractures. All patients with a traumatic vertebral fracture 1950-1972, 0 - 18 years at injury, still city residents were invited to the study. Four denied, leaving 28 boys and 18 girls with mean age 14 (range 7 - 18) at fracture, 36 stable one column compression fractures, one Denis A, 8 Denis B and one Chance fracture, all but one without neurological deficits, to be re-examined after mean 33 years (range 27 - 47). All were non operatively treated. Follow-up included subjective (Oswestry score), objective (Frankel score) and radiographic outcome.
Results: Epidemiology: The incidence of thoracic and lumbar vertebral fractures was 0.07 0/00 in children < age 16 and 0.18 0/00 in children age 16 - 18 at injury. Subjective: Thirty-nine individuals had at follow-up no subjective complaints, seven had occasional back pain (mean Oswestry 15, range 8 - 28), with no difference found when comparing children below or above age 16 at injury.
Objective: Forty-two individuals were classified Frankel E and 4 Frankel D, one below age 16 and 3 above age 16 at injury.
Radiographic: The radiographic ratio anterior height/posterior height in the fractured vertebra increased from 0.75 at fracture to 0.87 at follow-up in children < age 16 at injury ($p < 0.001$) while no remodelling was found in those age 16 - 18 at injury. The post-traumatic kyphosis was unchanged in children < age 16 but increased in children age 16 - 18 at injury ($p < 0.05$). No reduced disc heights or scoliosis was seen.
Conclusion: Non operatively treated one column compression fractures, burst fractures Denis A and B and Chance fractures in children without neurological deficits have a predominantly favourable long-term outcome. A remodelling capacity, reducing the fracture deformity, exist in children with a large remaining growth potential.

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THE INCIDENCE OF VERTEBRAL METASTASES FROM A SECOND PRIMARY TUMOUR

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Background: The vertebral column is frequently involved in metastatic disease and may represent the 1st manifestation of malignancy in up to 40% of patients. The rate of vertebral metastasis from a second tumour in patients with a known primary is not well known. We sought to identify the incidence of a second primary in patients referred to our unit with spinal malignancy and a previously diagnosed primary tumour.
Method: A retrospective case note review was performed on 222 patients of whom 135 had a prior history of malignancy. Histology reports were reviewed and where possible comparison was made between prior histology and that obtained at biopsy or definitive surgery. The known malignancies were prostate (4), breast (3), colon, thyroid (2) and ovary, Non-Hodgkins lymphoma (NHL), bladder, melanoma and squamous cell carcinoma (1).
Results: In 16 patients (11.9%) the vertebral histology differed with the initial primary. The period between first and second malignancies varied widely (19 months - 22 years). Thirteen patients had (9.6%) clearly different tumours the most frequent of which was myeloma/plamscytoma (31% of cases). One patient had similar light microscopy but significant differences in immunochemical staining between tumours following surgical decompression and 3 showed changes such that it was probable that this represented a further primary of unidentified origin. Four patients has the second primary diagnosed prior to presentation of the vertebral metastasis Of the remaining twelve, 4 previously unrecognised tumours were diagnosed on biopsy and seven on tissue obtained at

definitive surgery. In one patient the second malignancy was suspected based upon preoperative imaging and confirmed at definitive surgery.
Discussion: The incidence of second primaries presenting with vertebral metastases is significant and should always be borne in mind when assessing patients and planning treatment. Biopsy should be performed when possible especially in those with long periods between initial primary and the development of spinal metastases and those with a changes in tumour behaviour. Comparison needs to be made between the histological features of the previous primary and metastasis. The incidence of myeloma as a second malignancy is higher than other groups and may be related to previous treatments.

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GIANT INTRASACRAL SCHWANNOMAS

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Introduction: Large benign neurogenic tumors arising from sacral canal and forming a presacral mass are uncommon. We report 6 cases with a giant intrasacral schwannoma.
Patients and Methods: A retrospective review of 6 patients with giant sacral schwannoma operated upon over an 8 year period (1994-2002) was performed. There were two male and four female patients with a mean age of 40.6 years (range 14-60 years). All patients presented with low back and leg pain. Three patients had sphincter impairment and one patient foot weakness. After biopsy and learning the histology, we performed intralesional resections. Three patients had undergone both anterior and posterior approaches, and three patients had posterior resections alone. One patient had an iliac vein injury during anterior surgery and she was operated again to perform an embolectomy and vein graft due to thrombosis. The mean follow-up is 4.1 years (1-8 years). All patients underwent annual MR scans during follow-up period. In two patients a small focus of residual tumor was detected, but they were not operated again.
Conclusion: This report and the few cases reported in the literature, show that the management of this rare tumor grants favorable results. Preoperative biopsy and diagnosis is important for surgical decision making. Benign nature and slow progression of the tumor direct us to prefer less agressive intralesional resections, and recurrence rates may be high.

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CHIARI MALFORMATION WITHOUT MYELODYSPLASIA. SURGICAL TREATMENT OF 50 CASES

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In a 14-year period, 1989 through 2002, 50 patients with hindbrain malformation (Chiari I, II type) have been surgically treated at the authors institution. The patients presented with various symptoms and signs of rather long history. The diagnose was established by MRI and according to the MRI the patients were divided into two groups: A - syringomyelia present, B - syringomyelia absent. Spinal cord symptoms overwhelmed those of increased intracranial pressure, cerebellar and brain stem symptoms in all Chiari A patients. In group B increased intracranial pressure and cerebellar signs dominated the clinical picture. Surgical procedures varied, although foramen magnum decompression has always been the first and main procedure. In group A intradural revision with adhesion lysis, tonsillar shrinkage and CSF pathways restoration was used, often with various shunts (hydrocefalus, syringomyelia). Foramen magnum decompression only was used in group B patients. Surgical approach was tailored according to the MRI finding and also according to the results of intracranial/intraspinal dissociation monitoring tests. The tests were designed to prove/exclude the presence of a CSF block. Test positive B patients (with no syrinx on MRI) were surgically treated as the A patients (with syringomyelia), i.e. by neocisterna magna creation. In group A 10 patients improved, 10 are stabilised, 7 worsened; in group B 20 patients improved, 3 are stabilised, none is worsened in the 12 months follow-up. The results in group A patients are worse then those in patients without syringomyelia (group B). The authors accept arresting the disease progression as a therapeutic success in group A, while such a stabilisation only is considered a failure in group B. From the surgical point of view they consider the MR A/B classification superior to the Chiariís morphological (I/II) description.
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DYNAMIC ELECTROPHYSIOLOGICAL EXAMINATION IN PATIENTS WITH LUMBAR SPINAL STENOSIS: IS IT USEFUL IN CLINICAL PRACTICE?

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Neurogenic claudication (NC) is typical of lumbar spinal stenosis (LSS). One suspected pathophysiological mechanism underlying NC is intermittent hypoxia of cauda equina fibres resulting from venous pooling, which may lead to ischaemic nerve conduction failure and to transient clinical and electrophysiological changes after exercise.
The aim of this study was to evaluate the appearance of significant transient electrophysiological abnormalities after walking exercise in patients with LSS and to establish the contribution of dynamic electrophysiological examination in the differential diagnostics of patients with LSS.
Thirty-six consecutive patients with LSS demonstrated by computed tomography (CT) participated in this study. The control groups included twenty-eight patients with diabetes mellitus and clinically manifested polyneuropathy, and thirty-two healthy volunteers. The LSS patients were divided into four subgroups based on the clinical severity of the disease (with respect to the presence or absence of NC in the history and pareses on neurological examination). Soleus H-reflex, tibial F-wave and MEP to abductor hallucis muscle were examined in all groups before and after quantified walking on a treadmill. The electrophysiological parameters measured after an exercise treadmill test (ETT) in LSS patients and in both control groups were compared with the same parameters obtained before ETT. The study shows that the electrophysiological parameters reveal minimal but statistically significant changes after walk loading in patients with LSS (a prolongation of the minimal latency of the tibial F-wave and of the latency of the soleus H-reflex). The changes in these parameters were demonstrated not only in patients with NC but also in patients without NC. More pronounced changes were found in LSS patients exhibiting chronic lower extremity pareses.
Conclusions. From among a large battery of electrophysiological tests, only the minimal latency of the tibial F-wave and the latency of the soleus H-reflex exhibit changes after walk loading in patients with LSS; these are minimal but statistically significant. Dynamic electrophysiological examination can illustrate the pathophysiology of NC in LSS, but from a practical point of view its

contribution to the differential diagnostics of LSS or diabetic polyneuropathy is limited by an absence of established cut-off values.
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EFFECT OF GRADED FACETECTOMY AND LAMINECTOMY ON THE MECHANICAL BEHAVIOUR OF THE LUMBOSACRAL SPINE

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Facetectomy and laminectomy are techniques for decompressing spinal stenosis. Resection of posterior bony or ligamentous elements should lead to a decrease in stability. The degree of instability depends among others on the extent of resection. Little is known about the correlation between these parameters. The aim of the study was to determine analytically the influence of different extents of posterior resection on the mechanical properties of the lumbosacral spine.
A three-dimensional, non-linear finite element model of the osseoligamentous lumbosacral spine was created. Besides an intact spine, the situations after left and bilateral hemifacetectomy, hemilaminectomy, bilateral laminectomy and two-level laminectomy were studied. The computer model was validated using intersegmental rotations experimentally determined by Quint et al (Z Orthop 1998; 136:350-357). This parameter shows a high degree of conformity for most of the 30 loading situations compared. In the present study the model was loaded with a torsional moment simulating axial rotation as well as with partial body weight and muscle forces simulating standing and forward bending of the upper body.
A left hemifacetectomy already increases intersegmental rotation for the loading situation of axial rotation. Expanding the resection to bilateral hemifacetectomy increases intersegmental rotation even more while further resection up to bilateral laminectomy has only a minor additional effect. For forward bending, intersegmental rotation is increased after a hemilaminectomy and further increased after a laminectomy. For standing, it is increased after two-level laminectomy. Resection of bony or ligamentous posterior parts has only a minor effect on the biomechanical behaviour of the adjacent region. A left or bilateral hemifacetectomy increases intersegmental rotation and thus decreases spinal stability only for the loading situation of axial rotation. Patients should avoid excessive upper body rotation after undergoing a facetectomy or laminectomy. For forward bending, intersegmental rotation is increased not until a hemilaminectomy and a bilateral laminectomy is performed. Thus patients submitted to a laminectomy should strengthen their stabilizing trunk muscles and avoid excessive forward bending.

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CLINICAL SIGNIFICANCE OF ADJUSTED CANAL AND DURAL SAC MEASUREMENT IN DEGENERATIVE LUMBAR SPINAL STENOSIS

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This study was to investigate whether adjusted measurement of spinal canal and dural sac cross-sectional areas could predict surgical outcome in degenerative lumbar spinal stenosis (LSS). This is the first study with adjusted measurement of spinal canal and dural sac in predicting outcome after decompressive surgery in LSS.
Preoperative CT myelographic slices in 53 patients were digitized. An adjusted canal and dural sac cross-sectional area measurements were introduced, in which the spinal canal by vertebra body at mid-pedicle level was expressed as canal vertebra ratio (CVR), and dural sac at disc level by spinal canal at superior mid-pedicle level was expressed as dural sac canal ratio (DSCR) (Figure 1 & 2). Average CVR and DSCR were calculated from L1 to S1. Patient's characteristics and clinical data were collected from chart review. Independent variables included average DSCR, average CVR, age, gender, type of procedure, number of level decompressed, and previous lumbar spinal surgery (limited to single level discectomy). Oswestry disability questionnaire was used to evaluate the surgical outcome, which was set as dependent variable. All the patients were followed up for more than 2 years post decompressive surgery. SPSS software was used in the process of multiple regression analysis.
The average DSCR was 64.6% (36.8 -- 81.8%), and average CVR was 20.7% (13.6 – 31.9%) from L1 to S1. The mean Oswestry disability score (ODS) was 19.6 -- 8.7. Female patients had significantly higher ODS ($P = 0.002$). Patients with previous lumbar surgery had significantly higher ODS than those without previous surgery (23.7 vs. 18.2, $P = 0.059$). The average CVR was higher in female than in male patient (23.2 vs. 19.1, $P = 0.001$), but the average DSCR was not significantly different between male and female (65.8 vs. 63.9, $P > 0.05$). There was negative correlation between average DSCR and ODS but without statistically significant ($r = -0.25$, $P > 0.05$). Number of level decompressed was significantly correlated with average DSCR ($r = -0.74$, $P < 0.001$), but was not correlated with average CVR ($P > 0.05$). Multiple linear regression analysis revealed that significant predictors for high ODS included female patient ($P < 0.001$), previous lumbar spinal surgery ($P = 0.001$), number of level decompressed ($P = 0.011$), and low average dural sac canal ratio ($P = 0.014$).
CT myelogram is the gold standard for the evaluation of LSS, especially in patient selected for surgical decompression. Previous studies have never considered the considerable variety of spinal canal and dural sac between individuals. Since degenerative LSS always presents as multi-levels compression, the measurement of the stenostic level could not reflect the real canal capacity and its neural content in individual spine, and may not be a good parameter in predicting natural history and outcome in the longitudinal study. Female gender, previous surgical history, more numbers of level decompressed have been confirmed to relate to unfavorable surgical outcome. This is the first time to reveal the correlation between severity of dural sac compression and poor outcome of decompressive surgery with adjusted cross-sectional area measurement.
The predictors for unfavorable surgical outcome in this study included female gender, previous history of lumbar spinal surgery, number of level decompressed, and more severe of dural sac compression.

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RIGID VS. SEMIRIGID & DYNAMIC INSTRUMENTATION FOR STABILIZATION THE DEGENERATED LUMBOSACRAL SPINE ASSOCIATED WITH SPINAL STENOSIS

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This prospective comparative randomised study was conducted to compare the effects of a rigid versus a semirigid versus a dynamic instrumentation on the standing global and segmental sagittal lumbar spine and the complications in three equal groups of 45 adult patients, who suffered from degenerative lumbar spine disease and

underwent primary lumbar spine surgery for degenerative disease associated or not with spinal stenosis. The patients received either the rigid (Group A), either semirigid (Group B) or dynamic (Group C) spinal instrumentation with decompression and fusion. The age of the patients, who received rigid, semirigid and dynamic instrumentation was 65+9, 59+16 and 62+10 years respectively. The SF-36 survey was used in all patients. The following roentgenographic parameters were measured and compared in all spines: lumbar lordosis, total lumbar lordosis, sacral tilt, distal lordosis, intervertebral angulation, vertebral inclination and disc index.
Results. Total lordosis was decreased at 3% (P=0.025) following dynamic instrumentation only (Group C), where the L5-S1 junction was not included. The intervertebral angulation L2-L3 was increased postoperatively at 8.5% (P=0.04) following in Group C, while the intervertebral angulation L4-L5 was significantly decreased in Group A at 9.8% (P=0.01) and C at 16.2% (P=0.0013). The disc index L1-L2 was decreased in Group B at 8.25% (P= 0.09). The disc index L2-L3 decreased in Group A at 17% (0.04) and in Group C at 23.5% (P=0.015), while it was clinically but not statistically increased in Group B at 11% (P=0.09). The disc index L3-L4 there was an increase in Group C at 18.74% (P=0.0014). The disc index L4-L5 was decreased in all three Groups: Group A 21% (P=0.01), Group B 13% (P=0.015) and Group C 13.23% (P= 0.043). The disc index L5-S1 there was a significant decrease in Group B 13% (P=0.015). In the first year postoperatively there was a significant improvement in the preoperative scores of all 8 items of SF-36 and in all groups, that was continued thereafter in a moderate mode. All fusions healed in all three groups without pseudarthrosis or malunion within the expected time. Hardware failure (one screw and two rod breakage), without pseudarthrosis or complaints was observed one year postoperatively or later in 2/15 patients of Group C. Asymptomatic radiolucent areas around the pedicle screws were radiologically shown (2 screws in Group C, 3 screws in Group A and 4 in Group B) around screws in the pedicles L5 and S1 solely. There were either adjacent segment degeneration in any spine. The preoperative back pain was progressively improved postoperatively equally in all three groups in the first and second year postoperatively. Then there was an increase of back pain below the instrumented area in all patients with adjacent segment degeneration.
Discussion and Conclusion. The stabilization of the degenerative symptomatic lumbar spine with rigid, dynamic or semirigid instrumentation did not change either global lumbar lordosis or segmental lordosis at any level. All three instrumentations changed (increased or decreased) the height of the intervertebral disc within the instrumented area with the most significant disc space changes following the dynamic instrumentation. The delayed symptomless hardware failure following dynamic instrumentation seems to be a biologic adaptation phenomenon because it was not followed by pseudarthrosis or loss of correction. Because the clinical and radiological data in all three groups were similar it is difficult to recommend any of them a more advantageous as compared with the other.

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DECOMPRESSION AND DYNAMIC STABILIZATION FOR SPINAL STENOSIS WITH DEGENERATIVE SPONDYLOLISTHESIS OF THE LUMBAR SPINE A PROSPECTIVE CLINICAL STUDY

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Introduction: In spinal stenosis with degenerative spondylolisthesis, several studies have shown that decompression combined with fusion significantly improves patients outcome as compared to decompression alone. The addition of transpedicular instrumentation leads to higher fusion rates and reduces progression of spondylolisthesis. However, this procedure often causes donor site morbidity. A novel dynamic system (Dynesys) was introduced to the market, stating that stabilization was possible with this system without bone grafting. We therefore conducted a prospective study to evaluate this system in elderly patients with spinal stenosis and degenerative spondylolisthesis of the lumbar spine.
Material and methods: 26 patients (8 males, 18 females, mean age 71 years) with lumbar spinal stenosis and degenerative spondylolisthesis (22 cases L 4/5 and 4 cases L3/4) underwent interlaminar decompression and stabilization with Dynesys. In all patients, pre-operative plain and functional X-rays were obtained in addition to an MRI and/or to a lumbar myelogram. All patients had plain X-rays immediately after surgery and were followed for a minimum period of 24 months (mean follow-up = 26 months). At this time, plain and functional X-rays were obtained and compared to the pre- and post-operative X-rays.
Results: 24 patients were evaluated after 2 years. Two patients were excluded from this study: one patient had subsequent surgery due to a traumatic vertebral fracture and one patient died due to unrelated pathology. Mean operative time was 137 minutes (90-210), mean blood loss 415 cc (100-700), mean hospital stay 16 days (10-43). We had 3 complications (2 cases of transient leg paraesthesia, 1 patient required revision scondary to insufficient decompression). Mean leg pain on VAS had decreased from preoperative 80 to 14. Mean walking distance had improved from 245 meters to more than 1000 meters. 5 patients still suffered from claudication but only 2 of these patients had shown no improvement. 21 (81%) patients stated that they would undergo the same procedure again. Plain and functional radiographs showed one screw breakage (in a patient diagnosed with multiple sclerosis and abnormal gait) and 3 patients with screw loosening (16%). Intervertebral height and segmental lordosis showed no significant alteration. There was a slight progression of spondylolisthesis in 4 patients (between 5 and 12%). However, none of these patients showed vertebral slippage of more than 4 mm in functional radiographs (mean 0,7 mm). 9 patients (41%) had signs of degenerative alterations in the adjacent segments. One patient developed an instability at an adjacent level and was treated with extension of Dynesys.
Conclusion: Dynamic stabilization with Dynesys in elderly patients suffering from spinal stenosis with degenerative spondylolisthesis leads to similar clinical results as seen in established protocols using pedicle screws and bony fusion. However, when using Dynesys, no bone grafting is necessary, therefore avoiding donor site morbidity. This is in our population, a major advantage of this system.

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SPINAL STENOSIS SURGERY IN SWEDEN 1987-1999

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Study Design. Retrospective population based national register study.
Objectives. To analyze surgical interventions in patients with lumbar spinal stenosis, patient characteristics, geographic distribution, subsequent development, and case fatality rate, based on Swedish national data for 1987-1999.
Summary of Background Data. No analysis of national data has been reported previously. Complete follow-up of incidence and type of spinal stenosis surgery, rate of multiple operations, mortality, underlying causes of death, length of hospital stay, and case fatality rate by linkage of the National Inpatient Register and Swedish Death Register.
Results. The study cohort consisted of 10 494 patients. The overall mean age at surgery was 64 years. Over the study period, the

mean age increased from 60 to 67 years. Only 7 % of the patients underwent multiple operations for spinal stenosis during the study period. The mean hospital stay decreased from 15 to 8 days during the study period. Laminectomy was performed in 89 %, and additional fusion in 11 %. The mean rate for the whole of Sweden was 9.7/100 000/year, ranging between 6 in the northern part of Sweden to 13 in the south-east part of the country. The annual number of operations performed increased from 4.7 to 13.2 per 100 000 inhabitants and year. The case fatality rate within 30 days after surgery was 3.5 per 1 000 operations. Cardiovascular disease was the most common cause of death (46 %). Relative risk of dying within 30 days of admission was doubled in males, and for fusion surgery, and increased four times in patients older than 80 years. The relative risk of dying decreased during the study period.
Conclusion. Spinal stenosis surgery in Sweden has increased. Within an ageing group of patients, mortality has declined.

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rhBMP-6 EXPOSED OSTEOPROGENITOR CELL IMPLANTATION TIME: DOES IT MAKE A DIFFERENCE IN ACHIEVING SPINAL FUSION?

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Introduction: Survival and performance of a cell-based product implanted into a devascularized spinal fusion bed may be suboptimal since surgery disrupts the blood supply affecting the delivery of oxygen, nutrients and growth factors. Our purpose was to optimize the spinal fusion rate of rhBMP-6 exposed osteoprogenitor cells (rhBMP-6 cells) by delaying their implantation into a more vascularized fusion site.
Methods: L5-L6 posterolateral intertransverse fusions were performed in 39 skeletally mature NZW rabbits.
Rabbits were assigned to 4 groups. In group I, each decorticated fusion bed was grafted with 2.5 cc of guanidine extracted demineralized bone matrix (gDBM) carrier only. In group II, each fusion bed was grafted with 2.5 cc of morselized iliac crest bone graft (ICBG). Prior to the spine surgery in groups III and IV, rhBMP-6 cells were generated in the following manner. 1-2 cc of bone marrow were harvested from each femur; the cells were isolated, cultured and expanded on an rhBMP-6 containing matrix. Animals assigned to group III and group IV, received 2.5 cc of gDBM carrier and 15M rhBMP-6 cells per side. In group III, cells were implanted at the same time of the spinal fusion procedure; in group IV, each fusion bed received an injection containing 15M rhBMP-6 cells 10 days after the fusion procedure. Animals were sacrificed 6 weeks post-operatively. Specimens were assessed by X-rays and manual palpation.
Results: Radiographically, new bone growth was more apparent in the ICBG and rhBMP-6 cell treated animals. Fusion masses were less prominent in the gDBM group. Manual palpation: animals from group IV had the highest fusion rate (6/7; 86%). Rabbits from group III had a better fusion rate (10/13; 77%) than those from group II (5/9; 55%) and I (2/10; 20%).
Discussion: Our data demonstrates the osteogenic capacity of autologous rhBMP-6 cells. The preliminary results using a novel method of cell implantation suggests that a delayed injection of BMP-6 cells over a more vascular fusion bed containing gDBM can improve the rate of spinal arthrodesis. rhBMP-6 cells therefore, seems to have potential clinical applicability in spinal fusion surgery as a graft substitute/expander.

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CEREBROSPINAL FLUID BIOMARKERS IN EXPERIMENTAL SPINAL NERVE ROOT INJURY

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Introduction: The relationship between mechanical compression, biochemical effects of nucleus pulposus and nerve root injury in disc herniation is still unclear. In the present experimental study we investigated biomarkers for nerve injury, inflammation and pain in cerebrospinal fluid (CSF) after mechanical compression (MC) and/or nucleus pulposus (NP) application to spinal nerve roots.
Methods: The unilateral S1 nerve root was exposed in twenty pigs. The animals were divided into four groups (n=5 each): 1. Slow-onset mechanical compression with an ameroid constrictor (MC). 2. Autologous nucleus pulposus application (NP). 3. MC+NP 4. Sham-operation. After one week 6 ml of CSF was collected and four structural nerve proteins, neurofilament (NFL), S-100, glial fibrillary acidic protein (GFAp), neuronspecific enolase (NSE), the proinflammatory cytokine interleukin-8 (IL-8), the neurotransmitter nociceptin and substance P endopeptidase activity (SPE) were analyzed and compared between the groups. Immunoassays were used for the SPE, S-100, nociceptin (Radioimmunoassay), NSE (Luminiscence immunoassay). NFL, GFAp and IL-8 were analyzed with ELISA.
Results: The concentration of NFL was increased in the MC group, 17.0 µg/l±5.0, and in the MC+NP group, 19.8±12.1 µg/l, compared to the sham group, 0.9±0.9 mg/l, and the NP group, 0.4±0.1 ug/l ($p<0.01$ both). The concentration of nociceptin was significantly increased in the MC group, 24.0±8.6 fmol/ml, and in the MC+NP group, 31.2±6.6 fmol/ml, compared to the sham group, 7.0± 1.3 fmol/ml ($p<0.05$ and $p<0.01$ respectively). A correlation was found between NFL and nociceptin ($r=0.50$, $p<0.05$). There were no differences between the groups regarding GFAp, NSE, s-100, IL-8 or SPE activity.
Discussion: The present study demonstrates increased concentrations of NFL and nociceptin in CSF after nerve root compression. A simultaneous application of NP did not increase the response. The increased concentrations of NFL and nociceptin indicate axonal nerve root injury and an involvement of pain related systems. No increased inflammatory response in CSF could be demonstrated in any of the groups.

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THE SIGNIFICANCE OF IMPLANT STIFFNESS RELATIVE TO BONE FUSION MASS. ANALYSIS BY DEXA SCANNING AND HISTOMORPHOMETRY.

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Introduction: Titanium (Ti) implants has been found to have a lower elastic modulus than Stainless steel (Ss). A material with a low modulus of elasticity possesses the advantage of reducing stress shielding, as more stress will be transferred to the bone. Such could improve the healing process of the spinal fusion mass. The aim of the present study was to evaluate the influence of Ss- contra Ti-pedicle screw implants on posterolateral fusion mass healing.
Methods: 16 adult mini-pigs underwent posterolateral spinal fusion at L3-L4, and each was randomly allocated to receive either a Ss- or Ti-pedicle screw device (CCD). The postoperative observa-

tion period was 3 months. Two independent observers, each from a different institution and blinded for randomization, performed the analyses. The one employed standardized quantitative DEXA-scanning, and the other, histomorphometry.
Results: The Ti-group showed significantly higher fusion mass volume (BMC) as analyzed by DEXA scanning compared to the Ss-group ($p<0.03$). There was a higher bone volume percentage in the fusion mass from the Ti-group compared to the Ss-group, but the level was not significant.
A correlation was found between the fusion mass volumes measured by histomorphometry and DEXA scanning ($R=0.73$ and $p< 0.001$).
Discussion: Our animal study points up the significance of the choice of implant material. Ti-pedicle screw instrumentation seems to improve bone fusion mass remodeling in comparison to Ss instrumentation. A good correlation was found between DEXA-scanning and histomorphometry in the analysis of bone fusion mass.

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INTERVERTEBRAL DISC DEGENERATION INCREASES VERTEBRAL BODY VULNERABILITY TO „OSTEOPOROTIC" FRACTURE

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Introduction: Anterior wedge („osteoporotic") fractures affect upper lumbar and thoracic vertebrae alike, causing spinal deformity and distress to many elderly people. Changes in hormones and physical activity cause a systemic reduction in bone mineral density (BMD) with age, but do not explain why the anterior vertebral body is so often and so drastically affected. We hypothesise that disc degeneration alters the distribution of compressive load-bearing in old spines in such a manner that BMD is reduced in the anterior vertebral body, leaving it vulnerable to fracture when the spine is flexed.
Methods: Thirty-five thoraco-lumbar motion segments, aged 64 - 92 yrs, were subjected to a 1.5kN compressive load while the distribution of compressive „stress" was measured along the antero-posterior diameter of the disc. Measurements were repeated in simulated erect and slightly flexed postures. „Stress" measurements were integrated over area to determine the percentage of the applied 1.5kN resisted by the anterior and posterior halves of the disc (and hence vertebral body) and by the neural arch. Volumetric BMD was obtained for these regions using dual energy X-ray absorptiometry (DXA).
Results: Disc degeneration was associated with reduced load-bearing by the anterior vertebral body ($P<0.001$), and reduced load-bearing correlated with reduced BMD in this region of the vertebra ($P<0.01$). BMD in the anterior vertebral body was a better predictor of compressive strength ($R2 = 0.77$) than BMD of the whole vertebral body ($R2 = 0.59\%$).
Discussion: These results clearly support the hypothesis. Disc degeneration is associated with reduced loading of, and reduced BMD in, the anterior vertebral body. This in turn is strongly correlated to reduced vertebral compressive strength in flexion. In this way, we suggest that disc degeneration can increase the risk of osteoporotic vertebral fracture.
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CLINICAL COMPARISON OF TWO DIFFERENT OSTEOTOMY CORRECTION TECHNIQUES FOR KYPHOSIS DEFORMITY OF ANKYLOSING SPONDYLITIS

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Objective: To investigate the indication of two different osteotomy techniques for the correction of kyphosis secondary to ankylosing spondylitis and evaluate the selection of osteotomy level, instrumentation area and their clinical outcome.
Methods: 54 patients (male 49,female 5) were covered in this study with mean age 36 years (ranging from 25 to 56 years). These patients were divided into two groups according to the different osteotomy techniques. Group A: 23 cases was operated on with polysegmental "V" shape osteotomy, Group B: 31 cases were operated on with single--level transpedicular wedge osteotomy. These two different osteotomy techniques were selected depending on the ossification of the discs. After correction of kyphosis deformity all cases underwent transpedicular screw instrumentation and autogenous bone grafting.
Results: No death and infection. 2 cases of dural tear occured (one for each group) and 1 case of pedicle fracture during operation in Group A, transient lower extremity numbness were seen in 2 patients in Group B, superior mesentery artery syndrome (SMAS) was found in 1 case in Group A. The mean correction in Cobb angle for polysegmental "V" shape osteotomy group was 44°, whereas for single--level transpedicular wedge osteotomy group it was 36°. After a mean follow-up of 20 months ranging from 11 to 45 months, the average correction loss of 6°was seen in Group A, 3°correction loss in Group B_The patient satisfactory rate was 95% and 93% in Group A and Group B respectively.
Conclusion: Similar clinical outcomes were seen in two groups with different osteotomy techniques in terms of correction rate, complication and patients satisfactory rate_The main decisive factor to select the osteotomy techniques is the extent of anterior column ossification. Offset laminar hook is a good resolution for enforcing internal fixation in case of osteoporosis.

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RESULTS OF KYPHECTOMY WITH THE TECHNIQUE OF WARNER AND FACKLER IN CHILDREN WITH MYELOMENINGOCELE

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Pathological lumbar kyphosis occurs in approximately 8 % to 20 % of patients with myelomeningocele. It is the origin of severe complications including functional deficits, pressure sores, inability to sit or lie supine as well as cardio/pulmonary and intestinal problems. Since 1994 the Warner and Fackler technique is the standard procedure for children with lumbar kyphosis and myelomeningocele in our institution. The purpose of this study was to evaluate the outcome and to identify complications of this treatment modality.
Patients and Methods: From 1994 to 2003, 22 children with lumbar kyphosis and myelomeningocele and an average age of 7,6 [range: 1,6-16,2] years were treated with the Warner and Fackler technique. The average preoperative kyphosis was 116° [range: 80°-150°]. Five children had pressure sores over the apex of the kyphosis.
Results: All patients were able to sit and to lie supine after surgery. Functional improvements, as well as better quality of life was

also observed in all cases. All pressure sores have healed. In average the lumbar kyphosis could be corrected from 116° [range: 80°-150°] preoperatively to 42° [range: 20°-90°]. At follow-up (mean 3; range: 2-6 years) the result was stable (mean 42°, range 20°-90°). Surgery took 4,7 [range: 2,0-7,2] hours. The average blood loss was 1240 [range: 300-3000] ml. Four [range: 2-7] days of the intensive care unit treatment were necessary after surgery. Severe complications were noted. As surgical problems, there were two cases of excessive blood-loss (>3000ml). Failure of instrumentation occurred in 6 cases, requiring revision surgery for three patients. One patient died due to rhabdomyolysis induced by an anaesthetic medication (propofol). Additional problems consisted of prolonged postoperative respirator dependency and cardiocirculatory adaption problems.
Conclusion: Kyphosis correction emplying Warner and Fackler´s technique is highly demanding but effective. The results of Warner and Fackler, the results of Ghanem et al., McCall and our own experience show that the kyphectomy with Luque rod instrumentation and pelvic fixation through the first sacral foramina provides excellent results concerning correction and gain of functional capacity. However there is a significant risk for serious complications and the patients have to be advised accordingly.

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MANAGEMENT AND SURGICAL PLANNING OF SEVERE INFANTILE CERVICAL KYPHOSIS

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Introduction: Congenital cervical kyphosis may, due to cord compression, lead to grave neurological deficit in the infant. The choice of surgical procedure and the age at which it is indicated, pose a considerable challenge. Inappropriate surgical procedure can produce graver deformity and neurological damage despite best intent. Purpose of the study: To present a series of 6 patients with this complex problem, outlining the goals of treatment and the difficulties caused by previous surgeries.
Materials and methods: Six infants with congenital cervical kyphosis aged 2 to 7 yrs, underwent surgery at our institution. Most of them presented with severe neurological deficit in the form of tetraparesis. Three had been previously subjected to neurosurgical posterior decompression and fusion, which led to recurrence and increase of kyphosis over time. Pre -operatively kyphosis measured 130°, 125°, 125°, 66°, 60° and 40°. The post-operative follow-up ranges from 3 - 48 months.
Results: Five cases underwent combined posterior and anterior surgery and one case was operated from anterior only. Correction was attained and cord decompression was performed in all cases. On average 78% correction of kyphosis was achieved. In one case nerve root neurapraxia was recorded post-operatively but was noted to have recovered completely during follow-up at 6 months. Two cases demonstrated improvement of tetraparesis post-operatively. There were no intra-operative complications. One infant died 1 week postoperatively due to bolus aspiration. In one case kyphosis progressed below the instrumented levels. Wound infection and implant failure were not evidenced postoperatively nor during follow-up. Correction in previously operated patients was more difficult to obtain.
Discussion: Infantile cervical kyphosis with neurological deficit poses a significant challenge for the spine surgeon. Posterior decompression and fusion in our previously operated patients did not seem to solve the problem. On the contrary, continuing anterior growth in these patients seem to aggravate the condition necessitating further combined surgery. We therefore recommend a timely intervention with a combined anterior-posterior approach to balance the spine for future growth in a corrected position. Our initial results have been most encouraging and would lead us to believe that surgical intervention is warranted.

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WEDGE OSTEOTOMY IN SPINAL DEFORMITIES: SURGICAL PLANNING, CONSEQUENCES FOR POSTOPERATIVE SPINAL BALANCE

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The consequences of monosegmental osteotomy are evaluated on overall sagittal balance of spine and pelvis according to the osteotomy level.
Material and methods: 68 patients (1980 to 1999) underwent wedge osteotomy for global kyphosis related to ankylosing spondylitis (n=37) or failed back surgery (n=31) (Minimum follow-up 3 years). Opening wedge osteotomy was performed in the first 19 patients and closing wedge osteotomy in the remaining 49 patients. Sacral tilt (normal, 41°), T9 sagittal tilt (normal 11°), and T9 tilt (normal -11°) were measured on radiographs. 26 osteotomy were above L2 L3 disc and 42 below.
Results: Overall, mean local correction was 44° and T9 sagittal tilt correction 30.6°. In the below L2 L3 group, mean local correction was 49° and T9 sagittal tilt change was +28° (from-2° to +26°); T9 tilt changed from -21° to -3° and ST from 6° to 18°. In the above L2 L3 group, mean local correction was 36.6°, T9 sagittal tilt changed from -12° to + 23° (gain, 35°), T9 tilt changed from -24° to 4°, and ST changed from 4° to 7°. 7 functional kyphosis developed (hip extension limitation precluding adaptation to the correction).
Conclusion: Overcorrection of posterior trunk tilt at T9 can be tolerated in patients with a good range of hip extension. Correction of pelvic retroversion (moving the sacrum to a more horizontal position) is more important in osteotomies below L3.

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COST-EFFECTIVENESS ANALYSIS ON DIFFERENT REHABILITATION STRATEGIES AFTER LUMBAL SPINAL FUSION - A RANDOMIZED PROSPECTIVE STUDY

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Introduction: The present study takes an economic view in analyzing 3 different rehabilitation strategies for patients who have undergone lumbar spinal fusion. Hence, the aim is to analyze which rehabilitation strategy supporting the best quality of life for the patients per cost unit.
Methods: 90 patients were randomized 3 months postoperatively to one of three rehabilitation strategies. Video group participants watched a video of exercises for the purpose of the patientís individual training. Back-café group was provided the same as video-group but furthermore, 3 meetings with other fusion-operated patients during an 8 weeks period. Training group was provided physical therapy training twice weekly for 8 weeks. The lumbar spinal fusion operations took place from 1996-2000. Functional outcome was evaluated 6, 12 and 24 months postoperatively and exact cost data were collected from the Danish health insurance agency covering all contacts to primary sector in Denmark e.g. contacts to general practitioners, physical therapists, chiropractors, psychologists and other medical specialities. On this basis a decision-analytic model to evaluate costs and benefits of the three rehabilitation strategies was developed.

Results: A highly significant difference ($p<0.001$) was identified among the 3 rehabilitation groups in relation to number of contacts outside the hospital, but within the primary sector, during the follow-up period. Thus, 24 months postoperatively, the patients within the video group represented a tripled cost compared to the back café group ($p<0.05$). This massive difference covers a greater demand towards primarily general practitioners and physical therapists increased by a ratio of 1.5 and 4.2 compared to back café group ($p<0.05$).
Discussion: By a fairly modest effort patientís life quality per cost unit, after lumbar spinal fusion, can be increased significantly. The costs saved by a poor rehabilitation strategy returns multiplied by patientís contact to primary sector.

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EFFICACY OF SACROILIAC ORTHOSIS IN TREATMENT OF SACROILIAC JOINT SYNDROME

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Introduction: Sacro iliac joint (SIJ) has been implicated as a possible cause of low back pain. Manual therapy and correction exercises have been shown to result with satisfactory outcome in a majority of patients. Stabilization of SIJ in addition to manual therapy may influence outcome. The purpose of this study was to evaluate the efficacy of sacroiliac orthosis in the treatment of patients with SIJ dysfunction
Materials and Methods: A total of 40 patients with SIJ dysfunction diagnosed by using clinical parameters and eliminating the other possible causes of back pain were included in the study. Patients were simply randomised into two groups. Group A included 20 patients treated by manual therapy and correction exercises and Group B included 20 patients treated by sacroiliac orthosis in addition to the same treatment program. Treatment program continued 8 weeks (3 sessions per week) in both groups. Sacroiliac orthosis was used for 4 weeks. All patients' pain intensity and functional levels were evaluated by using visual analog scale and Oswestry disability index at the end of the treatment period.
Results: Both groups were similiar according to age, gender, duration of symptoms before treatment and average follow-up ($p< 0.05$). Pretreatment VAS (Group A: 7.82, Group B: 7.84; $p=0.195$) and Oswestry scores (Group A:30.95 vs. 31.50; $p=0.768$) were also similiar in both groups. Postreatment VAS revealed a better pain relief in Group B (0.72) than Group A (5.62) ($p=0.001$). Average Oswestry disability index score was also significantly better ($p=0.007$) in Group B (7.90) than Group A (10.45).
Conclusion: Pelvic belt was found to provide a significant decrease in the sagittal rotation of SIJ and has been considered to decrease the symptoms of SIJ dysfunction in a previous biomechanical study. However, no prospective randomised clinical study with a control group has been reported up to now to confirm this finding.
We conclude that sacroiliac orthosis may be used as an adjunctive to manual therapy in the management of SIJ dysfunction

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THE EFFECT OF THE DURATION OF RADICULOPATHY ON THE OUTCOME OF DISCECTOMY SURGERY

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Objectives: To evaluate prognostic factors that influence outcome particularly those related to duration of symptoms in surgery for lumbar radiculopathy.
Method and results: In primary care 75% of patients are pain free after the onset of sciatica within 28 days. The optimum timing of surgery for unresolved leg pain secondary to herniated lumbar disc is unclear. There is variation between countries and specialties in perceived best timing of surgery for this common condition. We prospectively recruited 113 patients into this study and at one year the follow-up was available on 103 (91%). We investigated the prognostic value of a number of variables, the duration of sciatic symptoms, age at operation, Modified Zung Depression Score (MZD) and Modified Somatic Perception Score (MSP) using multiple regression analysis. The outcome was measured by the change of the Oswestry disability index (ODI), Low back outcome score (LBOS) and of the Visual analogue scale (VAS).Patients with contained and non-contained herniated disc were compared.
The change in ODI is statistically significantly associated with the duration of sciatica symptoms ($p=0.05$) with a one month increase in the duration of symptoms being associated with a decrease in the change of ODI of 0.6 (95% CI, -1.014 to -0.187). A clinically significant change in the ODI of 10% would occur with a delay of 16 months. The duration of sciatica and the MZD are associated with significant reduction in LBOS ($p=0.034$ and 0.028 respectively). VAS change was not significantly associated with all the prognostic factors investigated. A shorter duration of sciatic symptoms was associated with a greater degree of patientsí outcome satisfaction. Non-contained herniated disc had a shorter duration of symptoms and a better functional outcome compared to contained herniated disc. Unemployment and smoking were not risk factors for poor surgical outcome.
Conclusion: Our study indicates that the duration of radicular pain of more than 12 months has a less favourable outcome. Patient's satisfaction is greatest if surgery occurs within one year.

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EFFECTIVENESS OF BILATERAL L2 ROOT SLEEVE BLOCK IN THE DIAGNOSIS AND PREDICTION OF THERAPEUTIC OUTCOME IN THE DISCOGENIC LOW BACK PAIN

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Objective: A multitude of pain generators are responsible for discogenic low back pain (DLBP) and there are many therapeutic modalities in DLBP. The most important factor in the successful treatment of DLBP is the accurate diagnosis of DLBP. Recently it has been suggested that the neural pathway transmitting pain from the lower intervertebral discs are through the L2 spinal nerve roots, presumably via sympathetic afferents from the sinuvertebral nerves. To enhance the diagnostic accuracy in the selection of surgical candidate of DLBP, we conducted bilateral L2 root sleeve blocks (L2RSB) after provocatve discography and assessed its response in relation to therapeutic outcome.
Methods: Our inclusion criteria were 1) no positive radiologic findings except decreased signal intensity of one level lower intervertebral disc (L45 or L5S1) on T2-weighted MRI; 2) and chronic

low back pain which was not relieved despite at least 6 months of conservative treatment; 3) exclusion of low back pain related to the facet arthropathy. To assess the role of bilateral L2RSBs, L2RSBs were performed after discography with provocation of pain. For the assessment of pain relief of the provoked pain, visual analogue scale (VAS) was used before and after bilateral L2RSB, and the response to bilateral L2RSB upon provoked back pain was graded into 3 groups (exellent: more than 70% reduction, borderline: 30-70% reduction, equivocal: less than 30% reduction). Twenty patients were included in the inclusion criteria, and provocative discography and L2RSB were also conducted in another 8 patients with somatic pain caused by lumbar HNP or spinal stenosis for comparison. All 28 patients were treated surgically, and the postoperative VAS reduction was assessed to detect possible correlation with the preoperative bilateral L2RSB results.
Results: Thirteen of 20 patients in the inclusion criteria showed exellent responses to L2RSBs. In the remaining 7 (35%) of 20 included patients and 8 patients with somatic pain, borderline or equivocal responses were observed. Following surgery in 20 DLBP patients, all 28 patients showed significant VAS reductions, however, postoperative mean VAS reductions in the patients with exellent response to L2RSB was more significant than those of the borderline or equivocal response to L2RSB ($p<0.05$).
Conclusion: In addition to the provocative discography, bilateral L2RSB can be an effective means to increase the diagnostic accuracy as well as to predict the outcome in the surgical treatment in one level DLBPs. Our results also confirm that DLBP is a kind of visceral pain in respect to its neural pathwaysas documented in previous studies.

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THE EFFECT OF PREVIOUS LOW BACK SURGERY ON GENERAL HEALTH STATUS - RESULTS FROM THE NATIONAL SPINE NETWORK INITIAL VISIT SURVEY

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Introduction: Several studies have described the possible role of psychological abnormalities in patients with chronic low back pain. Some of these patients have had previous spinal surgeries performed. Psychosocial parameters exert an increasingly important role in patient-based outcomes. The objective of our study is to examine whether patients who had previous low back surgeries had poorer general health status than patients with no surgery.
Methods: We conducted a cross-sectional study on 18325 patients with back pain enrolled at first visit in the National Spine Network (NSN) database from January, 1998 to April, 2000. The Short Form Health Survey 36 was administered to these patients. Of the 18325 patients enrolled, 3632 had previous low back surgeries. These surgeries were divided into discectomy/laminectomy without fusion, posterolateral fusion, posterior interbody fusion, anterior interbody fusion, and anterior-posterior fusion of the lumbar spine.
Results: Even after adjustment for all possible confounding factors, patients who had previous lumbar surgeries fared significantly poorly in all 10 scores of the SF-36 health survey. Among patients who had previous surgeries, decompression or discectomy without fusion achieved significantly higher scores for General Health, Role Physical, and Mental Component Summary scales. Patients who had decompression or discectomy as their most recent surgery had higher scores for General Health, Role Physical, Role Emotional, and Mental Component Summary scales, when compared to those who had other surgeries.
Conclusion: Previous back surgery has a significant worsening effect on the general health status of patients presented to the NSN database. Decompression or discectomy, without fusion seems to have the least deleterious effects on SF-36 health status among patients who had previous surgeries.

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EVIDENCE OF AUGMENTED CENTRAL PAIN PROCESSING IN IDIOPATHIC CHRONIC LOW BACK PAIN

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Background: For many individuals with chronic low back pain (CLBP), there is no identifiable cause. In other chronic pain conditions considered to be idiopathic, sensory testing and functional MRI (fMRI) have identified generalized increased pain sensitivity, hyperalgesia, and altered brain processing, suggesting central augmentation of pain processing. This study applied these methodologies to the regional syndrome of chronic low back pain (n=11), and compared the results of this group to patients with widespread pain (fibromyalgia, n=17) and control subjects (n=11).
Methods: Idiopathic CLBP subjects were identified that had low back pain for at least 6 months, unexplained by MRI/radiographic changes. Experimental pain testing was performed at a neutral site (thumbnail) to assess pressure pain threshold in all subjects. For functional MRI (fMRI) studies, stimuli of equal pressure (2kg, EPr-condition)) and of equal subjective pain intensity (slightly intense pain, EPa-condition) were applied to this same site.
Results: In the Epr fMRI condition, 2 kg of pressure applied to thumb resulted in evidence of five common regions of neuronal activation in the CLBP and FM groups (contralateral primary [S1] and secondary [S2] somatosensory cortex, inferior parietal lobule [IPL], cerebellum, and ipsilateral S2). In contrast, this same stimulus resulted only in a single activation in controls (contralateral S2). Experimental pain testing revealed hyperalgesia in both patient groups; the pressure required to produce slightly intense pain was significantly higher in the controls (5.6 kg) than in CLBP (3.7 kg, p=.03) or fibromyalgia (3.5 kg, p=.006). fMRI data collected in this EPa condition revealed common, overlapping neuronal activations in all three groups (contralateral S1 and S2, ipsilateral S2, IPL, insula, anterior cingulate cortex, and cerebellum).
Conclusions: At equal pressure, patients with chronic low back pain or fibromyalgia experienced significantly more pain and showed more extensive, common patterns of neuronal activation in pain-related cortical areas. With equally painful stimuli, elicited by significantly lower pressure in both patient groups, the patterns of neuronal activations were similar in the three groups. These findings are consistent with augmented central pain processing in this cohort of idiopathic CLBP patients.

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METRIC CHARACTERISTICS OF THE SIX-QUESTION "CORE SET" IN THE EVALUATION OF BACK PAIN

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The general recommendations for outcome assessment in spinal disorders published in the Outcome Research Spine Focus Issue include the necessity of evaluating 5 domains: back function, generic health status, pain, work disability and patient satisfaction

(1). The use of a specific questionnaire for each domain can be so time consuming that most clinicians will not follow the recommendations in a daily basis. An international group of back pain researchers recommended a standardized "core set" of 6 questions, feasible for routine clinical use, to evaluate the 5 domains (2). The metric characteristics of this 6-question "core set" have not been studied.

Aim: To evaluate the metric characteristics of the "core set" of 6 questions and to compare them with the generic health status questionnaire SF36 as well as to the Oswestry Disability Index (ODI).

Material & Methods: 131 consecutive patients with back pain (82 women and 49 men with a mean age of 58.71 years) were included in the study: 81 suffered degenerative low back pain and 50 had a subacute osteoporotic spine fracture. The patients completed the "core set" of 6 questions, the SF36 and the ODI at baseline. For the "core set" of 6 questions we evaluated metric properties of the 5 domains independently as well as a general score corresponding to the mean value of the measured domains, including: reliability (internal consistency-cronbachís alpha coefficient); floor and ceiling effects; and validity. To assess responsiveness (sensitivity to detect change) the fifty patients with osteoporotic fracture completed again the 3 questionnaires 3 months after vertebroplasty. The effect size (ES) was calculated to compare responsiveness between different domains and questionnaires.

Results: Internal consistency of the "core set" (Cronbach's alpha 0.91) is comparable to ODI's (0.92) and SF36's. The pain domain has the worst internal consistency (0.46) and the back function (0.92) and satisfaction (0.90) domains the best. Percentage of patients with missing items is low for all domains except for daily functioning and work disability (22% and 52%, respectively). Ceiling and Floor effect are remarkable (>20%) only for work (ceiling 43%, floor 41%) and generic health status (ceiling 63%) domains. As the SF36 and ODI, the "core set" of 6 questions discriminates significantly ($p<0.01$) between groups of patients divided according to pain intensity. Among the fifty patients re-evaluated 3months after surgery, changes were statistically significant ($p<0.01$) for all scores of the three questionnaires, except for SF-36 general health domain. Responsiveness of the "core set" scores (ES range 0.91 to 6.15) is similar or better than ODI's (ES= 2.48) or SF36's (ES range 0.25 to 3.42).

Conclusions: The "core set" of 6 questions is a valid and responsive instrument for standardized outcome assessment in spinal disorders, practical for routine clinical use. The high percentage of missing items and high ceiling and floor effects of the work domain needs further research.

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SF-36 SCORES IN LUMBAR SPINE DISORDERS. PROFILES AND COMPARISON WITH OTHER CHRONIC CONDITIONS

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Purpose of the study: There is an increasing consensus towards HRQoL evaluation in assessing outcomes of spine surgery. Normative data for different diagnoses are needed to allow comparisons across existing and future studies. Aim of this study is to determine the baseline SF-36 characteristics of patients operated on for spine problems and to compare it with Swedish normative data and existing data for other musculo-skeletal chronic conditions (e.g. RA, Fibromyalgia).

Methods: This is a prospective observational study of Health-Related Quality of Life (HRQoL), as measured by SF-36 scores, in surgical patients of one institution included within the framework of a national registry for lumbar spine surgery. 451 consecutive patients, median age 52 (13-88) years, operated from 1998 to 2002 were included in the study. 49,7 % were males. In addition to SF-36 questionnaire responses, local pain, radiating pain, analgesic intake and walking ability were recorded.

Results:

	PF	RP	BP	GH	VT	SF	RE	MH
Disc Herniation	43,77	12,67	25,17	65,87	39,14	53,21	36,11	62,06
Centr. Stenosis	29,68	8,13	26,56	58,71	40,50	57,54	32,92	63,43
Lat. Stenosis	38,82	10,91	29,45	56,84	37,12	57,05	35,76	61,25
DDD	30,02	4,32	18,39	56,29	30,44	42,98	28,07	56,73
Spondylolisth.	43,39	16,35	30,13	64,00	45,00	69,71	53,85	68,15
Total sample	37,29	10,51	25,81	61,19	38,82	55,57	36,25	62,40

Discussion: Preoperative SF-36 scores were significantly lower than the norm, both in physical and mental domains. Significant correlation was found between SF-36 scores and other variables recorded, i.e. walking ability and pain. SF-36 scores were also lower than the reported normative values for patients with chronic disorders and low-back pain, but showed no significant difference when compared to values in HRQoL studies on selected musculoskeletal chronic conditions.

Conclusions: HRQoL reported by patients scheduled for lumbar spine surgery was low, although comparable to that reported in some studies of patients with permanently disabling musculoskeletal chronic conditions. The most important consequence of this study is that the normative SF-36 values provided can now be used as a benchmark comparison in future studies of patients with lumbar spine disorders.

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THE NATURAL COURSE OF PRE-CLINICAL SPONDYLOTIC CERVICAL CORD COMPRESSION AND PREDICTORS OF IT'S CLINICAL MANIFESTATION

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Background. In a previous study (Bednarik et al., 1998) we showed the value of somatosensory and motor evoked potential (MEP) parameters in assessment of the clinical relevance of cervical cord compression in clinically „silent" cases. We felt that a comparison of the predictive value of some other electrophysiological, clinical and radiological variables was indicated, in a larger group of patients over a longer follow-up period.

Methods. A group of 66 patients (32 women, 34 men, median age 50 years) with magnetic resonance signs of spondylotic cervical cord compression and without clear-cut clinical signs of spondylotic cervical myelopathy (SCM) was prospectively followed for at least 2 years (range: 2-8 years, median follow-up period: 4 years).

Primary endpoint was the development of clinical myelopathic signs. Clinical, radiological and electrophysiological parameters were assessed by three independent observers and then correlated with the clinical outcome.
Results. Clinical signs of myelopathy were detected in 13 patients (19.7%) during the follow-up period. The only variables significantly associated with the development of clinically symptomatic SCM were the presence of symptomatic cervical radiculopathy (92% of SCM cases), abnormal somatosensory (SEP) and/or motor evoked potentials (84.6%) and EMG signs of multisegmental anterior horn cell lesion (61.5%). In contrast, radiological parameters, such as Pavlovís ratio, spinal cord compression ratio, and spinal cord hyperintensity and area, showed no significant association with the development of symptomatic SCM. Thirty-four patients showed no signs of clinical radiculopathy and normal EP and EMG findings at the beginning: none of them developed clinical signs of clinically symptomatic SCM during the follow-up period.
Conclusions. Evoked potentials and EMG signs of subclinical cervical cord lesion together with clinical signs of cervical radiculopathy may predict the development of clinically manifest SCM and could thus serve as valuable tools in its management.
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AGE-RELATED CHANGES IN CLINICAL FEATURES OF CERVICAL MYELOPATHY

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Purpose: There have been many clinical studies regarding cervical myelopathy in elderly patients, but few reports describing changes in clinical features with age. This study was performed to clarify these age-related changes.
Methods: 113 patients with an average age of 62 years (range: 38 - 81) were studied retrospectively. They were divided by age into the following five groups: 36-45, 46-55, 56-65, 66-75, 76-85 years old in Groups 1 (12 patients), 2 (21 patients), 3 (32 patients), 4 (32 patients), 5 (16 patients), respectively. The clinical data were evaluated according to the Japanese Orthopaedic Association (JOA) score. Affected levels of the spinal cord were determined using MRI showing intensity changes. The ranges of motion in C2/3 to C6/7 were measured on flexion and extension lateral films.
Results: The most frequent underlying causative condition was disc herniation, ossification of the posterior longitudinal ligament, spondylosis, spondylosis in Groups 1, 2, 3, 4, respectively. The percentages of the three conditions in Group 5 were almost equal. The disease duration was longer in the elderly, but there was no significant difference. The average preoperative JOA score was 10.9, 10.8, 11.0, 9.1, 8.9 in Groups 1, 2, 3, 4, 5, respectively ($p< 0.05$). For detailed assessment, motor dysfunction and sensory deficit of the upper extremity was significantly lower in the older groups; however, there was no significant difference in the motor dysfunction of the lower extremity, sensory deficits of the trunk and the lower extremity, and sphincter dysfunction. 84 patients underwent laminoplasty, and 29 underwent anterior decompression and fusion. The average postoperative JOA score was 15.2, 14.8, 14.9, 13.3, 12.1 in Groups 1, 2, 3, 4, 5, respectively ($p<0.001$). The average recovery ratio was 65.2%, 66.3%, 64.0%, 52.3%, 36.9% in Groups 1, 2, 3, 4, 5, respectively ($p<0.01$). Affected levels of the spinal cord were significantly more cranial in the older groups. However, there was no significant difference in ranges of motion at each disc level.
Conclusion: Although the outcome of the surgery was poorer compared to younger patients, elderly patients obtained neurological improvement. Therefore, decompression surgery could be the optimal treatment even in elderly patients.

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GAIT ANALYSIS AS A DIAGNOSTIC TOOL IN PATIENTS WITH CERVICAL MYELOPATHY

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Introduction: The management of patients with cervical spondylotic myelopathy (CSM) is still a matter of controversy. Clinical scores depend on subjective judgement of the observer, and CT or MRI show structural changes only. Electrophysiological methods (SSEP and MEP) have been shown to be sensitive, but not very specific in the evaluation of surgical treatment. The purpose of the study was to investigate if gait disturbances due to CSM can be detected by a complex gait analysis.
Methods: 10 patients (age: 63y; range:45-75) with cervical myelopathy (European Myeolopathy Score: 13; range 9-16) were evaluated preoperative, 1 week and 1 year after the operation. Full gait analysis was performed using an optoelectronic motion-analysis-system (VICON), two force plates (Kistler plates) and a ten-channel surface EMG. Data collection of joint motion, electromyographic activity and ground-reaction force (GFR) were obtained simultaneously in real time with 24 gait cycles for each individual. For further evaluation 58 parameters relative to time-distance, kinematic and kinetic variables were calculated and statistically analysed (Wilcoxon and Mann-Whitney U-Test). Data were compared with a control group of healthy subjects.
Results: Repeated measurements in healthy subjects showed high reproducibility of the protocol. Compared to the control group significant gait abnormalities could be identified in patients with SCM. Kinematic changes were seen at the hip, knee and ankle. Kinetic variables showed significant differences with respect to the ground-reaction force and the joint moments at the hip and ankle. Early improvements were seen one week after surgical decompression for certain kinematic and kinetic variables. At one year follow-up no further improvement could be identified.
Conclusion: Gait disturbances due to SCM could be quantified by gait analysis. Decompression surgery led to early changes in gait patterns that did not further improve after 1 year. Future studies will investigate if the changes detected by gait analysis correlate with clinical improvement in patients with CSM.

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THE RELATIONSHIP BETWEEN THE DURATION OF WEARING A CERVICAL COLLAR AND EXTENSOR MUSCULATURE OF THE CERVICAL SPINE

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Introduction: Posterior procedure usually involves the extensor musculature of the cervical spine, also, long-term postoperative

external fixation usually causes muscle weakness and atrophy. This study investigated the relationship between the duration of wearing a cervical collar and the cervical extensor musculature in patients undergoing laminoplasty.
Materials and methods: Twenty-four patients with cervical myelopathy who underwent laminoplasty and wore a cervical collar for eight weeks post-operatively were conducted and followed for an average of 27 months (Group A). Average patient age at surgery was 62 years. A second group of 25 patients who underwent laminoplasty and wore a cervical collar for 4 weeks were followed for an average of 27 months (Group B). Average patient age at surgery was 59 years. In both groups, post-operative cervical alignment was compared with that preoperatively using lateral cervical radiographs. The post-operative range of motion of the cervical spine was also compared with that preoperatively. The alignment of the cervical spine was determined by measuring the angle formed by two lines, extending from the inferior border of the C2 vertebral body and the superior border of C7 vertebral body on lateral radiograph in the neutral position. By subtracting the value of this angle at the neutral position from those at the maximal flexion and extension positions, the range of motion in flexion and extension could be measured, respectively. Also, the cross sectional area of the deep extensor musculature (multifidus, semispinalis cervics) was measured and pre- and post- operative findings were compared in both groups. Measurements were obtained at the C5/6 intervertebral level on MRI axial view using image program software (NIH images).
Results: In Group A, pre- and post-operative cervical alignment were 12.6 degrees and 12.0 degrees on average, respectively. In Group B, those values were 12.6 degrees and 11.9 degrees on average respectively. Cervical alignment was maintained postoperatively in both groups. In Group A, pre- and post-operative ranges of flexion were 30.8 degrees and 18.8 degrees on average, respectively. Those of Group B were 34.1 degrees and 21.6 degrees on average respectively. Thus, the post-operative flexion range was reduced to approximately 60% of the preoperative range in both groups. Pre-and post-operative ranges of motion in extension of Group A were 13.6 degrees and 5.6 degrees on average, respectively. However, those of Group B were 14.4 degrees and 13.6 degrees on average, respectively. Therefore, the preoperative extension range was maintained in Group B. In Group A, post-operative cross sectional area of the deep extensor was reduced to 40.9% of the preoperative value. In Group B, it was reduced to 56.8% of the preoperative value. There was a significant difference between the two groups ($P<0.03$, t-test).
Discussion and conclusions: Cervical laminoplasty usually reduces range of motion of cervical spine postoperatively. Recently, some authors observed that shortening of the postoperative immobilization period decreased the incidence of nape and shoulder pain, moreover, obtained more range of motion after laminoplasty. Based on the current results, we recognized that post-operative extension range of the cervical spine was maintained only in patients who wore a cervical collar for four weeks postoperatively. Moreover, the postoperative cross sectional area of Group B was significantly larger than that of Group A. According to the findings of this study, we suggest that early removal of the cervical collar reduces postoperative atrophy of the extensor musculature of the cervical spine and maintains the extension range of the cervical spine.

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RANDOMIZED, PROSPECTIVE, CONTROLLED CLINICAL TRIAL OF PULSED ELECTROMAGNETIC FIELD STIMULATION FOR CERVICAL FUSION

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Purpose: This study was a multi-center, prospective, randomized controlled clinical trial of the safety and efficacy of pulsed electromagnetic field stimulation as an adjunct to cervical spine fusion.
Methods: Patients with symptomatic radiculopathy and correlating radiographic evidence of cervical nerve root compression were candidates for entry into the study. All patients were either smokers (at least 1 pack/day) or required multi-level surgery and underwent anterior cervical discectomy and Smith-Robinson fusion using allograft bone and anterior cervical plating (single plating system). Patients were randomized to receive pulsed electromagnetic field stimulation (PEMF) or not (non-PEMF). They were assessed preoperatively and at 1, 3, 6, and 12 months postoperatively and annually thereafter until the last patient enrolled had reached 12 months follow-up. Parameters included a focused neurological exam, a visual analogue scale for pain, the Oswestry Neck Disability Index (NDI) for function, and radiographs. Radiographs were read blindly by an independent orthopedic surgeon and rated as „fused“ or „not fused“ based upon radiolucency, bony bridging, and motion on flexion-extension views. All patients were followed for adverse events to assess safety.
Results: 323 patients were enrolled in the study; 160 in the non-PEMF (control) group and 163 in the PEMF group. Both groups were comparable with regard to gender, age, race and risk factors. Equal numbers were lost to follow-up in both groups. Of the 235 patients available for evaluation at 6 months, the fusion rate was 79.5% (97/122) in the PEMF group and 65.5% (74/113) in the non-PEMF group ($p=0.0158$). Both groups showed a significant decrease in pain and NDI. The incidence of adverse events was comparable in both groups.
Conclusions: This is a report of the interim results of a multi-center, prospective, randomized controlled clinical trial of PEMF as an adjunct to cervical fusion. In this at-risk patient population (smokers, multi-level fusion), PEMF increased the fusion rate at 6 months postoperatively from 65.5% to 79.5%, with no difference in adverse events. The interim results of this study indicate that PEMF is a safe and effective adjunct to cervical fusion in a patient population at high risk for nonunion.

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LONG-TERM RESULTS OF THE OPERATED CERVICAL SPINE IN RHEUMATOID ARTHRITIS

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Purpose: To investigate the long-term results of the operated cervical spine in rheumatoid arthritis and prognosis of those patients.
Materials and Methods: A total of 103 patients who had rheumatoid arthritis underwent cervical arthrodesis in Hokkaido Orthopaedic Memorial Hospital over a period of 13 years (from 1979 to 1992), and 75 patients (73%) have been followed since their operation. Sixty-three patients who had isolate atlantoaxial instability or had a combination of it and a slight vertical subluxation, underwent atlanto-axial arthrodesis by Brooks' method. Thirty-four patients had anterior or posterior atlantoaxial subluxation, and 29patients had vertical subluxation. Eight patients who had severe ver-

tical subluxation underwent posterior occipito-cervical fusion. Four patients who had severe vertical subluxation and subaxial subluxation underwent combined anterior and posterior cervical fusion.
Results: In the 63 patients who underwent atlantoaxial arthrodesis by Brooks' method, reduced status after arthrodesis was maintained. The average anterior atlas-dens interval was improved from 7.9 mm to 1.6 mm and the average space available for spinal cord was improved from 11.8 to 16.2 mm (excluding the 4 cases of posterior subluxation). Only 4 patients developed superior migration of the odontoid and 2 patients required occipito-cervical fusion as a second operative procedure. In the 12 patients who underwent posterior occipito-cervical fusion or combined anterior and posterior cervical fusion, the reduced status after arthrodesis was also maintained. During the follow-up, 32 patients (43%) had been diseased (an average of 74 months after operation and at the average age of 62.2 years old) and 25 of those patients had vertical subluxation. Survival rate of 41 patients who had vertical subluxation was 48.8% 10 years after surgery, whereas that of the other 34 patients without vertical subluxation was 76.5%.
Conclusion: Early atlantoaxial arthrodesis seemed to prevent the development of vertical subluxation. This is because the reduced status after arthrodesis was maintained in all cases and the progression of the vertical subluxation at atlanto-occipital region was not common postoperatively. However, patients who had vertical subluxation even with a slight degree were at a risk of dying in the early postoperative period.

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LONG TERM OUTCOME AFTER VENTRAL FUSION ON THE CERVICAL SPINE - CLINICAL AND RADIOLOGICAL RESULTS AFTER 18.7 YEARS

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Purpose of the Study: As patients undergoing ventral fusions of the cervical spine are usually relatively young, the longterm outcome after this operation is of special interest. Do the results of the procedure meet the expectations also in the long run?
Method: The results after ventral fusions of the cervical spine were analysed after a minimal follow-up of 11 years by questioning and functional examination. The radiological results and alterations of the cervical spine were compared to the perioperative situation.
Results: 57 patients could be seen for a control after an average follow-up of 18.7 years. At the time of operation the average age was 44.9 years. 89% were operated according to the technique of Robinson/Smith and 11% by the method of Cloward. Mainly the segments C5/6 (53% of the cases) and C6/7 (26%) had been fused. In the control 54% of the patients evaluated the result with „very good“, another 25% with „good“. While the majority of the patients symptoms (e.g. cervical or nuchal pain, brachialgia, vertigo, tinnitus) decreased, 15 patients complained of constant problems. Radiographs documented a secure osseous fusion in all cases. The maximal mobility of the whole cervical spine was reduced by 13.2° in average after 15 years. In the segments next to the fused ones an increased mobility for flexion and extension with increased signs of degeneration was noted: in the segment directly above the fusion the range of motion increased by 10°, the next one above that by 8.3°. Below the fusion these values were measured with 7.8° and 5.6° respectively. Anyhow a correlation to the clinical outcome couldn’t be found.
Conclusion: The good short- and mid-term results after fusion of the cervical spine remain stable also in the long run, though radiologically an increased degeneration of the neighbour segments is observed.

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IMPLANT REMOVAL FOR LATE-DEVELOPING INFECTION AFTER INSTRUMENTED POSTERIOR SPINAL FUSION FOR SCOLIOSIS: REINSTRUMENTATION REDUCES LOSS OF CORRECTION. A RETROSPECTIVE ANALYSIS OF 45 CASES.

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Study Design. A retrospective follow-up study of patients who, having undergone instrumented posterior spinal fusion for scoliosis, experienced late infection and then underwent either implant removal alone or implant removal and instrumented refusion.
Objective. To determine whether it is possible to avoid loss of correction by a single-stage implant removal and reinstrumentation procedure.
Summary of Background Data. There have been a few reports of late-appearing infections after spinal instrumentation. Implant bulk, metallurgic reac-tions, and contamination with low-virulence micro-organisms have been suggested as possible etiologic factors. The clinical symptoms include pain, swelling, redness, and spontaneous drainage of fluid. Complete hardware removal and systemic antibiotics is usually curative.
Methods. We retrospectively reviewed 45 patients who underwent instrumented posterior spinal fusion for scoliosis and experienced development of late infections and, after a mean of 3 years after the initial procedure, either underwent implant removal alone (n=35, Hardware Removal (HR) Group) or additionally underwent re-instrumentation and fusion (n=10, Re-instrumentation and Fusion (RI&F) Group). Three patients were re-instrumented 1.5 years after hardware removal, and 7 underwent a one-stage rod removal and re-instru-menta-tion/refusion procedure with titanium implants.
Results. Allergic predisposition, protracted postoperative fever, and pseudarthrosis appear to increase the risk of late-developing infection after posterior spinal fusion. All wounds in both the HR and RI&F Groups healed uneventfully. Preoperative radiographic Cobb measure-ments showed no statistically significant between-group differences. At follow-up, however, outcome was clearly better in the RI&F Group: Loss of correction was significantly smaller in reinstrumented patients. Thus, the thoracic Cobb angle was 28±16° (range 0-55) in the RI&F Group versus 42±15° (21-80) in the HR Group, and the lumbar Cobb angle was 22±11° (10-36) in the RI&F Group versus 29±12° (13-54) in the HR Group.
Conclusion. The results of our study demonstrate that wound healing is usually uneventful after hard-ware removal for late infection, also when patients undergo instrumented refusion in a one-stage procedure. Re-instrumentation appears to achieve permanent correction of scoliosis.

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INCIDENTAL DUROTOMY IN LUMBAR SPINAL SURGERY, INCIDENCE AND MANAGEMENT

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As part of an attempt to audit and establish baseline complication rates for common spinal operations the members of the British Association of Spine Surgeons were invited to submit figures for incidental durotomy during commonly carried out procedures.
The aim was to establish a baseline for future data collection and allow some comparison of the relative risk of procedures for the purpose of improved informed consent.

There were 4,542 index cases, as a result of voluntary returns by 26 surgeons.
Accurate data was only available for 1549 cases.
Only 14 surgeons had prospectively acquired data or undertook a case note review. 11 surgeons estimated their cases and complications, one surgeon freely admitted to guessing.

	INDEX CASES	DURAL TEARS	PERCENT
PRIMARY DISCECTOMY	872	31	3.5%
REVISION DISCETOMY	106	14	13.2%
SPINAL STENOSIS	571	48	8.5%

All surgeons were within 2 standard deviations of the mean. The surgeons with the highest reported rate had included cauda equina cases within their figures. The time frame of the audit was not defined; it is possible that some surgeons deliberately selected a time interval with no tears occurring. These figures should be interpreted cautiously as no independent validation has been undertaken. Those who estimated or guessed their figures for the same case mix were optimistic. The estimates were:

Primary discetomy	0.95%
Revision discetomy	5.8%
Spinal stenosis	2.39%.

There were problems: these included definitions of incidental durotomy and decompression.
The management of intra-operative incidental durotomy was also requested. 24 replied to this, 12.5% did not repair the dura, 58% used prolene, 30% used a different stitch. 6 never used a drain, 3 sometimes used a drain, and 5 always drained. 18 used between 2 and 5 days of bed rest, while 1 did not. 12 always used antibiotics, 1 never did and 5 varied their practice.
There are therefore a number of acceptable ways to manage incidental durotomy.
This study highlights the difficulty of comparative data from different surgeons and emphasizes the need for prospectively gathering data.

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COMPLICATOINS OF LUMBAR DISC SURGERY

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This retrospective study focuses on complications of macrodiscectomy in a consecutive series of 2752 patients.
The material consisted of 2752 patients who underwent surgery for virgin lumbar disc herniation between June 1986 and June 2002. A triple antibiotic therapy was used for two days until 1990. After 1990 a prophylactic single IV dose of second-generation cephalosporin injected after the induction. Operative field was shaved and antiseptically cleaned using an iodine solution. A standard hemilaminotomy, flavectomy and discectomi were performed. Surgical hemostasis was performed using bipolar cautery, gelfoam, and surgicell. Following careful control of bleeding an autologous fat graft was placed epidurally. No drain was used. All the patients were mobilized on the first postoperative day.
One thousand four hundred and sixty eight of the patients were male (% 53.3), and 1284 of the patients were female (% 46.7). Age of the patients varied from 14 years to 76 years (mean 40.4 years) at admission.
A total of 150 (5.5%) complications occurred, and two patients died. Mortality was encountered in two cases (% 0.07), one secondary to major vascular injury, and the second due to DIC. Table 1 presents the surgical complications.

Table 1: The list of complications.

1. Mechanical complications	77 (2.8%)	
*Dural injury**		*61 (2.2%)*
*Neurological complications *****		*12 (0.4%)*
Vascular injury		*1 (0.03%)*
Epidural hematom		*3 (0.1%)*
2. Infectious complications	43 (1.6%)	
Superficial wound infection		*33 (1.2%)*
Discitis		*10 (0.4%)*
3. Systemic complications	25 (0.9%)	
Deep vein thrombosis		*16 (0.6%)*
Pneumonia		*7 (0.3%)*
Myocardial infarction		*2 (0.07%)*
4. Positioning-related complications	5 (0.2%)	
Total	150 (5.5%)	

*: Four patients (0.1%) suffered of CSF fistulas.
**: It includes root injury in 5 cases, postoperative cauda equina in 2 cases and additional neurological deficits in 5 cases

In summary, LDS complications occurred in 5.5% of 2752 virgin disc cases. The common complications of LDS can be categorizer into four groups: (1) Mechanical complications; (2) Infectious complications; (3) Systemic complications, and (4) Positioning-related complications.

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SEXUAL FUNCTION AFTER SURGERY FOR CHRONIC LOW BACK PAIN

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Background. Sexual ability after lumbar surgery has mainly focused on male biological function (retrograde ejaculation). Possible disturbance of female sexual function and of sexual enjoyment have not received the same attention.
Aim of study. To assess changes in sexual function and enjoyment in men and women after posterior (PF) and anterior fusion (AF) for chronic low back pain (CLBP).
Patients and methods. Of 222 surgically treated patients with CLBP within the Swedish Lumbar Spine Study, 173 (78%, 89 women, 84 men) answered a mailed questionnaire including gender specific and general questions about sexual function and enjoyment at the 2 years FU. Of these, 58 women and 67 men were randomised to posterior fusion, 27 women and 17 men to anterior + posterior fusion. The Chi2-test and the Mann-Whitney U-test were used for statistical analysis.
Results: Overall, women's sexual function/enjoyment increased in 42%/66%, was unchanged in 40%/22% and decreased in 18%/12%. Corresponding figures in men were 44%/36%, 37%/39% and 19%/25%. Sexual improvement was significantly associated with good functional outcome ($P<0.001$) and decreased back pain ($P<0.001$), but was not associated with type of fusion. Specific questions, however, revealed that, in men ejaculatory disturbance was reported in 41% AF vs. 11% PF ($P=0.007$). Sensory change (genital numbness) was 47% in AF vs. 12% in PF ($P=0.003$). Retrograde ejaculation was 13% in AF vs. 5% in PF (n.s.).

In women there was no significant difference in orgasm disturbance, 22% AF vs. 16% PF, but a trend for sensory change, 26% AF vs. 12% PF (P=0.13).
Discussion. A majority of patients treated surgically for CLBP experienced an improved or unchanged sexual ability, related to decreased back pain. However, a significant proportion of both women and men reported genital sensory change and disturbed orgasm/ejaculation. It was displayed after both anterior and posterior surgery and was significantly elevated after anterior surgery in men.
Conclusions: The overall improved sexual ability after fusion surgery for CLBP, may be counteracted by genital numbness and orgasm/ejaculation disturbance, particularly after anterior fusion. Sexual complications need to be specifically investigated to be reported.

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THE PEDICLE SCREW POSITIONING IN THE THORACIC AND LUMBAR SPINE: COMPLICATIONS

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This was a prospective study of 350 consecutive patients in whom pedicle screw position was assessed after surgery, using lateral radiographs and computed tomography. To evaluate the accuracy of plain radiographs and computed tomography in assessment pedicle screw position. Imaging techniques such as postoperative anteroposterior and lateral plain radiographs and computed tomography, are currently the primary means of assessing pedicle screw placement. Postoperative radiographs and computed tomographic scans were used to evaluate the position of 2655 pedicle screws inserted in the spines of 350 consecutive patients who underwent thoracic and lumbar spine fusion and instrumentation. No recognized neurologic complication resulted from pedicle screw placement. Screw position was graded as in, out, or questionable. All observations were performed independently by three observers. The authors also analyzed the position of the screws according to the underlying spinal disease. The overall findings regarding the pedicle screw position of the three observers proved that the screws were correctly positioned in 95,9% and 93,8% (Plain Vs C.T./scan) of the cases, they were positioned out in 1,22% and 3,63% (Plain Vs C.T./scan) and were questionable in 2,88% and 2,57% (plain Vs C.T./scan). More misplaced screws were clearly seen on computed tomographic scans than on plain radiographs; however, this difference was not statistically significant. Interobserer differences were not statistically significant. Interobserer differences approached statistical significance when the results of the two tests were compared. Although the accuracy of computed tomographic imaging is better than that of plain radiographs, the difference does not reach statistical significance. Postoperative use of plain radiographs remains a reliable method for evaluation of pedicle screw insertion in the absence if neurologic deficit.

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A NEW DEVICE TO DETECT IATROGENIC INITIAL VERTEBRAL CORTEX PERFORATION: FIRST CLINICAL RESULTS

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Accidental perforation of the vertebral cortex is a surgical risk associated with the standard methods of pedicle screw insertion. Depending on criteria, over 14% of screws are reported misplaced. Complications such as dysesthesia or paraplegia may result from these misplaced implants. Current techniques do not guaranty correct pedicle screws placement. A new drilling tool (*) allows for instant detection of perforation by emission of variable audio beeps.
A preliminary clinical evaluation was conducted to assess the safety and efficacy of this system.
Methods: 147 manual pedicle drillings were performed in 11 European hospitals during 28 spinal surgeries, performed between September 2002 and March 2003.
A comparison was made between the device indications and the others detection possibilities (surgeonís tactile feeling, mechanical probing, fluoroscopy, CT-scans, EMG, SEEP, surgical navigation; depending on their availability, per- and/or post-operatively). Thus were registered and compared the detections of vertebral cortex fractures indicated: - by the device, - by any other available possibility.
Results: On 147 drillings, 23 vertebral cortex fractures (16%) were confirmed. Out of these 23 fractures the device detected 22, leading the surgeons to stop drilling, check and reconsider initial trajectories when necessary. In one case, the neuro-stimulator integrated to the device induced visible leg twitches, simultaneously with an audio signal rise of the drilling instrument. There was one false positive detection (beeps rise but no fracture confirmed). The use of this instrument did not add any noticeable time to the surgeries and it was considered as simple and easy to run. No adverse effect was observed.
Conclusion: This device appears to be a simple and effective way to more safely perform pilot holes in vertebral pedicles. A future study will determin its formal sensibility and sensitivity.

(*) PediGuard TM, SpineVision TM, France. Patents pending.

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COMPUTER ASSISTED PEDICLE SCREW FIXATION - A NEW LESS EXPENSIVE SYSTEM

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Ever since Roy Camille popularized the technique of pedicle screw fixation, it enjoyed the preference of most of the spine surgeons. Different conventional techniques of pedicle localization are in

practice today and choice depends on the surgeonís preference; with several published series showing high pedicle wall violation rates (15- 50%). In this dismal background, attempts at computer assisted pedicle screw fixation have gained much importance and reports from research work done in few centers in the world, is showing high accuracy rates. The prohibitive cost and non-availability of these gadgets developed by these centers, limit their use in countries like India. Hence a software and hardware was developed indigenously at our institution for computer assisted pedicle screw fixation and the total cost of the system was much less (< 500$) when compared to other systems available. In this prospective study, 96 pedicle screw fixations done (80- in formalin-preserved cadavers 16- in patients with various spine pathologies) were grouped in two. In Group1 (n=48) our computer assisted system was use and in Group 2(n=48) conventional fluoroscopic technique was used for pedicle screw insertion. Post-insertion thin slice CT was taken and an independent senior radiologist evaluated pedicle cortical violation. Evaluating our results we found that in Group 1 Forty-four (92%) were ideal screw placement (GRADE I) and four (8%) were <2mm (GRADE II) cortical perforation. There was no case of >2mm (GRADE III) perforation. In Group 2 twenty (41%) were GRADE I, sixteen (33%) were GRADE II and twelve (25%) were GRADE III screw placement. The difference in pedicle cortical perforation rates between the two groups was found to be statistically significant (p= 0.01). In conclusion pedicle screw fixation done using this new less expensive system has got high accuracy compared with conventional techniques.

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PLACEMENT OF PEDICLE? SCREWS AT THE ENTIRE SPINE WITH A NEW (ISO-C-3D FLUOROSCOPY) GUIDING SYSTEM

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Due to the proximity of neuronal elements and the vertebral artery and the small dimensions of the pedicles, the placement of transpedicular -, and C1-C2-screws is a demanding task. Furthermore the pedicle diameters at the cervico-thoracic junction and the upper thoracic levels are very small and the visibility with conventional fluoroscopy is limited. CT-based image guided insertion is proven to facilitate the placement of screws and enhance significantly the safety, but is time consuming and the registration process to every vertebral is challenging. Furthermore only the preoperative anatomy is described. Virtual fluoroscopy has only limited value at the cervical spine because appropriate planes for screw-insertion cannot be obtained and the lower cervical spine is often not clearly visible. Since computed fluoroscopy utilizing 50 or 100 fluoroscopic shots in an isocentric trajectory of 190° is available using an isocentric fluoroscope with 3-D data - reconstruction, image guided surgery with this ISO-C-3D method appears to be an alternative.
Methods: After evaluation of the possibility of introducing C1-C2-screws, cervical -,thoracic and lumbosacral transpedicular -, screws utilizing the 3D reconstruction of 100 fluoroscopic views obtained in an isocentric trajectory of 190° (ISO-C-3D; Siemens-Medical; Erlangen, Germany) as data - set for navigation with the software Mach 4-Iso-Star TM. (Medtronic Surgical Navigation Technology; Louisville, Colorado) in a feasibility study (Phantom and Cadaver ? Study), this system was used to guide pedicle screw insertion at the entire spine in clinical practice since August 2002. In 54 Patients a total of 312 pedicle screws were inserted. 8 at C1-C2, 42 at C7-T6, 52 at T7-T12 and 210 at the lumbosacral spine.The screw position was evaluated with a postop. ISO-C-3D scan and multiplanar reconstruction for each screw.
Results: The in vitro accuracy of the system was found to be 0.7 mm, +/- 0.1mm. Appropriate planes for the placement of C1-C2-screws as well as transpedicular screws at the cervical and upper thoracic region and the lumbosacral spine can be reconstructed with a sufficient image quality. The in vivo accuracy of the system did not exceed the in vitro accuracy taking an additional 0.5mm error of the screw-driver and the manufacturing tolerances of the screws into consideration. The accuracy of the screws placed in clinical practice was determined as follows: 7 of the 84 C1-C2 screws were ideally placed, 96% of the screws at the upper thoracic spine, 100% of the screws at the lower thoracic spine and 97 % of the lumbosacral screws were ideally placed. No medial malplacement occurred and no screw related neurologic deficiancy was observed.
Conclusions: The use of the 3D reconstruction of 100 fluoroscopic views obtained in an isocentric trajectory as a base for image guided placement of C1-C2-screws as well as transpedicular-screws at the entire spine seems to be a very promising approach towards an improvement of the accuracy and safety of the screw-positioning. It appears that with the automatic registration process and the imaging of the actual anatomical status of the cervical spine the main disadvantages of CT-based navigation are eliminated. Therefore this method might be an alternative to CT-based image guided surgery and due to the features of the automatic registration process and on-line planning suitable for everyday routine use.

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DO VERTEBRAL END PLATE CHANGES CORRELATE WITH DISCOGENIC LOW BACK PAIN? A SINGLE BLINDED PROSPECTIVE STUDY

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Introduction: We describe a single blinded prospective study evaluating vertebral end-plate changes with the pain provocation response of awake lumbar discography.
Methods: Consecutive patients with low back pain unresponsive to conservative treatment and being considered for spinal fusion were subjected to magnetic resonance imaging followed by lumbar discography as a pre-operative assessment. The single discographer was blinded to the results of the MRI scans, which were later independently analysed for the presence of vertebral end plate changes. The X2-test was used to analyze the results.
Results: Of the 154 patients that underwent discography, we identified 28 (18%) patients (18M, 10F), average age 46 years, with vertebral end plate changes affecting 62 lumbar disc levels that exclusively occurred at either the L4/5 and L5/S1 levels. End plate changes showed statistically significant correlations with high-intensity zone (HIZ; $P<0.02$), disc degeneration on MRI ($P<0.001$), loss of disc height ($P<0.001$), abnormal disc morphology on discography ($P<0.004$) and pain reproduction ($P<0.002$). For pain reproduction and endplate changes, respective sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were 66%, 81%, 87% and 55%. For pain reproduction, abnormal disc morphology and end plate changes, the respective sensitivity, specificity, and PPV and NPV were 68%, 79%, 84% and 61%. When lumbar discs exhibited both end plate changes and HIZ, the PPV for pain reproduction was 95%.
Discussion: There is still disagreement in the literature as to the significance of vertebral end plate as a pain indicator. However, our single blinded prospective study of vertebral endplate intensity changes reveals a high positive predictive value for pain reproduction suggesting that these MRI radiological entities strongly correlates with lumbar discogenic low back pain that is associated with internal disc disruption. A biochemically mediated response to a

degenerate, painful and inflammatory intervertebral disc segment is postulated.

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CLINICAL RESULTS FOR 30 PATIENTS IMPLANTED WITH THE PDN® PROSTHETIC DISC NUCLEUS DEVICE

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The purpose of this study is to evaluate the safety and performance of the PDN prosthetic disc nucleus device in 30 patients with disc herniation and degenerative disc disease.
Thirty-five patients were implanted with PDN devices between May 1997 and May 2001. For each patient, two devices were inserted and positioned transversely within the disc space following a unilateral hemilaminotomy and disc enucleation. The study group consisted of disc-herniation cases with chronic low back pain (LBP), with or without leg pain. A majority of these patients had suffered from LBP for more than 2 years, some up to 10 years. The initial fourteen patients were implanted using first-generation surgical instruments and devices. The subsequent twenty-one patients were implanted utilizing improved surgical techniques, tools, and devices.
For the first 14 patients, there was a high rate of device migration, with seven patients experiencing device extrusion. Five of these extrusions were converted to PLIF (and therefore excluded from the study), while in two cases the partially extruded posterior devices were removed, and the anterior devices remained in the disc (these two patients were included in the study). Complication rates decreased significantly for the last 21 patients with only two instances of device extrusion. In both of these, only the posterior devices were removed, and the patients continued to be monitored. For the 30 patients remaining in the study group, one-year follow-up clinical data showed improvement of low back pain in 86% of the cases, with 73% being excellent/much better (from National Swedish Lumbar Spine Surgery Registry). In comparison to this PDN device data-set, corresponding results on our PLIF material shows only 50% excellent/much better results.
The early experience with the PDN device showed a high extrusion rate. Subsequent modifications to the surgical protocol have minimized the extrusion problem. Proper patient selection is critical to the success of the PDN device, with appropriate patients having moderate degenerative disc disease with, or without, a disc hernia. Though this study represents results from a limited number of patients, the clinical outcomes are very satisfying with improved pain levels in 86% of patients with chronic LBP.

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MAVERICK TOTAL LUMBAR DISC REPLACEMENT. PROSPECTIVE STUDY PRELIMINARY REPORT OF 30 CASES AT 1 YEAR FOLLOW-UP

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Objective: Reconstruction of a failed intervertebral disc with a functional disc prosthesis should offer the same benefits as fusion while simultaneously providing motion and thereby protecting the adjacent level discs from the abnormal stresses associated with fusion. This study was designed to determine if a lumbar disc prosthesis can provide relief from objective symptoms and signs, improve the patient's ability to perform activities of daily living, decrease pain, and provide stability and normal range of motion.
Methods: We conducted a prospective trial of the Maverick lumbar Disc Prosthesis (Medtronic, USA) for single-level degenerative disc disease of the lumbar spine. Patients with symptomatic low back pain resistant to conservative treatment since more than 1 year underwent implantation with the prosthesis. At scheduled follow-up periods, the effectiveness of the device was characterized by evaluating each patient's pain (VAS), neurological function, Oswestry and SF36 scores and range of motion at the implanted level.
Results: Analysis included data regarding 30 patients (operated at level L4L5 or L5S1) at 1 year. Clinical success (oswestry) at 6 months and 1 year after implantation was 82% and 86%, respectively, exceeding the study's acceptance criteria of 75% (required in the FDA pivotal randomized study for ALIF using cages with BMP2). VAS showed an improvement in back pain from 7,1 (+/- 2) pre-operatively to 2,7 (+/- 1,8) post-operatively. At 1 year, there was no measurable subsidence of the devices (based on a measurement detection threshold of 2 mm). Evidence of anterior and/or posterior device migration wasn't detected. There was no evidence of spondylotic bridging at the implanted disc space. The measured range of motion in flexion-extension, as determined by an independent radiologist, ranged from 3 to 12 degrees (mean range of motion, 6 +/- 4 degrees). No devices have been explanted or surgically revised. One complication non related to the implant, occurred during the procedure, a ureter injury.
Conclusion: Discectomy and implantation of the device alleviates neurological symptoms and signs similar to anterior lumbar discectomy and fusion. Radiographic evidence supports normal range of motion. The procedure is safe and the patients recover quickly. However, only long-term follow-up of at least 5 years will confirm these early favorable results. In addition, the influence on adjacent motion segments can be assessed after at least 3 to 5 years of follow-up.

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TOTAL LUMBAR DISC REPLACEMENT: PRELIMINARY RESULTS AFTER 2 YEARS FOLLOW-UP WITH PRODISC II

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We hypothesized that lumbar total disc replacement with the PRODISC II prosthesis would result in clinically and statistically significant improvement in low back pain, radicular leg pain, and disability in patients with symptomatic degenerative disc disease.
Materials and methods: We prospectively assessed 53 patients who had single or multilevel lumbar disc replacement at mean 2.4-years (minimum 2-years) follow-up. Patient evaluation consisted of pre- and postoperative back and leg pain VAS scores, Oswestry disability questionnaires, and radiographs. Clinical evaluation and questionnaire administration was performed by individuals not directly involved in patient selection, surgery, or postoperative care.
Results: There were clinically and statistically significant improvements in back and leg pain VAS and Oswestry disability scores that were maintained at final follow-up. Mean lumbar VAS decreased from 7.4 to 1.3 at final follow-up. Mean radicular VAS decreased from 6.7 to 1.9. Oswestry disability scores improved from 56 to 14. VAS and Oswestry improvements were statistically significant ($p<0.05$). The clinical results of patients with single and multilevel surgery were equivalent. Satisfactory results were achieved in 90% of patients who had previous lumbar surgery. Complications occurred in 9% of patients and included vertebral body fracture, transient radicular pain, implant malposition, and transient retrograde ejaculation. Three patients (6%) required reop-

eration to address complications. No mechanical failure of the implants or loosening was observed.
Discussion Total disc replacement has the potential to replace fusion as the gold standard surgical treatment for degenerative disc disease. Potential advantages of disc replacement over fusion include avoidance of pseudarthrosis, postoperative orthoses, and junctional degeneration. There are no published studies with minimum 1 year follow-up of the PRODISC II prosthesis. Randomized trials comparing fusion to disc replacement with long follow-up periods are required to determine to relative value of the two procedures.
Conclusion: In properly selected patients, lumbar total disc replacement with the PRODISC II has excellent clinical and radiographic results at mean 1.4-year follow-up. Patients with single or multilevel degenerative disc disease are candidates for this procedure. Implant malposition and intra-operative fracture resulted in a 6% reoperation rate.

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INITIAL COMPLICATIONS IN 67 INTERVERTEBRAL DISC REPLACEMENT PROCEDURES UTILIZING THE SBIII-LINK CHARITÉ IMPLANT

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Introduction: Replacement of intervertebral discs is a procedure that has caught the worldís attention given that it is an advantageous technique in the treatment of spinal pathologies. Widespread acceptance on behalf of the surgeon population, however, is still being awaited.
Purpose: To determine complications encountered in 67 disc replacement cases in which the Link Charite III implant was utilized.
Materials and Methods: A total of 55 patients were chosen, operated on between the months of January and December of 2002, to determine the initial complications of the procedure. The sample group consisted of 29 female patients and 26 male patients between the ages of 22 and 59, with an average age of 37,3 years. Breakdown of the levels replaced is as follows: 1 Level L2-L3; 4 Levels L3-L4; 30 L4-L5 and 32 L5-S1ís, totaling 67 implants. Of the patients, 44 had one replacement, 10 had two-level replacements and one had a three-level replacement. Causes leading to the replacement were the following: 35 patients had DDD; 7 had had previous spinal surgery; 6 patients presented pathology on the vertebra adjacent to fusion; 4 had a previous failed PDN; 2 had Isthmic Spondylolisthesis, and one patient presented a non-union at the level of fusion.
The surgeries were conducted by anterior approach of the lumbar spine, minimally invasive retroperitoneal. For levels L5-S1 a horizontal incision was utilized starting at 3 cm from the mid line and for multiple levels such as L4-L5 a vertical incision was made 3 cm from the mid line.
Immediate intra and post-op complications were taken into consideration, as well as medical histories and radiology material.
Results: Patients range between 11 months and 1 month since the surgery was done. Intra-op complications consist of: 1 end plate fracture due to excessive distraction; 2 iliac vein lesions; 1 ureter lesion. In post-op complications we found the following: 1 abdominal hernia, 2 instances of implant subsidence, 1 seroma, 1 transitory premature ejaculation and 2 foraminotomies due to fibrosis (in cases of previous spinal surgery). As we can see, complications are a result of the surgical approach technique and are not of a serious nature. Only 2 cases show complications inherent to the prosthesis (subsidence) and those are asymptomatic.
Conclusion: The study shows that short term complications are related to the surgical procedure and not to the implant itself, indicating that total disc replacement is a procedure with a low index of complications at the time of surgery and short term. Only time will tell if this stays true. We recommend intra-op assistance of a surgeon experienced in the retroperitoneal space to avoid possible eventualities.

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THE SB-CHARITÉ III DISC PROSTHESIS: A COMPARISON OF THE RESULTS BETWEEN IMPLANTATION IN A PAINFUL DEGENERATIVE DISC DISEASE VERSUS POSTNUCLEOTOMY SYNDROME

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Problem: The results of the surgical treatment of degenerative disc disease seem to be equal in short term follow-up studies when fusion is compared with the implantation of an artificial disc prosthesis. In addition, it is generally agreed that the surgical outcome is better in patients with degenerative disc disease compared to patients with postnucleotomy syndrome independent of the surgical technique. The aim of our study was to evaluate if the result of artificial disc surgery follows those experiences.
Patients and Methods: Retrospectively we performed clinical and radiologic follow-up of two groups of patients with degenerative disc disease (n=29, DD-group) and with postnucleotomy syndrome (n=10, PNS-group) undergoing an operation with implantation of SB-Charité III Disc Prosthesis at the L5/S1 level (n=27), L4/5 (n=8) or both levels L4-S1 (n=4) between 2000 and 2002. In addition, the patients were asked to answer a questionnaire preoperatively and at follow-up. The average age for operation was 41+6 (25-59) years, follow-up was performed after 2+1 years. Discography and memory pain was positive in all patients. Patients whose operation was less than 12 months ago were excluded.
Results: At follow-up 23 patients of the DD-group (79%) reported a complete or satisfying improvement of their preoperative complaints but 6 patients had no benefit from the artificial disc implantation. In contrast only 4 patients of the PNS-group said that they had improved after surgery and 2 patients had improved in part. 4 patients had the same complaints as they reported preoperative. All implants were mobile at follow-up with a tendency of less mobility in the PNS-group (6+2°) compared with the DD-group (8+2°). Relordosation of the operated segments of 9° on average was equal in both groups. Rates of complication (2 fractures of a small fragment of the dorsal wall of the vertebral body, 1 posterior subluxation of the implant and reoperation, 1 fusion after 4 months) were identical with 10% in both groups. We did not observe neurological deficits in either group.
Conclusion: According to the results of this small study we found good results of the SB-Charité prosthesis in degenerative disc disease treatment. The indication for an artificial disc in postnucleotomy syndrome remains unclear and further investigation is required.

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PERCUTRANEOUS TRANSPEDICULAR DISCECTOMY AND DRAINAGE IN PYOGENIC SPONDYLODISCITIS

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Purpose: To describe the technique, and the pitfalls of transpedicular discectomy and drainage for pyogenic spondylodiscitis. This technique permits drainage and antibiotic irrigation, and provide a channel for granulation tissue to invade the infected space.

Material and Method: Thirty-eight patients suffered by spondylodiscitis of the thoracic or lumbar spine underwent percutraneous transpedicular discectomy, biopsy, debridemen, and drainage. All patients suffered from severe back pain. Imaging investigation in 28/28 patients showed that scintigrafic investigation was positive, and in 38/38 patients the MRI signals were pathological. We used modified Kambin Graig instrumentation, which was introduced into the affected disc through a transpedicular approach under fluoroscopic control. After completion of the discectomy metal a metal braided sheaths was left into the disc space for irrigation and drainage (48 hours).
Results: Thirty two of 38 (84.2%) cultures were positive with the following diagnoses: Staphylococcus aureus 16, Staphylococcus sp. 4, Streptococcus viridans 3, Enterococcus sp, 1 Pseudomonas aeruginoasa 1, Candida sp. 1, Brucella 4, and 1 Serratia marcescans 1. Of 38 patients 30 (79%) showed an immediate pain response, in the other 8 patients improvement of the pain was observed after a week. Neurological deficit improved immediate after procedure in all patients. In this series there was a minor complications; retained drain tub in 1 case which was easily retrieved with biopsy forceps under fluoroscopic guidance.
Discussion: Percutraneous transpedicular discectomy for spondylodiscitis is a technically safe surgical procedure and is feasible in the lumbar and the thoracic spine. The transpedicular tract allows the use of relatively large instruments for aggressive decompression without concern for possible spinal cord, nerve root, or vascular injuries. Also, promote quick healing with excellent surgical outcome, with minimally complications

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SINGLE-STAGE AUTOGENOUS BONE AND POSTERIOR INSTRUMENTATION IN INFECTIOUS SPONDYLITIS

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Objective: The purpose of this study was to determine the efficacy of combining debridement, arthrodesis in which iliac autograft is used, and short segmental posterior instrumentation in a single-stage procedure for patients in whom nonoperative management of infectious spondylitis has failed.
Patients and methods: A retrospective analysis of 53 (33 male, 20 female) consecutive patients with infectious spondylitis treated between April 1996 and March 2002 was performed. There were 43 pyogenic spondylitis, 9 spinal tuberculosis and one spinal mycosis. Forty-nine patients were treated combining debridement, arthrodesis in which iliac autograft is used, and short segmental posterior instrumentation in a single-stage procedure. There were 5 cervical, 13 thoracic, 8 thorocolumbar, 24 lumbar and 3 lumbosacral lesions. Mean follow-up period was mean 35 months, and patientsÅf ages ranged from 15 to 82 years (mean, 63.9 years). All patients were performed radiologic and clinical evaluation. According to Malawski classification, 28% were acute stage, 40% were subacute stage and 32% were chronic stage.
Results: All patients experienced significant postoperative reduction in pain, 77% complete relief and 23% partial relief. Neurological deficits were improved more than one grade (Frankel) in 75%, and Grade D or E accumulated 92% of cases. Forty-seven patients were independently ambulatory, and three required a walker; only three had been ambulating independently preoperatively. In one case was pseudarthrosis demonstrated on dynamic radiography. Solid bony fusion rate was 98% (47/48), and none was observed instrumentation failure. The deterioration of post operative infection state was observed in two casesÅCtwo of them were required removal of instrument and bony fusion was obtained. One patient died during the 1st postoperative week of medical complications; another developed a wound dehiscence that was managed with debridement, prolonged antibiotic administration, and removal of the hardware 2 month later. Most patients received only a 4-week course of intravenous antibiotics postoperatively.
Conclusions: Single-stage debridement, arthrodesis, and internal fixation can be effective in the treatment of infectious spondylitis. The harvesting of iliac autograft through the same operative exposure may not increase the risk of secondary infection.

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DISABILITY, PAIN AND WORK STATUS FOLLOWING LUMBAR MICRODISCECTOMY OR CONSERVATIVE TREATMENT IN PATIENTS WITH BACK PAIN AND SCIATICA: A RANDOMISED CLINICAL TRIAL

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Introduction: There is significant variation in the threshold and rate of surgery for lumbar disc herniation(LDH), particularly for patients with LBP as well as sciatica, and moderate disability. Surgical rate in the USA is 10-15 times the UK rate. Cochrane review of surgery in LDH identifies the need for randomised trials of treatment for specific patient groups.
Methods: 88 patients, with LBP plus sciatica, and small/moderate LDH, participated in a randomised trial of standard microdiscectomy(MD) versus conservative treatment involving physical therapy including exercise and education. Data were collected over 24 months, using Oswestry Disability Index (ODI), questionnaire on disability days (DD -days lost from work or "normal" activities), pain (VAS) health status (SF-36) and walking ability (Shuttle Walk Test).
Results: At baseline, mean age was 39.8 years. 68% were employed. Mean ODI, sciatica and LBP (VAS: 0-10) were 41.2, 6.2 and 5.4. At three months there were significant differences favouring MD (ODI 25.2/37.4 p=.001; sciatica 2.6/5.2 p=<.001; LBP 3.1/5.0 p=<.001). Conversely, MD patients had more DD (33.3/15.1 p=<.001). Significant differences remained at 12 months (ODI 17.9/28.5 p=.003; sciatica 2.3/3.9 p=.007; LBP 2.4/4.2 p=.002), other than in accumulated DD (DD 39.1/34.3 p=.466). Health status of the conservative group continued to improve gradually whereas in the MD group there was little change after 12 months. By 24 months slight differences favoured MD but were not statistically significant (ODI 16.4/22.1 p=.200; sciatica 1.9/2.4 p=.346; LBP 2.2/3.1 p=.079; accumulated DD 43.0/50.5 p=.389; employment 80.0%/64.7% p=.14). Similar trends were seen in other measures. Ten patients in the conservative group had surgery (at mean 11.8 months, seven with good outcome). Nine patients in total (10.2%) were lost to follow-up at the end of the study. All analyses were on an "intention to treat" basis.
Discussion: It is noteworthy that LBP as well as sciatica was significantly reduced in the surgical group following treatment. By two years there were no significant differences between groups, however the magnitude of differences in the first year is considerable. MD should be considered for this patient group, often not given the option. These results should facilitate informed choice of treatment.

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A RANDOMIZED, DOUBLE-BLIND, CONTROLLED EFFICACY STUDY: INTRADISCAL ELECTROTHERMAL THERAPY (IDET) VERSUS PLACEBO FOR THE TREATMENT OF CHRONIC DISCOGENIC LOW BACK PAIN

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Introduction: Intra-Discal Electrothermal Therapy (IDET) is increasingly used for the treatment of chronic low back pain (CLBP). Reports from prospective outcome studies demonstrate statistically significant improvements, but to date there are no published randomized controlled trials.
Methods: Ethical committee approval was obtained prior to the study. Patients with CLBP 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 randomized 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 6 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 workerís compensation status, sitting tolerance, initial LBOS, ODI, SF-36, ZDI and MSPQ were similar for both groups. No neurological deficits occurred. 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 6 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 group 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.

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RANDOMISED CONTROLLED TRIAL OF EPIDURAL STEROID INJECTION FOR SCIATICA

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This study set out to establish whether epidural steroid injection (ESI) had any short term or long-term efficacy in the treatment of sciatica caused by nerve root compression.
Method: Ninety three patients with sciatica and MRI evidence of disc prolapse or spinal stenosis were recruited (1996-1999), and followed for at least two years. All patients approached had symptoms severe enough to consider surgical treatment. Patients were randomly and blindly allocated to either ESI or intramuscular steroid injection. Pain was assessed for 35 days after treatment using the Oxford Pain Chart. Patients were followed for 2 years, and assessed for the need for surgery during that time. Ethical committee approval was obtained. The Chi-squared test was used for statistical assessment.
Results: There were 44 in the ESI group and 48 in the control group.One patient was lost to follow-up, 2 died. There was no significant difference between the variables in the two groups. The diagnosis was disc prolapse (43), spinal stenosis (32), combination of prolapse and stenosis (17). Average age was 49 (23-79), one level was affected in 77 patients two levels in 13 and three levels in 2, average Oswestry Disability Index was 41. 40% had some neurological dysfunction. After treatment 85% returned their pain form with a significant improvement in pain relief in the ESI group at 35 days (p=<0.004). 36% of patients underwent surgical decompression; more patients in the ESI group underwent surgery than in the control group, but the difference was not significant. A post hoc power calculation showed that the study had 60% power to demonstrate a halving of the rate of surgery.
Conclusion: The natural history of nerve root compression favours resolution in many patients even after 6 weeks of conservative treatment. ESI reduces acute pain in sciatica. However there is no evidence that ESI alters the natural history of sciatica secondary to nerve root compression, and it does not reduce the necessity for surgery in a population at risk.

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POSTURAL CHANGES OF INTERVERTEBRAL FORAMEN IN NORMAL INDIVIDUALS (A STUDY OF WHOLE BODY VERTICAL OPEN POSITIONAL MRI)

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Introduction: Clinical symptoms in lumbar spinal stenosis are posture-related. Pain and numbness in the buttock and leg are provoked either by walking or by prolonged standing and symptomatic relief can be obtained by lying and sitting.
Materials and methods: 17 volunteers, without LBP and sciatica were studied with a pMRI in lying, standing, sitting neutral, sitting flexion and sitting extension. On sagittal images, foraminal width, foraminal height and cross-sectional area of inter vertebral foramina were measured at the pedicle level (L1/2 - L5/S1) On midsagittal images, intervertebral disc height (L1/2 - L5/S1) and Lordosis (L1-S1 Angle) were measured. Measurements and interobserver reproducibility were performed independently by an orthopaedic surgeon and radiologist. The lowest vertebral body separated from the sacrum by a complete intervertebral disc was designated at L5. Measurement results were analyzed with one-way ANOVA and multiple comparison posttests.
Results: At L3/4 the greatest mean foraminal height was found in sitting flexion, followed by neutral sitting, supine, erect and sitting extension. At L4/5 the greatest mean foraminal height was found in sitting flexion, followed by neutral sitting, sitting extension, supine and erect. At L3/4 the greatest mean foraminal width was found in sitting flexion, followed by neutral sitting, sitting extension, supine and erect. At L4/5 the greatest mean foraminal width was found in sitting neutral, followed by sitting flexion, sitting extension, supine and erect. At both L3/4 and L4/5 the greatest mean foraminal area was found in sitting flexion, followed by neutral sitting, sitting extension, supine and erect.
Discussion: We have found a significant difference in foraminal dimensions as a function of posture. In extension, the posterior disc height decrease because of the compression of the posterior part of the disc and the distance between neighboring pedicles decreases accompany increased lordosis. Not only spinal canal area but also intervertebral foraminal space can decrease with exten-

sion. The nerve root is constrained in the intervertebral foramen (IVF) and may be easily compressed or mechanically irritated under unfavourable conditions of degeneration and movement. Basic data from this current study may be useful for the clinical study in lumbar spinal stenosis patients.

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ONE-YEAR FOLLOW-UP IN THE SWEDISH NATIONAL LUMBAR SPINE REGISTER

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Background The Swedish lumbar spine register today includes more than 80% of lumbar spine surgery for degenerative disorders performed in Sweden.
Methods The pre- and postoperative protocol is entirely patient-based and completed prior to surgery and at one and two years after surgery. Surgical data (diagnosis, type of surgery, implant, complications and hospitalization data) are completed by the surgeon. The patient-based questionnaires include demographic data and pain on the VAS scale, pain drawing and the SF-36 and EuroQol questionnaires. In 2002, 85% of patients operated on 2001 completed a follow-up questionnaire.
Results Within a year from index surgery, 7% had been subjected to repeat lumbar surgery. For all patient categories studied (disc herniation, central and lateral spinal stenosis, spondylolisthesis, degenerative disc disease (DDD)), improvement was noted in parameters as VAS pain, self-rated back and leg pain and SF-36. Patient satisfaction with surgery was (satisfied, uncertain, dissatisfied): Disc herniation 72%, 19%, 9%, central spinal stenosis 67%, 21%, 12%, lateral spinal stenosis 58%, 19%, 23%, spondylolisthesis 68%, 26%, 6%, DDD 61%, 31%, 8%. Mean back pain preoperatively varied between 53 and 69 and leg pain between 48 and 68. Mean postoperative back pain varied between 27 and 42 and leg pain between 23 and 40. The most pronounced reduction of leg pain was seen in disc herniation and the most pronounced reduction of back pain was seen in DDD. In spinal stenosis the outcome was similar whether decompression was combined with fusion or not. In isthmic spondylolisthesis and DDD a wide variety of surgical interventions were performed, anterior, posterior and combined fusion with and without instrumentation and with and without decompression.
Conclusions It is possible to gather acceptably complete data in a national register, at least in a country the size of Sweden. Outcomes, changes in indication over time, identification of inferior implants and complication registration are some features that can be obtained. Areas needing deeper analysis in focused studies can be identified. The one-year outcome data substantiate the efficiency of lumbar spine surgery when performed in a national setting and demonstrates lumbar spine surgery as an exponent for evidence based surgery.

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A PROSPECTIVE RANDOMISED TRIAL COMPARING FEMORAL RING ALLOGRAFT VERSUS A TITANIUM CAGE FOR CIRCUMFERENTIAL SPINAL FUSION: TWO YEAR FUNCTIONAL AND RADIOLOGICAL OUTCOME

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Introduction: Our standard surgical procedure for discogenic low back pain is an anterior lumbar interbody fusion (ALIF) combined with posterior instrumentation. Current practice employs the Femoral Ring Allograft (FRA) as the anterior interbody fusion device. However, concerns regarding the possibility of disease transmission have lead to the introduction of a titanium interbody cage (Syncage). We present the two-year functional and radiological outcome from a prospective randomised study of circumferential fusion comparing a biological interbody fusion device with a titanium cage.
Methods: 62 consecutive patients with disabling low back pain were enrolled, having previously failed conservative treatment. Patients underwent MRI and lumbar discography. Only patients with one or two-level concordant pain were enrolled. Patients were randomised to receive either the FRA or the titanium cage. Posterior instrumentation consisted of Magerl translaminar screw fixation, or if this was not possible (eg previous laminectomy), pedicle screws were used. All patients had the Oswestry Disability Index (ODI), Visual Analogue Sore (VAS) and SF-36 questionnaires administered pre-operatively, at 12 and 24 months. Data analysis was performed using the Student t-test. The mean clinically important difference (MCID) was chosen as 10 points on the Oswestry Disability Index. Independent radiological analysis was performed to assess fusion. Complications were recorded for both groups.
Results: 63% of patients underwent a single level fusion, 37% underwent a two-level fusion. At two years, clinically significant improvements were noted in VAS, ODI and SF-36 (physical function, vitality, and social function) for the FRA group ($p<0.05$). For the Syncage group, the only significant improvement was in the VAS ($p<0.05$) The mean preoperative ODI for the FRA group was 56.5 (range 30-76) improving 12.1 points to a mean of 44.4 (0-82). The mean preoperative ODI for the SynCage group was 51.4 (range 26-78) improving just 4.3 points to 47.1 (11-74). The total number with documented pseudarthrosis was 7 (six in the FRA group and one in the SynCage group). Six cases with translaminar screw breakage (5 in FRA and 1 in SynCage) underwent revision of posterior instrumentation to pedicle screw fixation.
Conclusion: Circumferential fusion with FRA resulted in a clinically important improvement and better functional outcome when compared to the Syncage. The high incidence of translaminar screw breakage, particularly in two-level fusions has altered standard practice to the use of pedicle screws for two-level fusions.

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A NON-INVASIVE APPROACH FOR SCOLIOSIS ASSESSMENT

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Purpose: To investigate the correlation of spinal deformity measurements with Ortelius800TM radiation-free system as compared to the standard radiographic measured Cobb angles.
To assess Ortelius800TM clinical value while enabling significant reduction of X-ray exposure.
Materials and Methods: Patient population: 102 patients diagnosed with adolescent idiopathic scoliosis (AIS) from three different medical centers.
Protocol: Each patient was measured with the Ortelius800TM system by the same standard protocol. The entire process required an average of two minutes.
Statistical analysis: The Ortelius800TM measurements were correlated with the standard Cobb angle as measured on routine standing coronal and sagittal radiographs.
Results: Summary of findings: Two hundred and five coronal Cobb angles were measured for scoliosis with a mean of 18; for thoracic curves and 17.7; for lumbar curves and a median of 17.0; for thoracic and lumbar curves. Thirty-eight sagittal Cobb angles were measured with a mean of 36; and a median of 34;. No statistical difference was found when comparing median of Cobb angles with both measuring methods. The Pearsonís correlation coefficient was 0.85 in both the coronal and sagittal planes (P value of 0.0001). The mean difference between the two measuring methods was 0.29 [(95% confidence interval (-0.51; 1.09)]. The Wilcoxon signed-ranks test for matched pairs shows this difference to be statistically insignificant (P value=0.651). The golden standard for scoliosis assessment is the radiograph and Cobb angle measurement. The new procedure allows a radiation free method for scoliosis assessment in three planes (coronal, sagittal, apical) with simultaneous automatic calculation of the Cobb angle in both coronal and sagittal views.
Conclusions: The results reveal sufficient correlation between the two measuring methods in both coronal and sagittal views. We propose the Ortelius800TM as a clinical tool for the follow-up measurements of AIS patients, thus enabling a significant reduction of radiation exposure.

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BODY COMPOSITION PROFILE OF GIRLS WITH IDIOPATHIC SCOLIOSIS

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Objective: To assess anthropometric data, body composition parameters and fatness levels in adolescents girls with idiopathic scoliosis (AIS), and compare these estimations with an healthy age-matched population.
Methods: A total of 24 girls with AIS with an average age of 13.9 years (range, 11-18) and an average scolitic curve of 27° Cobb (range, 20-58°) underwent an anthropometric study. Weight, height, and skinfold thicknesses at 6 levels (tricpes, subscapular, abdominal, suprailiac and anterior tigh) were measured. Body mass index (BMI), Ponderal index (PI), fat mass, lean body mass, muscular and bone weight were calculated to estimated body composition. Percentage of body fat (%BF) and percentage of muscular tissue (%MT) were also obtained. Somatotopic charts according to Carter were drawn from each children. Ectomorphy was corrected as regards mean height. None of the AIS girls have been treated previously with spinal surgery. Similar studies were performed in a control group of 92 girls mathched in age (mean 13.8 years) without spine deformity.
Results: Compared to control population, scoliotic girls had a significant lower mean weight (50.6 ± 8.7 kg vs 54.6 ± 8.1 kg; $p< 0,05$) and a lower BMI (19.3 ± 2 vs 21.4 ± 2.4; $p<0.001$). Along the growth period, mean BMI and %BF for girls with idiopathic scoliosis did not show any difference as increasing age. The %BF was also lower in scoliotic girls, not showing statistical differences (13.9 ± 3 vs 15 ± 3.6). BMI showed a strong correlation with %BF. Of the 24 AIS girls, 12 were under 12.5% BF indicanting underweight. Four scoliotic girls had BMI lower than 17.5, reflecting poor nutritional conditions. The somatotype differed also between scoliotics and control, being lower the endomorphic component (3.64 ± 1.33 vs 4.41 ± 1.55; $p<0.05$) and higher the ectomorphic figures (3.51 ± 0.95 vs 2.40 ± 1.11; $p<0.0001$) in AIS patients.
Conclusions: To our knowledge, this is the first study showing body composition profile in girls with idiopathic scoliosis. Differences in weight, BMI, %BF and somatotype suggests that idiopathic scoliosis not only disturb the spine normal growth but also have implications in the development of other anthropometric parameters. In the aetiology of idiopathic scoliosis migth be involve therefore endocrine factors affecting body composition and growth. If these changes are related to abnormal spinal growth or subsequent to nutritional changes in AIS still remains uncertain.

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ADOLESCENT IDIOPATHIC SCOLIOSIS THROUGHOUT THE GROWTH SPURT: NATURAL HISTORY AND OUTCOME

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To compare outcome at different degrees of maturity, girls diagnosed with AIS, having at least two yearsí follow-up and not referred for surgery within 6 months of diagnosis were identified. Initial and latest values (age, height, Cobb angles), menarche, surgery and non-operative treatment were considered. They were divided according to the time of diagnosis relative to menarche: Group 1 (N=58), diagnosed at least one year before menarche; Group 2 (N=50) diagnosed in the year immediately preceding menarche and Group 3 (N=53) diagnosed any time after menarche. Statistical analysis was by chi square and ANOVA. A minimum increase of 10° was considered significant. Group 1 were aged at diagnosis 11.6+1.01, at last review 17.3+2.64, at menarche 13.7+ 0.98, with an initial Cobb angle 16.8°+8.58 and last 24.4°+17.14. 24 (41.8%) progressed, 9 were braced and 11 (19%) had surgery at age14.6+1.4. Group 2 were aged at diagnosis 12.8+0.74, at last review 17.2+2.95, at menarche 13.2+0.76 with an initial Cobb angle 23.3°+11.55 and last 27.7°+16.27. 13 (26%) progressed, 9 were braced and 10 (20%) had surgery at age 13.98+0.06. Group 3 were aged at diagnosis 13.7+1.03, at last review 18.4+3.5, at menarche 12.5+1.26 with an initial Cobb angle 27.7°+17.08 and last 28.5°+ 18.21. 4 progressed, 5 were braced and 7 (13%) had surgery at age 15.2+0.699. There was no statistically significant evidence that brace treatment had an effect on progression or the incidence of surgery. Analysis of variance showed statistically significant differences between the groups on age and height at diagnosis, age at menarche, initial Cobb angle and amount of progression. At last review, age, height and Cobb angle were not statistically different.

There was no statistically significant difference in the numbers who had received surgery by the end of follow-up (chi-square= 0.983, p=0.612) or in the age at which this was carried out (F= 2.376, p=0.114). At final review, Groups 1 and 2 had caught up with Group 3 on all parameters. These divisions show different overlapping stages of a growth process that is usually benign and does not respond easily to therapeutic intervention.

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COLOR DOPPLER ULTRASONOGRAPHY FOR EVALUATION OF ANTERIOR CHEST BLOOD SUPPLY. THE POSSIBLE ROLE OF ARTERIAL BLOOD SUPPLY BY INTERNAL MAMMARY ARTERY TO THE COSTOSTERNAL JUNCTION IN THE ETIOLOGY OF ADOLESCENT FEMALE RIGHT CONVEX IDIOPATHIC SCOLIOSIS

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This prospective comparative study was carried out to investigate the blood supply to anterior chest wall by measuring several anatomic and haemodynamic flow parameters of internal mammary artery with the use of Color Doppler Ultrasonography in female scoliotics with adolescent idiopathic right convex scoliosis. Previous investigations have postulated that the asymmetry of the breasts in female adolescents may be linked with the development of right convex thoracic scoliosis. This breast asymmetry is supposed to be linked with anatomic and functional asymmetry of the internal mammary artery that is the main supplier to the mammary gland. However, no measurements of anatomic and haemodynamic parameters of internal mammary artery have been made to justify or to reject the hypothesis of asymmetric blood flow volume to the breasts and costosternal junction in female adolescent scoliotics. Twenty female adolescents with right convex thoracic scoliosis and 16 comparable female individuals without spine deformity were examined with roentgenograms (scoliotics only) to measure scoliosis curve, vertebral rotation and concave and convex rib-vertebra-angle at three vertebrae (apical, one level above and one below the apical vertebra). The Color Doppler Ultrasonography was used to measure at the origin of internal mammary artery its lumen diameter, cross sectional area, time average mean flow and flow volume per minute in scoliotics and controls and were compared each other. The roentgenographic parameters were compared with the ultrasonographic parameters in the scoliotics to disclose any relationship. The reliability of color Doppler ultrasonography was high and the intraobserver variability low (ANOVA, P=0.92-0.94). There was no statistically significant difference in the ultrasonographic parameters of the internal mammary artery between right and left side in each individual as well as between scoliotics and controls. In scoliotics the right mammary artery time average mean velocity increases with the convex ($P<0.05$) and concave ($P<0.01$) rib-vertebra-angle one level above the apical vertebrae and with the apical convex rib-vertebra angle ($P<0.05$). The right internal mammary artery flow volume per minute increases with convex ($P<0.01$) and concave ($P<0.01$) rib-vertebra-angle one level above the apical vertebrae and with the apical convex rib-vertebra angle ($P<0.05$). Left internal mammary artery cross sectional area increases with convex apical rib-vertebra-angle ($P<0.01$) and concave rib-vertebra-angle one level above the apical vertebra ($P<0.01$). Conclusively, this investigation showed that haemodynamic flow parameters of the right internal mammary artery and anatomic parameters of the left internal mammary artery are significantly correlated with the magnitude of rib-vertebra-angles close to the apex of right thoracic scoliosis in female adolescents. This study did not find any evidence for side-difference in vascularity of the anterior thorax wall and thus it could not clearly justify previous theories for development of right thoracic scoliosis in female adolescents.

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ANTERIOR VS. POSTERIOR DOUBLEROD INSTRUMENTATION FOR IDIOPATHIC THORACOLUMBAR SCOLIOSIS: A COMPARISON OF RESULTS IN 141 PATIENTS

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Problem: Ventral Derotation Spondylodesis according to Zielke achieves good three-dimensional corrections of idiopathic thoracolumbar scolioses. In spite of a recommended cast treatment postoperatively the high rate of rod breakages represents a problem. By keeping to the correcting principle developed by Zielke anterior doublerod instrumentation is to be stable, however, in a similar way as posterior doublerod systems and is to facilitate brace-free postoperative care.
Patients and Methods: Retrospectively we performed clinical and radiologic follow-up of two groups of patients with idiopathic thoracolumbar scoliosis (King-II, -III and -IV) undergoing an operation with posterior approach (USS instrumentation, posterior group, n=104) in 1997 and 1998 or being corrected with an anterior fusion (micomed instrumentation, anterior group, n=37) between 2000 and 2001. The average age for operation was 15+5 years, follow-up was performed after 3+1 years.
Results: Preoperative measurements of the major and lateral curve, the lateral profile, rotation and balance (C7 to S1) did not show any significant differences apart from a more severe scoliotic curve in the lumbar spine for the anterior group with appropriately higher lumbar rotation. Postoperatively we noticed similar corrections of the thoracic major and lumbar curve in both groups which ranged from 49% to 56% (posterior or anterior group: thoracic curve 24+9° versus 25+12°, lumbar 16+8° versus 21+14°). A slightly kyphogenic effect on the thoracic spine only occurred in the anterior patient group (from 24+13° to 27+13°). In addition correction of thoracic and lumbar rotation in the anterior group by 37% or 30% was more significant than in the posterior group by 27% or 20%. Impact of posterior technique on the balance of the spine which was corrected by 3mm towards the midline was definitely more favorable whereas it deteriorated on an average of 7 mm to the left in the posterior group. The number of fused segments was significantly smaller in the anterior group with 7±1 vertebral bodies (posterior: 11±1 vertebral bodies). Rates of complication were identical with 9% or 10% in both groups.
Conclusion: Anterior and posterior doublerod instrumentations result in approximately comparable corrections for idiopathic thoracic scolioses. In case of posterior technique, however, 4 vertebral bodies less were integrated in spondylodesis on average. Furthermore balance of the spine is improved by the anterior technique, by posterior technique, however, it is declined.

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EARLY RESULTS OF THORACOSCOPIC INSTRUMENTED FUSION VERSUS CONVENTIONAL POSTERIOR INSTRUMENTED FUSION IN TYPE-3 ADOLESCENT IDIOPATHIC SCOLIOSIS

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The objective of our study is to compare the safety and efficacy of two different techniques in the surgical treatment of type-3 adolescent idiopathic scoliosis i.e. conventional posterior instrumented fusion and thoracoscopic instrumented fusion. Thirty-four consecutive patients with type-3 scoliosis treated with one of the above techniques were analyzed by an independent physician. Twenty-two patients (group I) underwent posterior fusion and instrumentation (Moss-Miami). Twelve patients (group II) had thoracoscopic fusion and instrumentation (Eclipse). We found no statistical difference between the two groups in terms of age at menarche and surgery. Pre-operative Cobb angles in the coronal and sagittal planes did not differ between the two groups. Estimated blood loss at surgery and duration of parenteral analgesia also did not differ between the two groups. Group I patients had significantly higher transfusion requirements ($p = 0.032$). Operative time ($p = 0.0001$), ICU stay ($p = 0.005$), and hospital stay ($p = 0.037$) were longer in group II cases. There were no complications in group I. Complications in group II included lobar collapse (1 case) and scapula winging (1 case). Improvement in scoliosis among group I patients averaged 75% (1 week), 70% (6 months), and 65% (1 year). In group II patients, mean improvement in scoliosis was 66% (1 week), 62% (6 months), and 62% (1 year). The differences between the 2 groups in terms of scoliosis improvement were not significant. Curves with apex at T8 or higher had better correction of scoliosis ($p = 0.05$). The sagittal alignment (thoracic kyphosis and lumbar lordosis) after surgery was similar between the two groups at 1 week, 6 months, and 1 year post-operatively. The efficacy of thoracoscopic surgery is similar to standard posterior procedures. Advantages included lower transfusion requirement. A longer operative time leading to longer ICU and hospital stay was attributed to the steep learning curve of this endoscopic technique.

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VULNERABILITY OF THE SPINAL CORD IN ANTERIOR SPINAL DEFORMITY SURGERY

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Introduction Recent reports suggest a low incidence of neurological complications following anterior deformity procedures. In patients with intra-spinal anomalies undergoing such surgery the incidence is believed to be higher. However, no studies have quantified this risk and its relationship to anterior surgery. There is also debate regarding whether SSEP monitoring or soft clamping of segmental vessels prior to division during anterior surgery is necessary. This study aims to determine the incidence of significant SSEP changes in patients undergoing anterior spinal deformity surgery; to ascertain if patients with "cords at risk" were more likely to produce significant intra-operative SSEP changes and the extent these changes resulted in post-operative neurologic deficit.
Method A retrospective analysis of charts and traces for all patients who had an anterior deformity operation between 1990-2001 and who had complete data sets (preoperative MRI scan, patient and procedural documentation and adequate intra-operative SSEP traces) was conducted. Significant SSEP changes and post operative neurological deficit were noted in all patients whether or not those patients had a "cord at risk".
Results Of the 871 patients who underwent anterior spinal deformity surgery, 95 (11%) demonstrated intraspinal abnormalities, of which 27 showed abnormal pre-operative SSEP i.e. cord at risk (CAR). Abnormal intraoperative SSEP responses were found in seventeen of the CAR group and ten in the normal group. Post operative paraparesis incidence was 0.6% (four in the CAR group, one from the normal group). There was 100% sensitivity of SSEPs in detecting potential neurological deficit. Specificity was found to be 98.6%, positive predictive value 29.4% and negative predictive value 100%. The CAR group were more likely to demonstrate intraoperative SSEP changes and suffer post operative paraparesis.
Conclusions In experienced hands SSEP monitoring is sensitive and specific with no false positive results. It should be adopted and supplemented with soft clamping of segmental vessels in patients with cords ?at risk? undergoing anterior spinal deformity surgery.

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RATIONALISING BLOOD TRANSFUSION IN SPINAL SURGERY

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Spinal fusion surgery can result in blood loss necessitating transfusion. Human variant CJD poses a relatively new and difficult concern with allogeneic blood transfusion. Cost is an additional consideration. Where colloid is used to replace blood loss in real time such as in the acute hypervolaemic and normovolaemic haemodilution (AHH and ANH) settings, blood loss displays 1st order kinetics. This is described by the formula $Hbx = Hbi/e(EBL/EBV)$ (Hbx = haemoglobin concentration at time x, Hbi = initial Hb, EBV= estimated blood volume, EBL= estimated blood loss). Using the above mathematical model we devised a computer aided means for:

1. preoperative prediction of allowable blood loss before a threshold Hb is reached
2. perioperative realtime prediction of Hb concentration
3. perioperative realtime prediction of transfusion requirements

We present the first clinical trial of such a model. The model was validated in a consecutive series of 13 patients undergoing spinal fusion (8/13) or burn related surgery (5/13) with 29 separate measurements. Average age was 42.8 years (range 1.6-77). Blood loss in this series ranged from 3% to 80% of estimated blood volume (mean = 16%). Results were analysed using the Bland Altman statistical method, plotting the mean of measured and calculated Hb against the measured minus calculated Hb. The spread of values was demonstrated by plotting all 29 values and there is no evidence that the spread increases or decreases with mean level of blood loss (independence was ensured by looking at only the 1st measurement in each case and there was no difference in spread). Where the model was adjusted to take into account real time fluctuations in blood volume with fluid input and blood loss mismatching, limits of agreement are set at 0.64 and +0.91 with no evidence of bias. Using a simplified model where it is assumed that the estimated blood volume remains constant, limits of agreement are set at 1.03 and +1.14 with no evidence of bias. In summary we present the first clinical validation of an inexpensive non

invasive method for predicting real time per-operative Hb levels and transfusion requirements in spinal and burns surgery.

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POSTOPERATIVE PAIN IN ADOLESCENCE DOES NOT PREDICT FOR FUTURE PAIN AND FUNCTION - OUTCOME 23 YEARS AFTER FUSION FOR ADOLESCENT IDIOPATHIC SCOLIOSIS

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Introduction/Purpose: Few reports exist on correlation between experienced postoperative pain and later function. The aim of this study was to determine whether postoperative nociceptive pain reaction measured by the amount of analgesics used postoperatively could predict for future chronic pain syndromes or decreased physical or mental function. A consecutive series of patients with adolescent idiopathic scoliosis, treated between 1968 and 1977 before 21 years of age, with distraction and fusion using Harrington rods (n=156; 145 females and 11 males) were followed at least twenty years after completion of the treatment. Until 1973 surgery was performed as a two-stage procedure and thereafter in one stage preceded by Cotrel-traction.

Methods: One hundred and forty-two (91%) of the surgically treated patients were reexamined as part of an unbiased personal follow-up, of which 139 had complete follow-up. This follow-up included a clinical examination with dolorimetry testing, also performed on age and sex matched controls, and evaluation of curve size (Cobb method) in full standing frontal radiographs. Validated questionnaires in terms of general and disease-specific quality of life aspects as well as present back and pain symptoms were used. Information on given analgesics and tranquilizers postoperatively; type, dose and number of days used, were collected through chart reviews and summarized. Morphine-like drugs were recalculated in doses comparable to morphine and the total amount given during the first five days was adjusted for body weight.

Results: Sixty-five patients were operated with a one stage and 74 patients a two stage procedure. The procedures were not comparable from the postoperative pain situation. For the first/only procedure, patients who needed analgesics more days postoperatively had a significantly larger curve size before and after completed treatment and a longer fusion. In neither the one- nor two-stage group the consumption of analgesics or tranquilizers postoperatively related to pain and function 25 years later. Pain sensitivity by dolorimetry, was significantly correlated to physical function at the present follow-up. The patients were not more sensitive than controls.

Conclusion: The nociceptive pain reaction in surgically treated adolescent girls measured by the postoperative anlagesics consumption did not predict pain or function twenty years later.

ANATOMY

P 1

FINITE ELEMENT MODELING OF REGIONAL VARIATION OF ANULUS FIBROSUS IN THE INTERVERTEBRAL DISC

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Introduction: In most finite element models of the intervertebral disc, tension-only cable elements are used to represent the fiber-induced anisotropy of the anulus fibrosus (AF). These physically isolated fibers models are able to describe well the mechanical behavior of the motion segment at the structural level. However, interactions between the fiber populations and the surrounding matrix in the AF had to be neglected. In addition, in models using the cable elements connecting two anchor nodes one can hardly include the regional variation of the material properties because one can not generate nodes that fully satisfy both the fiber directions and the complicated anulus geometry.
Methods: We used a micromechanics model to calculate the macro scale material properties of the AF from the constituent material properties and their volume fraction which varies regionally within the AF. In the anisotropic continuum model, the material properties were determined by the fiber orientation. A continuum model with a specific fiber orientation was then implemented into a finite element model. In this way, we have fully included regional variations in fiber orientation and volume fraction in the radial and circumferential directions. A comprehensive geometric model of an intervertebral disc was also implemented into a finite element model. Material properties most recently available in the literature were incorporated into our models, allowing prediction of the site-specific mechanical behavior of the intervertebral disc. Geometric nonlinearity due to deformation and the material nonlinearity of the anulus fibrosus were considered in the analysis. Various types of physiological loadings were also considered, including flexion, lateral bending, axial rotation, and axial compression.
Results: Little difference was observed in the overall range of motion (ROM) at the structural level between the anisotropic continuum model and the physically isolated fiber model. It was found that the hypothesis that the AF has physically isolated fibers within the matrix is inaccurate, because interactions between the fiber populations in the AF appear to be significant determinants of AF material behavior. Up to 20% differences in stress were observed between the two models.
Conclusions: Regional variations should be included in analyses of the biomechanical behavior of the intervertebral disc. The continuum model based on the micromechanics model is very effective in capturing both micro- and macro-level stresses and deformations.

P 2

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 & 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 patients' symptoms and require no specific treatment. This has been confirmed when the primary pathology has been treated and the patients 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 patients' 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 patients' 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 Patients' symptoms. Our classification system addresses this and offers guidance on patient management.

BACK PAIN

P 3

ARE THERE ANY RELATIONSHIPS BETWEEN HAMSTRING MUSCLE TIGHTNESS, POSITIVE STANDING HIP FLEXION TEST AND PELVIC LATERAL TILT IN SACROILIAC JOINT DYSFUNCTION?

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Hypothesis: The hamstring as a group muscle works for rotating the iliac bones backwards relative to the sacrum. Higher tension of the hamstring will force the pelvis to rotate backwards. Diminished or unbalanced muscle function can lead to sustained counternutation in the sacroiliac joint (SIJ). The hamstrings that attach to the pelvis may influence SIJ movement through their attachments. Muscle tightness and postural deformities may be important factors in SIJ dysfunction (3,4,5). The purpose of this study was to determine the possible relationship between tightness of hamstring muscles, positive standing hip flexion test and pelvic lateral tilt in SIJ dysfunction.
Methods: Between 2000-2003, 51 (19 male, 32 female) patients with SIJ dysfunction included in the study. Their mean age was 39.91. All the patients were evaluated for hamstring tightness, pelvic lateral shift and standing hip flexion test which is a test for confirming the SIJ dysfunction. Pelvic lateral shift was tested in

standing position which anterior and posterior observation palpating the pelvic landmarks. Standing hip flexion test was performed by asking the patient to flex alternate hips on standing position.
Results: The patients with SIJ dysfunction showed a significant correlation between pelvic lateral tilt and hamstring tightness (r: 0.417, p:0. 004). There was also significant relationship between pelvic lateral tilt and positive standing hip flexion test, which confirmed SIJ dysfunction (r: 0.404, p: 0.005). Hamstring muscle tightness on involved side significantly correlated with positive standing hip flexion test (r: 0.361, p: 0.01).
Discussion: Cibulka et al (2) stated that there was a high correlation between hamstring muscle strains and an anterior tilt of the innominate bones resulting from SIJ dysfunctions. In our previous study (1) we found that the similar results which shows the significant correlation between SIJ pain, pelvic lateral shift and positive walk test in SIJ dysfunction
Conclusion: We concluded that the length of hamstrings plays an important role in SIJ dysfunction. Correcting the SIJ may have reduced the length of the hamstring muscles or correcting the hamstring tightness and pelvic tilt may restore the SIJ dysfunction.
Key words: Sacroiliac joint dysfunction, Hamstring tightness, Pelvic lateral tilt

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P 4

WHOLE BODY VIBRATION EXPOSURE AND LOW BACK PAIN: A FIELD STUDY OF THREE GROUPS OF OCCUPATIONAL DRIVERS

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Introduction: It seems evident that occupational drivers have an increased risk to develop back pain. Not only are they often exposed to whole body vibration (WBV) and the seated posture, they may also engage in performance of manual materials handling (MMH). WBV, the seated posture and MMH are the three main risk factors that have been associated with symptoms of back pain amongst different groups of drivers. Unfortunately, most of the information has generated from studies restricted to one of the typical occupations and it is not yet clear how WBV acts alone and in association with posture and MMH as a causative factor for back pain. The present study compared three groups of occupational drivers for 12 months prevalence of low back pain and the joint effect of exposure to whole body vibration and postural load.
Methods: A cohort of 111 drivers (31 of buses, 29 of tractors and 51 of trucks) responded to questions about their health history (particularly problems to the back, neck and shoulder), driving experience, siting postures and handling, using a validated questionnaire. A visual analogue scale (0 to 10) was used to obtain ratings of perceived discomfort (each minute for a maximum period of 30 minutes) when typical driving postures were adopted with and without WBV. Records were taken of representative vehicular vibrations (at the seat pat) for each group of drivers using a vibration meter.
Results: Of the three occupational groups, bus drivers smoked most and exercised least. They also showed to be most likely to suffer low back pain Tractor drivers showed to be exposed to the highest average vibration values in the three axes, and truck drivers the lowest. Tractor and bus drivers reported higher ratings of perceived postural discomfort with idling vibration than with no vibration for upright seated posture but lower ratings when the vehicle was actually moving.
Conclusion: This field study was conducted to evaluate the health hazards associated with three driving occupations. It was clear that the levels (magnitude) of vibration exposure differed between the groups and this appeared to influence the driver's perceptions of postural stress.

BASIC SCIENCE

P 5

THE EFFECT OF PEDICLE SCREW PLACEMENT WITH OR WITHOUT COMPRESSION ON THE MORPHOLOGY OF THE SPINAL CANAL AND PEDICLE IN IMMATURE PIGS

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Summary of background data: Pedicle screw fixation has become popular in treatment of numerous disorders and deformities of the spine. Although it is increasingly used in pediatric spinal problems, safety of the procedure has not been clearly proven, yet. The risk of development of iatrogenic spinal stenosis secondary to the destruction of neurocentral cartilage in the immature spine is the major concern for its limited usage.
Objectives: The purpose of this study is to investigate the effects of pedicle screw insertion, with and without compression, on spinal canal and pedicle morphology in immature pigs.
Materials and methods: 12 newborn domestic pigs; 4 to 6 weeks of age were operated. The spine of the pigs were exposed subperiosteally on both sides. Right sides of the spines served as a control to eradicate the possible effects of the spontaneous fusion secondary to subperiosteal exposure. Pigs were randomly assigned into 3 groups. Left sided pedicles from L1 to L5 were operated.

Group 1 (sham operation): Pedicles were probed only.
A new pedicle screw with a core diameter of 2 mm, distal thread diameter of 3.5 mm, distal threaded portion length of 6 mm, smooth portion proximal to distal threaded part of 5 mm, was designed.
Group 2: After probing of the pedicles, these screws were inserted.
Group 3: After pedicle screws were inserted, a washer and a nut were engaged to the screw at the pedicle entry point enabling compression across the neurocentral cartilage. Pigs were sacrificed at the end of 4 months. Multi-detector spiral CT was used to evaluate spinal canal and pedicle morphology. Using specific software, pedicle lengths, and size of the halves of the spinal canal were calculated. Statistical analysis was performed.

Results: 3 pigs, one from each group died during follow-up. Misplacement of the screws and local infection made analysis impossible at 16 levels. As a result, 10 levels in group I, 10 in group II, and 9 in group III could be evaluated. In group I, the operated

hemicanal area was not statistically different from the non-operated side (p=0.159). Pedicle screw insertion either with (p=0.007) or without (p=0.005) compression resulted in smaller hemicanal area, and statistically significant shorter pedicles at the operated side (p=0.008 and p=0.021, respectively). There is no significant difference between group II and group III in terms of size of the operated (p=1.000) and non-operated (p=0.243) sides of the canal.
Conclusion: Probing of the neurocentral cartilage does not have a negative effect on the development of the spinal canal. Even without compression, whenever a pedicle screw is inserted passing through the neurocentral cartilage, spinal canal growth is disturbed significantly. Clinical relevance of these findings for young children should be further studied. However, pedicle screw utilization for this age group under the lights of these findings, is discouraging.

P 6

A BIOMECHANICAL COMPARISON OF ANTERIOR AND POSTERIOR STABILIZATION METHODS IN A SEVERE ATLANTOAXIAL INSTABILITY MODEL

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Introduction: This study analyzed and compared the biomechanical stabilities after destabilization of the anterior and posterior atlantoaxial transarticular screw fixations, the anterior Harms plate fixation, and the posterior Harms screw and rod fixation methods.
Methods: Sixteen human cervical spines with the occiput attached (C0-C3) were tested in three-dimensional flexion-extension, axial rotation, and lateral bending motions after destabilization using a C1-C2 instability model. In each loading mode, moments were applied to a maximum of 1.5 Nm. All loadings were performed in the following sequence onto the intact spine and the spine after destabilization and after fixation. The range of motion, neutral zone and elastic zone were determined and compared using the intact spine, the destabilized spine, and the spine post-fixation by instrumentation at each loading sequence. It was determined that the lateral bending NZ and ROM for the anterior Harms method differs significantly from the other three methods ($p<0.05$), while there were no statistical differences for all other values of ROM and NZ for the different fixation methods. Except for the anterior Harms fixation method, the other 3 methods restored the biomechanical stability for a safe C1- C2 stabilization to better than that of the intact specimens.
Conclusions: The anterior Harms fixation method revealed inferior biomechanical results when compared with the other fixation methods. The anterior C1- C2 TA screw and posterior Harms screw rod fixations could be considered as good methods for stabilizing the atlantoaxial joints, even though precise fixation methods are determined by the proper clinical and radiological characteristics in each patient.

P 7

MORPHOLOGICAL CHANGES IN THE TRAUMATIC INJURED CERVICAL SPINE. DO CHONDROCYTES DIE BY NECROSIS AFTER TRAUMA? AN ULTRASTRUCTURAL STUDY

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Study Design: *Animal study group:* The annulus fibrosus (AF) of the lower cervical spine from healthy 6 to 8 month old pigs was used to evaluate different stages of necrosis in chondrocytes. Histological and ultrastructural specimen were collected from 1 up to 24 hours after death of the pig.
Patients study group: Specimens from the lower cervical spine of traumatic injured patients were taken during operation. Anterior fusion was performed in between two weeks after trauma.
Objective: The aim of the study was to evaluate typical morphological signs of necrosis in early and late stages in chondrocytes of healthy, non-traumatised pigs. Another question was the time-dependent changes in cervical discs directly and in a period of two weeks after trauma. Do chondrocytes die by necrosis after trauma?
Summary of Background Data: Recent investigations showed that chondrocytes undergo apoptosis in a degenerative disc (Ariga et al. Spine 2001; Chen et al. J Orthop Res 2001). Evidence has been presented so far that apoptotic cell death occurs in degenerative discs. The possibility taken into account that necrosis is possibly more important in traumatic injured discs, has not yet been published. Thus, we thought to answer this tempting question by transmission electron microscopy. It is probably the method of choice to evaluate, whether necrosis or apoptosis is present in dying cells (Gruber et al., Spine 2000).
Methods: Investigations were done by light microscopy and transmission electron microscopy (TEM). Removal and fixation of the AF of the cervical spine of 10 pigs was investigated after 1 - 6 - 12 and 24 hours after death. Specimens from 10 patients (18 - 46a) were taken during operation and fixed immediately (less than 15 minutes) for histological and fine structure evaluations. The specimens were fixed for light microscopy investigations with Schaffer solution (600ml 80% Alkohol und 300ml 37% Formol with $CaCO_3$) for two days followed by dehydration with Ethanol and embedded in Methylmethacrylat. The tissue blocks were sectioned at 4-6µm (Polycut S 2500 Leica). Staining was performed with Goldner and Methylenblue. Light microscopy sections were examined on an AX70 Olympus-Microscope. For transmission electron microscopy (TEM) tissue samples were diced in one millimetre cubes. Samples were fixed separately from the outer to the inner (A-D) AF. They were fixed in 0,1 M Glutaraldehyd in Cacodylat buffer for twelve hours. The specimens were rinsed with Cacodylat buffer and post-fixed with Osmiumtetroxyd. Embedding was procedured in the routine manner with Araldit. Semithin (6µm) and ultrathin (0,90µm) sections were cut (Ultracut R Leica) and stained with Uranyl acetat and lead citrat (Reynolds). Sections on 200µm mesh grids were examined in a TEM 10 (Zeiss). Five cells of each time were studied.
Results: *Animal study group:* Changes could be realized after 6 hours, starting with swelling of the organelles and sometimes also with leaking in the cell membrane. At 24 hours swelling of the organelles and leaking of the membranes becomes worse. Osmiophilic cell detritus was identified in the disc tissue same time.
Patient study group: Within the first two weeks after trauma chondrocytes die by necrosis. Yet it is impossible to speculate about periods beyond the time frame used in our study. A change from necrosis to apoptosis within later periods after trauma leading to posttraumatic degeneration is currently being explored by our laboratory. In our patient group up to two weeks after trauma, no apoptotic bodies or any apoptotic changes were recognized. With our morphological investigations of the posttraumatic period we expect to clear the specific reaction of the chondrocytes in traumatic disc disorders. This might influence not only the clinical procedure but also may address forensic aspects.

P 8

A HISTOLOGICAL ANALYSIS OF THE EFFECTS OF PMMA AND CALCIUM PHOSPHATE CEMENT AFTER VERTEBROPLASTY IN THE GOAT SPINE

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Introduction: Percutaneous vertebroplasty is relatively safe and effective. Minimal data exist on the short- or longterm effects of

PMMA on the integrity of the endplate and disc therefore application in young patients is unwarranted. In this study, PMMA and calcium phosphate cement (CPC) are compared histologically in a goat vertebroplasty model.
Material & Methods: In twelve goats 24 defects, located cranially in L3 and L5, were created by transpedicular drilling and reaming. Twelve cavities were directly filled with PMMA or CPC; the others were filled with either cement after creating a defect in the cranial endplate allowing for direct communication between the nucleus pulposus and the cavity. Six goats were used as controls. Anteroposterior and lateral fluoroscopical images were obtained after surgery and after termination to assess disc height changes. Six months after surgery the vertebral bodies (VB) and cranial discs were harvested. After fixation, dehydration and PMMA-embedding the specimens were stained and sawed to five 10 micron slices for microscopical analysis. The degradation of the disc and endplate, new bone formation, inflammatory reaction and fibrous layer around the cement were scored semi-quantitatively.
Results: The surgery and recovery were uneventful. An estimated 0.5 ml of cement could be injected on average per VB (14% of VB volume). No degradation of the disc (0/36) or endplate (0/36) was found in any of the specimens. A fibrous layer was present in all PMMA specimens (12/12) but not in the CPC group (0/12) while new bone formation was found in 4 CPC VBs (4/12). A mild inflammatory reaction was found in 2 PMMA VBs (2/12). No obvious differences could be detected between the groups with and without a defect. The disc height at the time of surgery and termination did not differ.
Discussion: Contrary to the work by Osti and Moore, who established disc degeneration six months after damaging the anulus fibrosus in sheep, a defect in the endplate and injection of cement did not affect the disc or remaining endplate in our study. Our findings support the suggestion that an impressed endplate resulting from a fracture, is comparable to an intraosseous (Schmorl's) herniation and is not necessarily the precursor to disc degeneration.
Conclusion: No gross pathological changes were found in any of the discs, endplates or VBs. Both PMMA and CPC seem to be suitable bone void fillers for vertebroplasty.

P 9

IMPROVING BMSCS STIMULATED SPINAL FUSIONS BY EXPOSURE TO A RHBMP-6 CELL DERIVED MATRIX

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Introduction: The most commonly used graft material in spinal fusion is autogenous iliac crest bone graft (ICBG) with nonunion rates as high as 35%. For these reason, bone graft expanders/substitutes are being actively sought for clinical use. Our purpose is to evaluate the osteogenic capacity of bone marrow stromal cells (BMSCs) by exposing them to a rhBMP-6 cell derived matrix (ECM) in the New Zealand white (NZW) rabbit spinal fusion model.
Methods: 46 NZW rabbits underwent L5-L6 posterolateral fusion and assigned to four groups:

Group A- 2.5 cc/side of guanidine extracted demineralized bone matrix (gDBM).
Group B- 2.5 cc/side of ICBG.
Group C- 15M/side plastic/rhBMP-6 (+) ECM BMSCs and 2.5cc/side of gDBM.
Group D- 15M/side of plastic/rhBMP-6 (-) ECM BMSCs and 2.5cc/side of gDBM.
Group E- 15M/side of plastic/plastic exposed BMSCs and 2.5 cc/side of gDBM.

Cell preparation: 1-2 cc of bone marrow was harvested prior to the spine surgery from each femur; BMSCs were then isolated, plated and expanded in a plastic substratum for 14 days. For group C, cells were then exposed for 7 days to an ECM derived from the C3H10T1/2 cell line transduced with a retroviral vector containing the rhBMP-6 gene. In group D cells were exposed for 7 more days to the same ECM lacking transduction of rhBMP-6. For group E cells were replated over a plastic substratum for 7 days. Each animal received its own BMSCs. Animals were sacrificed at 6 weeks post-operatively. Specimens were assessed radiographically and by manual palpation.
Results: Radiographically, new bone growth was more abundant in groups B and C. Manual palpation: the fusion rate from group A (2/10; 20%) was inferior to group B (5/9; 55%). Group C had the highest fusion rate (10/13; 77%). Animals from groups D and E had a lower fusion rate (3/6; 50% and 4/8; 50% respectively).
Discussion: Our results suggests that exposing BMSCs to a rhBMP-6 (+) ECM increases the fusion rate by 50%, thereby improving the success rate of spinal arthrodesis without the need for supplemental bone graft. This technique seems to have potential clinical applicability in spinal fusion surgery as a graft substitute/expander.

P 10

I.D.E.T. CAN EQUALISE COMPRESSIVE STRESS DISTRIBUTIONS INSIDE DEGENERATED INTERVERTEBRAL DISCS

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Introduction: Intradiscal electrothermal therapy (IDET) is a minimally-invasive technique which has been reported to have some success in eliminating discogenic back pain (1). IDET may possibly function by affecting the material properties of, and stress distribution within, the target intervertebral disc. Stress concentrations in discs have been associated with pain (2). We present an update of a previous smaller study investigating the effects of IDET on the distribution of compressive stress within human lumbar intervertebral discs (3).
Methods: Eighteen cadaveric lumbar "motion segments" (aged 64-97 yrs) were stored at -17oC. Subsequently, each was equilibrated at 37oC. A miniature pressure transducer, side mounted in a 1.3mm diameter needle, was used to measure the distribution of compressive "stress" along the mid-sagittal diameter of each disc while it was compressed at 1.5 kN (4). IDET was performed, using bi-planar radiography to confirm placement of the heating element, and an independent thermocouple to measure temperature in the inner lateral annulus. Stress profilometry was repeated immediately after IDET.
Results: Before IDET, all discs exhibited stress concentrations typical of mild degeneration (4). Accurate placement of the element was confirmed in all discs. Temperatures in the inner lateral annulus during IDET reached only 40oC (STD 2.3o). Differences between stress measurements repeated before IDET never exceeded 8% (NS), and a sham IDET procedure produced no consistent changes. After IDET, peak stresses (above nucleus pressure) were reduced by more than 8% in 12/18 specimens (mean reduction 78%), increased in 2/18, and were unchanged in 4/18. Overall, IDET produced a significant reduction in peak stress ($p < 0.003$) but no significant change in nucleus pressure.
Discussion: Stress concentrations in the annulus of mildly degenerated discs were consistently reduced by IDET suggesting that IDET can cause disc material to resist compression in a more coherent fashion. Reducing annulus stress concentrations could conceivably reduce pain in some individuals. Neutral or contrary results in 6/18 discs may explain why IDET has variable clinical success (1).

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P 11

SURFACE ANTIGENE ANALYSIS OF ILIAC CREST AND VERTEBRAL ASPIRATE FOR DELIVERY OF STEM CELLS ON BONE CERAMICS

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Introduction: Most spinal techniques use iliac crest graft for fusion. In the last years the focus is changing from pure iliac crest graft to bone substitutes. However, current bone substitutes provide only osteoconductive, but not osteoinductive properties. Therefore in most cases, the bone substitute is mixed with blood aspirated from the iliac crest. This study is analyzing the cells gained from iliac crest aspirate and vertebral body aspirate using wide antibody screening of surface antigens to determine exactly the content of the iliac crest and vertebral body aspirate.
Materials and methods: In 6 cases blood was aspirated from the iliac crest and at least one vertebral body (bilateral transpedicular) during standard spinal surgery, as a control we used whole heparinized peripheral blood from a male healthy donor. Immunofluorescent staining of the aspirated cells was performed with a set of FITC labeled and PE-labeled monoclonal antibodies directed at specified cell surface antigens. In addition CD117 PE was used alone and not binding isotype antibodies (IgG1 FITC/IgG2aPE) were used as negative control. Flow cytometric analysis of stained cells was made on a FACScan (Becton Dickson) using the CellQuest software. Fluorescence excitation was elicited using a single argon laser at 488 nm.
Results: On average we received 7 mls of blood from the iliac crest and 2 mls from the vertebral body per pedicle accordingly. The analysis of the aspirates showed significant higher antigene designation count than the control, however no difference in the antigene designations, especially in CD34/38 (hematopoetic precursors/B-, T-cells, plasma cells) and CD 45/123 (hematopoetic cells, Leukocyte common antigen, Fibronectin type III/heparan sulphate proteoglycan, collagen type I) was found between iliac crest and vertebral aspirations.
Conclusion: Aspirate from the iliac crest and from the vertebral body have the same potency regarding haematopoetic cells and stem cells to act as osteoinductive additive in the implantation of Ca/P ceramics. However due to the limited aspirate of the vertebral body it is advisable to use both pedicles to receive a higher amount of aspirate. This technique can be used to gain potent stem cells for osteoinduction and avoid iliac crest morbidity.

P 12

EFFECT OF TITANIUM ALLOY PARTICLES ON EPIDURAL SCAR FORMATION

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Objective: To study the effect of titanium alloy particles on epidural scar formation. Method: Laminectomy was performed in lumbar 5 segment in 36 rabbits which were divided into 3 groups. 10mm x 5mm dura mater was exposed. Titanium alloy particles were put on the dura mater of Group A, stainless steel particles were put in Group B, Group C was a control group without any metal particles. The epidural tissues were observed grossly and histologically at 4, 8 and 12 weeks postoperatively. Classification and computed imaging analysis of epidural adhesion and scar formation were done at 8 weeks postoperatively.
Result: Obvious epidural adhesion was formed in all groups at 4 weeks postoperatively. The scar tissue was not mature and some fibroblasts could be seen. At 8 weeks, the scar tissue became mature and there was no obvious difference on the score of epidural adhesion grossly and histologically among three groups ($p>0.05$). But the computed imaging analysis shew that the epidural adhesion in Group B was more serious than Group A and Group C ($p<0.01$). And there was no obvious difference between Group A and Group C ($p>0.05$). At 12 weeks, the scar tissue was ossified and new vertebral laminae were formed.
Conclusion: The titanium alloy has good biocompatibility with epidural tissues and its particles have no effect on epidural adhesion and scar formation.
Key words: Titanium alloy; Particle; Dura Mater; Adhesion

BIOMECHANICAL

P 13

PEDICLE CLAW IMPROVES ANTERIOR INSTRUMENTATION STRENGTH - A BIOMECHANICAL STUDY

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Study Design. Biomechanical study comparing the lateral pullout strength of three different screw constructs used for anterior thoracic spine instrumentation.
Objectives. A novel suprapedicular claw construct for anterior thoracic spine was mechanically tested and compared to other accepted methods. The effects of vertebra dimensions and bone mineral density (BMD) on the pullout strength were also analyzed.
Background Data. Failure of the most superior or inferior screw is a recognized problem in anterior thoracic instrumentation. Several methods were suggested to prevent screw pullout such as a spiked washer placed on the contralateral side. This however, requires extended surgical dissection, and might mechanically not be as effective.
Methods. The T4-T9 vertebral bodies from six cadavers had the coronal vertebral diameter and BMD measured. The 36 specimens were block randomized for level and subject into three different instrumentation groups: an anterior bicortical 6mm diameter universal vertebral body screw (Synthes Spine) tested alone, screw in combination with spiked 13.5mm diameter washer placed opposite to the body, and screw in combination with a laminar hook used as suprapedicular claw on the same vertebra. Claw and screw were both fixed to a 6mm diameter titanium rod. A material testing machine displaced the rod with 0.4mm/sec. Ultimate fixation strength (UFS) and failure patterns were recorded. Multilinear models were used to assess the effects of instrumentation, BMD and coronal diameter onto the UFS.
Result. BMD, coronal diameter and instrumentation were all highly significant (regression: $p<0.0001$, $r2=0.886$) explaining UFS. Means for UFS adjusted for BMD and diameter were 1,244N, 631N, and 711N, for the claw, screw and screw with washer, respectively. The claw was significantly stronger (Bonferroni, $p<0.0001$) than screw alone, or screw with washer. The screw and screw with washer were no different ($p=0.88$). First order interac-

tion term for BMD and instrumentation was significant ($p<0.0001$), indicating that specimens with low BMD did not benefit as much from claw construct as the ones did with a normal BMD.
Conclusion. The claw almost doubled the construct's pullout strength. Adding a suprapedicular hook may avoid screw pullout in anterior spine surgery. Osteoporotic spines, however, may not benefit from a claw construct.

P 14

THE STRENGTH OF THE CERVICAL SPINE

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Introduction: Little is known about how the cervical spine resists the high complex loading to which it is often subjected in life. In this study, such loading was applied to cadaveric cervical motion segments in order to: measure their strength in forward and backwards bending, indicate which structures resist bending most strongly, and indicate how compressive injury influences the bending properties.
Methods: Ten human cervical spines aged 65-88yrs were obtained post-mortem, dissected into 14 motion segments, and stored at -20oC. Subsequently, motion segments were defrosted and secured in dental plaster for testing on a hydraulic materials testing machine. An optical motion capture system recorded specimen movement simultaneously. Specimens were loaded in 2.5sec in combined bending and compression to reach their elastic limit in flexion, and then extension. Experiments were repeated following creep loading, removal of spinous processes, removal of apophyseal joints, and vertebral body compressive damage.
Results: On average, full flexion was reached at an angle of 7.2° and a bending moment of 6.8Nm; full extension occurred at 9.2° and 9.0Nm. Creep loading reduced specimen height by 0.37mm, increased flexion by 1.5° ($P<0.01$) but had little effect on extension. After creep, resistance to flexion came from the spinous processes and related ligaments (46%), apophyseal joints (30%), and disc (24%). Resistance to extension came from spinous processes (23%), apophyseal joints (45%), and disc (32%). The compressive strength of disc-vertebral body specimens was 1.87kN (STD 0.63kN). Compressive damage reduced specimen height by 0.83mm (STD 0.29mm). This reduced the disc's resistance to flexion by 44% and extension by 18%.
Discussion: Cervical motion segments have approximately 20% of the bending strength of lumbar specimens of similar age, and most of the resistance comes from ligaments joining the spinous processes (in flexion) and from the apophyseal joints (in extension). These structures could be common sites of damage in severe bending (whiplash-type) injuries. Compressive strength data refer to the cervical disc-vertebral body unit; nevertheless, values are approximately 45% of those reported previously for intact lumbar motion segments of similar age. Evidently, the cervical spine is relatively stronger in compression than bending compared to the lumbar spine.

P 15

EFFECTS OF HEIGHT AND POSITION OF THE PRODISC PROSTHESIS ON THE MOTION BEHAVIOUR OF THE LUMBAR SPINE

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Replacing a degenerated disc by an implant that preserves the motion ability of the segment is gaining in importance. The Prodisc prosthesis is a semi-constraint implant and has a fixed centre of rotation which alters the natural motion of the affected segment. Little is known about the influence of implant height and position relative to the vertebral body on the mechanical behaviour of the lumbar spine. The aim of the study is to determine the effects of height and position of the Prodisc prosthesis on the motion behaviour of the lumbar spine. A three-dimensional, non-linear finite element model of the lumbar spine was created. All seven ligaments were included in the computer model. After removing the disc L3/4, the Prodisc prosthesis was integrated in the model in a neutral position. In parameter studies implant height and position of the disc in a-p direction were varied up to 2 mm. The model was loaded with a pure torsional moment of 7.5 Nm and a superimposed follower load of 250 N as well as with the body weight and muscle forces simulating standing, 15° extension, and 30° flexion of the upper body. Intersegmental rotations, intradiscal pressures, forces in the ligaments and the facet joints, and stresses in the different structures were calculated. Here only the effects on intersegmental rotation in the loading plane are presented. Intersegmental rotation at the affected level is significantly increased due to the Prodisc prosthesis during extension if the anterior longitudinal ligament is transected. Both, implant height and position influence the intersegmental angle at the concerned level. A more ventral position reduces this angle by about 1° while lordosis increases with increasing implant height. In our model, an implant which is 2 mm higher than a normal disc increases the intersegmental angle by 7.5°. However, the Prodisc prosthesis allows only an extension of 7°. Thus contact at the rim of the prosthesis and separation of the superior implant part from the polyethylene inlay may occur. Care should be taken to chose the correct implant height and to place the artificial disc in the position recommended by the manufacturer.

P 16

INCREASED NUCLEUS PULPOSUS SHIFTING IN DEGENERATED DISCS AS A LIKELY CAUSE OF SEGMENTAL INSTABILITY

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Introduction: Studying intradiscal deformation indirectly allows for understanding disc mechanics. Others have found the nucleus pulposus (NP) to shift opposite to the side of bending, and the annulus fibrosus (AF) to bulge maximum at the side of bending. Since fiber content increases with degeneration, NP shifting may decrease. Contrary, degenerated discs typically show higher annular laxity, hypermobility and perhaps instability. The objectives of this study were to assess the effect of degeneration on NP shifting and AF bulging.
Methods: Nine healthy and degenerated lumbar IVDs each were subjected to axial compression (1000N), extension, flexion, and left lateral bending (all 10Nm). IVDs were instrumented prior to testing with a fine 9x7 wire grid. Twenty-four small beads were glued to the disc's surface. Cranio-caudal radiographs at unloaded and loaded steps documented wire and bead positions. Relative displacements of the central NP, as well as of anterior, posterior, antero-lateral, postero-lateral and posterior annular regions were compared during all loading modalities among healthy and degenerated discs.
Results: The NP displaced to the opposite side of bending regardless of bending direction. In degenerated IVDs, the NP shifted significantly more ($p<0.007$) compared to healthy ones (1.08-1.70mm compared to 0.55-0.80mm). The highest NP shifts were found during lateral bending. Degeneration also significantly increased AF

bulging during compression ($p<0.0411$) in the posterior and postero-lateral regions (from 0.45-0.48mm to 0.63-0.75mm) and during extension and left lateral bending ($p<0.0001$) in all regions (from 0.67-0.92mm to 0.84-1.14mm).
Conclusions: A healthy NP is important for axial spinal load transfer and as pivot (instantaneous center of rotation) for segmental mobility. During bending loads, the NP of degenerated IVDs shifts is about double of that in healthy IVDs. Total shift can be considerable (e.g., 3.4mm from full left to right lateral bending). Annular bulging is equally increased in degenerated IVDs. Increased NP shifts may adversely affect the axis of vertical load transfer across degenerated IVDs, or may result in increased shifting of the pivot point for bending movements. Segmental instability in degenerated motion segments therefore may likely be explained by increased NP shifting.

P 17

INTERNAL STRAINS IN THE HEALTHY LUMBAR INTERVERTEBRAL DISC (ALSO SUBM. FOR BASIC AWARD)

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Introduction: Morphological signs of intervertebral disc (IVD) disruption are frequently seen in the posterior and postero-lateral inner annulus fibrosus. The regional IVD predisposition to disruption suggests that circumferential and radial tensile stresses and strains may also be region specific and may possibly initiate IVD disruption. The objectives of this study were to: (1) identify intradiscal circumferential and radial strain peaks during sub-maximal loads; (2) assess how bending loads modulate intradiscal strain patterns and how they might explain mechanical IVD failure.
Methods: Nine healthy lumbar IVDs (mean age 29 years) were tested; each with a 9x7 wire grid placed within, and 24 beads glued onto the circumference. Marker movements in the IVD's mid-transversal plane were followed in compression (1000 N), extension, flexion, and left lateral bending (each under 10 Nm with 500 N axial compression). Cranio-caudal radiographs at unloaded and loaded steps documented wire and bead positions and allowed for calculation of relative wire and bead displacements. Circumferential and radial strains in the annulus fibrosus (AF) and transitional zone (TZ) under load were compared among all anatomical locations.
Results: All circumferential strains were tensile regardless of anatomical location and loading modality and were less than 5%. Circumferential tensile strains decreased from the TZ to the AF. Circumferential and radial tensile strains were maximal at the side of bending (e.g., anteriorly during flexion). Compressive radial strains and decreased circumferential tensile strains were observed on the side opposite to bending (e.g., posteriorly during extension). Maximal radial tensile strains (on average 14.9%, in individual samples as high as 27.6%) were observed in the postero-lateral TZ and AF regions during extension and lateral bending.
Conclusions: This is the first experimental study to provide a two dimensional intradiscal strain map. The inner postero-lateral annulus fibrosus is subjected to maximal circumferential and radial tensile strains during extension and lateral bending. The annulus fibrosus may ultimately fail due to its inability to resist radial tensile stresses, since the lamellar structure can not well resist strain acting perpendicular to its main fiber direction. The nuclear hydrostatic pressure present in healthy discs appears crucial in preventing excessive radial tensile strains.

P 18

THE DISTRIBUTION OF COMPRESSIVE STRESS INSIDE HUMAN CERVICAL INTERVERTEBRAL DISCS

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Introduction: Recent studies report extensive anatomical differences between cervical and lumbar discs, including annulus structure, and texture of the nucleus. We investigated the internal mechanical functioning of cervical intervertebral discs using "stress profilometery" to see if they differ fundamentally from lumbar discs.
Methods: Eight human cadaveric cervical motion segments aged 49;77yrs were stored at -17°C. Subsequently, they were defrosted, secured in cups of dental stone and loaded on a hydraulic materials testing machine (DartecLtd., U.K). An initial creep test was performed to bring disc hydration within the physiological range. Specimens were then subjected to a static compressive load of 200N for 20sec, while the distribution of compressive "stress" was recorded along the posterior;anterior diameter of the disc using a pressure transducer side; mounted in a 0.9mm diameter needle (Gaeltec, Scotland). Stress profiles were repeated with the transducer pointing horizontally and vertically, and with the specimen in simulated neutral, flexed and extended postures. Nucleus pressure was also recorded as a function of applied load. Discs were dissected, and degeneration assessed macroscopically on a scale of 1 to 4.
Results: C2/3 discs exhibited a stress gradient across their entire posterior-anterior diameter. Gradients depended on disc degeneration and flexion/extension angle. Nevertheless, vertical and horizontal "stresses" were equal to each other in the central region of these discs. C6/7 discs exhibited a central hydrostatic region in which "stress" did not vary with direction or location, even when the disc was flexed or extended. Localised stress peaks were observed in the annulus, but in the posterior annulus they were smaller than those reported previously in lumbar discs. Transducer output from the middle of all discs was proportional to applied load ($r2>0.99$).
Discussion: Stress distributions in C6/7 discs resembled those in lumbar discs. However, C2/3 discs showed unusual mechanical characteristics in the nucleus pulposus, which may be attributable to their more fibrous texture compared to lumbar discs of similar age. The nucleus of C2/3 discs appeared able to equalise stress in different orientations, but not over large distances. The absence of high stress peaks in the posterior annulus of C2/3 discs may reflect their small radial diameter.

P 19

BIOMECHANICAL COMPARISON OF EXPANDABLE CAGES FOR VERTEBRAL BODY REPLACEMENT IN THE CERVICAL SPINE

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Introduction: Recently, expandable cages for vertebral body replacement in the cervical spine have been developed. Purpose of this study was to compare the biomechanical properties of expandable cages with a tricortical iliac crest graft and a non-expandable cage.

Material and Methods: 40 human cervical spines (C3 to C5) were tested in flexion, extension, axial rotation, and lateral bending. First all motion segments were evaluated intact. After corporectomy of C4 the following stabilisation techniques were used (n=8/group): (1) autologous iliac crest bone graft (2) meshed titanium cage (Harms, DePuy Acromed) (3) anterior distraction device (ADD, Ulrich) (4) Synex-C titanium (Synthes) (5) Synex-C PEEK (Synthes). Additionally, anterior plating (CSLP, Synthes) and anterior plating plus posterior screw-rod fixation (Cervifix, Synthes) were applied. Stiffness, range of motion, neutral and elastic zones were determined.
Results: In comparison to the intact motion segment all implants significantly increased stiffness in flexion and bending, but decreased stiffness in extension. There were no biomechanical differences between the non-expandable cage and the expandable cages. Further, there were no biomechanical differences between the tricortical iliac crest graft and the cages, except for Synex-C in rotation. Additional anterior plating significantly increased biomechanical stiffness in all test modes. Especially in rotation combined anterior-posterior stabilisation increased stiffness up to 102% compared to anterior plating alone.
Conclusion: In comparison to a tricortical iliac crest bone graft and a non-expandable cage, expandable cages have no biomechanical advantages. Due to the low extension and rotational stiffness none of the implants can be recommended as a "stand alone" device. Additional anterior plating increased biomechanical stability adequately. Therefore, a additive posterior stabilisation should only be considered in severe rotational instability of the cervical spine.

P 20

SHOCK ABSORPTION CAPACITY OF TWO DIFFERENT TOTAL LUMBAR DISC ARTHROPLASTY: METAL/POLYETHYLEN AND METAL/METAL

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Study Design. Vibration and shock loading were applied to two lumbar total disc prostheses - Pro-Disc, manufactured by Spine Solutions, and Maverick TDR (total disc replacement), manufactured by Medtronic Sofamor Danek. The shock absorption capacity of the device was evaluated by comparing the input and the output force measurements. Objectives. To establish whether there was a difference in the shock-absorption capacity between a device having an UHMWPE (high density polyethylen) center core and a device having a metal-on-metal bearing.
Background Data. Lumbar disc prosthesis have been used in treating symptomatic degenerative disc diseases. A few prosthesis of ball-socket design are currently available for clinical use, the joint mechanism being materialized either with a hard polymer core or a metal to metal couple. Other prosthesis of "shock absorber" design were not available at the time of the study.
Materials and Methods. Two types of total lumbar disc prostheses (MAVERICK TDR and PRODISC) were used in this study. The disc prosthesis was mounted onto a test apparatus. Each side of the device was equipped with a force sensor. The input shock load and the output resulting forces were simultaneously measured and recorded. The loading force pattern included 1) a static pre-load of 350N plus an oscillating vibration of 100N with frequency sweeping from 0Hz to 100Hz, 2) a sudden shock load of 250N, applied over a 0.1 second interval. Both input and output signal data were processed and were transformed into their frequency spectrums. The vibration and shock transmissibility of the device, defined as the ratio of the output spectrum over the input spectrum, were calculated in sweeping the frequency from 0 Hz to 100Hz. The phase deviation was calculated to characterize the shock absorber effects.
Results. For both tested devices under vibration and shock loading, the phase angle displacement between the input and the output signals was less than 10°. Under oscillating vibration loading, both tested devices had a transmission ratio higher than 99.8%. Over the frequency interval 1Hz to 100Hz, the difference in transmission ratio between the two devices was less than 0.3% (+/- 0,1). Under sudden shock loading, both tested devices had a transmission ratio higher than 98%. The difference between the two devices was less than 0.8% (+/- 0,1).
Conclusion. Both tested devices have identical vibration and shock transmissibility.

P 21

THE BIOMECHANICAL EFFECTS OF AN EXTERNAL VEST FOR REDUCTION OF LUMBAR INTRADISCAL PRESSURE

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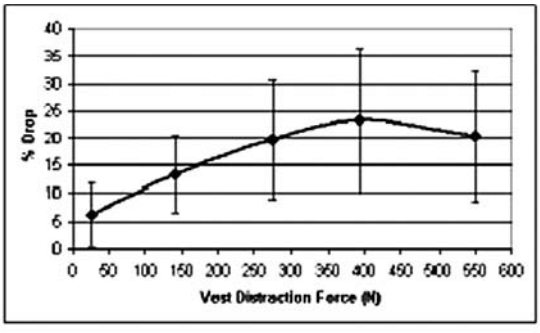
Purpose: The purpose of this study is to measure internal disc pressure at L4/L5 in response to forces exerted by an external bracing device.
Methods: Isolated cadaveric torsos were obtained from an approved tissue source. Six torsos were obtained (1 female, 5 male) with an age range of 65 ± 6 years. A microscopic pressure sensor (Samba, Gothenburg, Sweden) was placed into the nucleus of the L4/L5 disc using a 15 gage spinal needle under fluoroscopic imaging. The pressure sensor is 0.42mm in diameter, and has a calibrated range of 0-7500 mmHg. Once the sensor was in place in the nucleus, a pneumatically actuated lumbar vest was fit snugly to the torso ("Orthotrac", Orthofix Inc., McKinney Texas). The vest was inflated while the internal disc pressure was monitored and recorded. The torso was placed in a standing position during testing. The data was analyzed to test for correlations between the amount of distractive force provided by the vest and the intradiscal pressure measured in vitro.
Results: The results demonstrated a maximum reduction of internal disc pressure at L4/L5 of 23% when the vest was inflated to a level corresponding to about 400N of distractive force. The reduction in disc pressure was significantly different compared to baseline (standing pressure without the brace) for all distraction settings ($p<.01$) except for the very lowest setting which was significant only at $p=.025$.
Discussion: The application of lumbosacral-type braces is thought to assist patients with low back pain by the unloading of the spine through increased abdominal pressure. This study directly measured spinal unloading in the intervertebral disc in response to an applied distractive force provided by an external vest to the lumbar spine. The study hypothesis is that an observed decrease in pressure within the L4/5 disc correlates with an unloading of the lumbar spine provided by the external vest.



% Drop in Disc Pressure (± st. dev.) vs. Vest Distraction Force

P 22

STUDIES OF THE EFFECT OF HYPEREXTENSION ON THE DISC USING STADIOMETRY AND MRI

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Introduction: The normal diurnal decrease in spine height is increased under occupational exposures. We conducted an in vivo study to see how hyperextension after loading affects the spine using stadiometry and MRI.
Methods: We tested 10 male subjects, aged 23-30 and no LBP history. After lying supine, they were loaded with 5 Kg on each shoulder for 5 min. The hyperextension lasted for 10 min. via an inflatable cushion. Height changes were measured using a stadiometer. On another day, MRI was used to ascertain segmental changes.
Results: The stadiometer showed that height gained was almost the same as the height lost during the sitting posture before hyperextension. The height gained during hyperextension was greater than the height lost before hyperextension for most subjects. The height gain after 10 min. of hyperextension differed between individuals but everybody gained height. The values varied from 2.7 to 7.7 mm. The MRI images of the lumbar spine were used to measure the length of the spine from S1/L5 to T12/11. Nine out of ten subjects gained height during the 10 minutes of hyperextension. Half of them gained 2 mm, three others gained 3 mm, one gained 4 mm while just lost 2 mm. The mean gain in height was 2.1 mm, while the standard deviation (mostly due to the subject who lost height) was 1.57 mm. Images of the spine during a hyperextended posture showed that the lumbar curvature increased. Also the anterior height of each disc has increased while the posterior height decreased, when compared with the dimensions of the disc with the spine in neutral angle before the hyperextension intervention.
Discussion: All subjects lost height during sitting, as it was expected, since when a person is sitting the lumbar lordosis tends to flatten, so the intradiscal pressure rises, resulting to fluid transport out of the intervertebral disc. Most of the height is lost during the first minute. Both methods demonstrated a recovery of height due to hyperextension. Hyperextension should be considered as a prophylaxis against the height loss in occupational loading.

P 23

GEOMETRICAL AND MECHANICAL ANALYZE OF LUMBAR LORDOSIS IN AN ASYMPTOMATIC POPULATION. CLASSIFICATION PROPOSAL

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Purpose of the study: The main objective of this study is to describe the morphology and the mechanism of organization of the lumbar lordosis regarding the both position and shape of the pelvis. According to the orientation of the sacral plate, a classification of the lumbar lordosis is proposed.
Material and methods: 160 asymptomatic, young adult volunteers were X-rayed in a standardized standing position. Analyze of the spine and pelvis was performed with the SagittalSpine® software. The pelvic parameters were: pelvic incidence, sacral slope, pelvis tilt. The point where thoracic kyphosis and lumbar lordosis were divided, was named the inflexion point. The lumbar lordosis was bounded by the sacral plate and the inflexion point. At the apex, the lumbar curve was divided in two tangent arcs of circle, quantified by an angle and the number of included vertebrae. The lower one was geometrically equal to the sacral slope. Regarding the vertical line, a lordosis tilt angle was designed between the inflexion point and the frontal limit of the sacral plate.
Results: The value of the lumbar lordosis was very variable. The best correlation was between lumbar lordosis and sacral slope, then between sacral slope and pelvic incidence. The upper arc of a circle remained constant, when the lower one changed with the sacral slope. There were good correlations of the sacral slope with the position of the apex, and with the lordosis tilt angle.
Discussion and Conclusion: Regarding the sacral slope, the lumbar lordosis can be classified in four types. When the sacral slope is low, the lumbar lordosis can be either both short and curved with a low apex and a backward tilt (type 1), or both long and flat with a higher position of apex (type 2). When the sacral slope increases, lumbar lordosis increases in angle and number of vertebrae with an upper apex, and it tilts progressively forward (type 3and 4). Depending of the both shape and position of the pelvis, because of the relation between sacral slope and pelvic incidence, the morphology of the lumbar lordosis could be the main mechanical cause of lumbar degenerative diseases.

P 24

BIOMECHANICAL COMPARISON OF KYPHOPLASTY WITH DIFFERENT BONE CEMENTS

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Purpose: To compare the compressive properties of vertebral bodies (VBs) filled with PMMA (Simplex P; Stryker-Howmedica-Osteonics, Allentown, NJ) to those filled with a tricalcium phosphate cement (Biopex; Mitsubishi Materials Corp., Tokyo, Japan) after kyphoplasty.
Methods: Twenty four vertebral bodies were harvested from three osteoporotic female cadaver spines (mean DEXA t-score, -3.97 ± 0.54). The VBs (T6-T9, L2-L5) were assigned to one of two groups: K-S (kyphoplasty with Simplex P) or K-B (kyphoplasty with Biopex. Each VB was compressed 25% of its average height and initial VB strength and stiffness measured. A void was created in each VB using the kyphoplasty technique under fluoroscopic guidance and then was filled with the appropriate cement. The VBs in the K-S group were injected with Simplex P mixed as directed by the manufacturer. In the K-B group, each VB was injected with Biopex at the powder/liquid ratio of 3.0 g/mL. After injection, all VBs were floated for 24 hours in a saline bath (37°C) to allow complete polymerization or curing of the cements. Each VB was then recompressed according to the initial protocol. Posttreatment strength and stiffness were measured.
Results: In the thoracic region, mean (±SEM) posttreatment strength (3233±228 N) in the K-S group was significantly greater than in the K-B group (1560±228 N). There was no significant difference in posttreatment strength between K-S (2487±244 N) and K-B groups (1890±244 N) in the lumbar region. There was no significant difference in repaired stiffness of VBs in the thoracic (825±131 N/mm, 389±131 N/mm) or lumbar (463±111 N/mm, 337± 111 N/mm) regions between K-S and K-B groups, respectively.
Discussion: Kyphoplasty with Biopex restored strength but not stiffness. Kyphoplasty with Simplex P increased strength and restored stiffness in the thoracic region, but not the lumbar region. It remains unknown what support must be provided by the cement to result in satisfactory stabilization and pain relief clinically after kyphoplasty, however, the results of the current study suggest that if kyphoplasty with Simplex P provides sufficient mechanical support to the treated VBs, kyphoplasty with Biopex may result in similar mechanical support. This hypothesis needs to be tested clinically.

P 25

OSTEOGENIC PROTEIN-1 (RHBMP-7) INDUCED IN VIVO STABILIZATION OF HYDROXYAPATITE-CEMENT ENABLES BIOINTEGRATION IN LUMBAR INTERBODY FUSION. A CONTROLLED, RANDOMIZED STUDY IN THE SHEEP SPINE

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Introduction: Transpedicular lumbar interbody fusion is theoretically convincing for minimal invasiveness. Clinically, this technique fails due to the inferior stability of the autograft against axial compression leading to a significant loss of correction during follow-up. Substitution of the autograft with hydroxyapatite-cements that feature primary stability against compressive forces was not successful, either. Since these methods cannot withstand inherent shear and bending forces, cement fracture and subsequent fragmentation will occur with debris resorbtion.
The study objective was to evaluate early OP-1-induced osseous stabilization with hydroxyapatite-cement that may prevent fragmentation and resorbtion thereby enabling cement integration and spinal fusion. For this reason, an injectable composite of hydroxyapatite and microencapsulated OP-1 was developed.
Methods: Endpoints of this controlled, randomized, prospective study were total residual cement and interbody fusion rate at 8 weeks. In 14 sheep, L4/L6 had posterior instrumentation, intervertebral disc L4/L5 was removed under transpedicular endoscopic control, and endplates L4/L5 were decorticated. The defect was augmented transpedicularly with the composite (HA-OP-1) in 7 animals. The remaining 7 animals were treated with the hydroxyapatite cement without OP-1 (HA). Following euthanasia, the ratio between total volume of cement leftover (V8weeks) and total volume of cement initially applied (V0weeks) was measured by means of CT-assisted volumetry. Fusion rates were evaluated radiologically (plain X-ray and CT).
Results: V8weeks/V0weeks was significantly higher in the HA-OP-1 group ($p=0.007$, Wilcoxon test): 79.9 ± 13.8% (HA-OP-1) versus 54.0% ± 6.8% (HA). Radiomorphologic evaluation of the HA group revealed gross fragmentation of the formerly solid cement mass, especially within the interbody space along with loss of contact at the bone-cement interface. In contrast, cement masses in the HA-OP-1 group remained solid. Radiographic fusion rate was 71% in the HA-OP-1 group versus 0% in the HA group ($p= 0.002$).
Conclusion: Biointegration of an osteoconductive carrier without OP-1 does not occur, since shear and bending forces cause early cement fracture with subsequent fragmentation and gross resorbtion. In contrast, OP-1 enables early callus sheathing and in vivo composite stabilization resulting in full osseous integration and spinal fusion. Autograft associated morbidity and of the additional anterior surgical approach are avoided.

P 26

COUPLING MOTIONS OF THE UPPER CERVICAL SPINE IN ROTATION: IN VIVO THREE-DIMENSIONS ANALYSIS USING 3-D MRI

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Purpose: The *in vivo* three-dimensional motions of the cervical spine have so far remained largely unexplored. We have developed a quite unique motion analysis system and succeeded in disclosing the *in vivo* three-dimensional motions of the upper cervical spine in rotation. The purpose of this study is to accurately demonstrate for the first time *in vivo* coupling motions of the upper cervical spine.
Methods. Three-dimensional MR images of the upper cervical spine were taken for 15 healthy volunteers with a 1.0-T imager in progressive 15° steps of head rotation. The segmented three-dimensional MR image of each vertebra on the neutral position was superimposed over the image on each position using voxel-based registration, which is a method to determine relative position between images by using a corresponding method based on correlation of voxel values, and correlation coefficient was used as similarity measure. The relative motions between the occiput (Oc) and atlas (C1) and between C_and the axis (C2) were measured and described with six freedoms by the rigid body Euler angles and translations on the coordinate system according to Panjabi.
Results. The averaged axial rotation angle was 1.7° between Oc and C1, and 36.3° between C1 and C2 in maximum head rotation. Coupled lateral bending with axial rotation was observed in the direction opposite to that of axial rotation at Oc-C1 (4.1°) and C1-C2 (3.8°). Coupled extension with axial rotation occurred both at Oc-C1 (13.4°) and C1-C2 (6.8°).
Discussion: Kinematics of the upper cervical spine has been mainly investigated by *in vitro* studies with a cadaver specimen. However, the lack of physiological tonus of musculatures makes the results of *in vitro* study impractical. An *in vivo* study reported using bi-planar radiographs is an unreliable method due to too much observer's bias in tracking bony landmarks on plain radiographs. To describe the accurate three-dimensional motions of the spine, we developed a non-invasive motion analysis system using the voxel-based registration, which has the least examiner's bias. *In vivo* coupled motions of the upper cervical spine investigated with this system well agreed with the results of the previous *in vitro* study.

P 27

KINEMATICS OF THE SUBAXIAL CERVICAL SPINE IN HEAD ROTATION: IN VIVO THREE-DIMENSIONAL ANALYSIS USING 3-D MRI

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Purpose: Although a large number of kinematics studies about the normal cervical spine have been reported, no previous study has accurately elucidated the in-vivo three-dimensional(3-D) motions of the cervical spine during head rotation. We developed a unique 3-D motion analysis system, and have already reported the in-vivo 3-D coupled motions of the upper cervical spine during head rotation. The purpose of this study is to precisely demonstrate in-vivo 3-D coupled motions of subaxial cervical spine in head rotation.
Methods: Three-dimensional images of the cervical spine of 10 healthy volunteers were taken in a 1.0-T imager from neutral position to maximum rotation in 15° steps. Relative position between the segmented 3-D MR images of adjacent vertebrae was measured on the anatomic orthogonal coordinate system defined by Panjabi et al. using voxel-based registration. Three-dimensional motions were represented with six freedoms by the rigid body Euler angles and translations.
Results: The average axial rotation angle from neutral to maximum rotation was 1.8 degrees at C2/3, 3.9 degrees at C3/4, 4.0 degrees at C4/5, 3.7 degrees at C5/6, 2.3 degrees at C6/7, and 1.5 degrees at C7/T1; both cranial and caudal ends of subaxial cervical spine had less axial rotation. Coupled extension with axial rotation

was observed at upper levels (C2/3, C3/4, C4/5), but coupled flexion was found at lower levels (C5/6, C6/7, C7/T1). Coupled lateral bending with axial rotation was observed in the same direction as head rotation at all levels.
Discussion: The motion of subaxial cervical spine in axial rotation consists of complicated coupled motion, which would be very difficult to analyze with conventional images such as plain radiographs or computed tomography. Therefore kinematics of this region has been mainly investigated using cadaveric specimens. However, in-vitro studies do not provide physiological motions with no musculature around specimens. Our analysis system presented here could demonstrate in-vivo 3-D coupled motion of subaxial cervical spine during head rotation. The results were very precise and reproducible, and compatible with the previous in-vitro studies.

CERVICAL SPINE

P 28

SURGICAL MANAGEMENT OF CERVICAL SPINAL MYELOPATHY

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Purpose: To correlate cord atrophy (CA) and high intensity signal (HIS) on MRI with symptoms, cervical spine compressive lesions (CSM) and response to surgery.
Material & Methods: Fifty-nine patients with cervical myelopathy (including two with asymptomatic HIS) were treated and assessed at two university hospitals over a 5 year period. Minimum follow-up period was 12 months. Forty-nine were available for assessment. The average age was 60 (range 12-82). Surgery consisted: a) of anterior decompression by means of corpectomy, excision of posterior longitudinal ligament, bone graft and plating fixation (24 pts), b) laminectomy and lateral mass plate fixation (6 pts) combination of (a) and (b) (15 pts), and laminoplasty (4 pts).
Results: HIS was observed in 29/49 patients (59.1%) and CA in 32/49 (63.3%). In 2 patients HIS remained asymptomatic. Surgical outcomes: Laminectomy; 30% improved and with further anterior decompression improvement reached 80%. Laminoplasty; 25% improved (1/4). Anterior decompression; 22% failed to improve. Combined anterior and posterior decompression; 100% improved. There was no worsening of neurological status with surgery.
Conclusion: CA and HIS are not always associated with clinical manifestations. CSM reflects the extent of cord compression and was always associated with cord pathology. The incidence of CA and HIS in myelopathy patients was 63.3% and 59.1% respectively. HIS was associated with cervical spine pathology, but was not always correlated with static compression, CA and surgical outcomes. A combination of anterior and posterior decompression yields best surgical outcome.

P 29

MOTOR PARALYSIS IN THE UPPER EXTREMITIES AFTER DECOMPRESSION FOR CERVICAL MYELOPATHY

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Objective: Motor paralysis in the upper extremities that mainly involves C5 segment is occasionally seen in patients after decompression for cervical myelopathy. Purpose of this study is to elucidate the mechanism and to propose the involvement of the spinal cord as a possible mechanism.
Materials and methods: A retrospective review of patients who underwent decompression for cervical myelopathy between 1996 and 2000 was performed. Among 301 patients, 16 (5.4%) had postoperative motor paralysis. The average age of the 16 patients at the time of surgery was 63 years. The cause of spinal cord compression was cervical spondylosis in 12 patients, OPLL in 3 patients and disc hernia in 1 patient. Anterior decompression was performed in 8 patients and posterior decompression in 8 patients. The minimum follow-up period was 24 months. The clinical features and MRI findings were investigated.
Results: Levels of paralysis were C5 in 10 patients, C6 in 1 patient, C5-6 in 3 patients, and C5-7 in 2 patients. Seven of 16 patients experienced paralysis on both sides. Paralysis developed after an average of 5 days (1- 17). Twelve of the 16 patients (75%) had motor weakness in the upper extremities preoperatively. Seven of these 12 patients experienced postoperative deterioration. Twelve of the 16 patients newly developed postoperative motor paralysis. Three patients experienced both of the deteriorated preoperative paralysis and the newly developed postoperative motor paralysis. Recovery of paralysis was full in 13 patients, partial in 2 patients and unchanged in 1 patient. The levels of the preoperative spinal cord lesion (compression or T2 high-signal intensity area) corresponded well with the levels of postoperatively paralyzed segments in 13 of the 16 patients (81%).
Discussion: Motor paralysis in the upper extremities has been believed that nerve root lesions caused by technical immaturity or tethering effect induced by excessive posterior shift of the spinal cord after posterior decompression. However, our results suggest that the nerve root injury alone cannot fully explain the cause of the paralysis.
Conclusions: Pathology in the spinal cord rather than the nerve root plays an important role in the deterioration and the development of motor paralysis.

P 30

COMPARISON OF INTERVERTEBRAL FUSION RESULTS USING BIOCERAMIC IMPLANTS AFTER ONE AND TWO LEVEL ANTERIOR CERVICAL DISCECTOMY.

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Introduction: Hydroxyapatite [Ca10(PO4)6(OH)2] bioceramic replacements facilitate a good intervertebral fusion after ACD by the process of osteoconduction directly at the bone-implant interface, as well as around the implant. Due to their satisfactory mechanical properties they fulfil also other requirements, i.e. intervertebral and foraminal space height reconstruction, cervical lordosis restoration, and postoperative kyphosis prevention.
Material and Methods: We evaluated intervertebral fusion after ACD using Smith-Robinson technique and bioceramic replacement without titan plate fixation in 76 patients. All patients used rigid collar for 4 weeks after surgery. One-level discectomy was performed in 49 patients and two-level discectomy was accomplished in 27 patients. We used a total of 103 bioceramic implants. The fusion was evaluated one year after surgery using the following criteria for successful fusion:

1. absence of a radiolucent halo formation around implant
2. absence of a movement on dynamic X-rays

Results: We observed a good fusion in 91 segments (88,4%) from the total of 103. In 12 levels (11.6%) we detected a radiolucent zone around the implant together with instability (pseudoarthrosis). However, there were no clinical implications or correlation in this group of patients.

Pseudoarthosis was observed in 4 patients after one-level discectomy and in 8 segments after two-level discectomy, where 6 patients had solid fusion present in the other segment, and in 1 patient there was pseudoarthrosis present in both segments. A good solid fusion was more likely accomplished after one-level discectomy (91.8% of segments) as compared to the two-level discectomy (85.2% of segments).
Conclusion: We found that the presence of pseudoarthrosis on one year follow-up assessment was higher in our group of patients compared to published results of other authors using similar hydroxyapatite replacements. It will be important to follow these patients for longer time after surgery. A collapse of bioceramic replacement was recorded in 5 cases, however with solid fusion on one-year follow-up. We ascribe this to the physical properties of bioceramic replacements, which are strong and hard, but also rather fragile. When comparing the rate of fusion after one-level and two-level ACDs, we found that the rate of pseudoarthrosis emergence was 6.7% higher after two-level interventions.

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MORPHOLOGIC ANALYSIS OF THE EXTENT OF CERVICAL NEUROFORAMINAL DECOMPRESSION BY THREE DIMENSIONAL CT RECONSTRUCTIVE TECHNIQUE AND SURGICAL VIDEO

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Although several surgical techniques for anterior cervical foraminotomy have been developed, no definite surgical technique has documented a critical extent of uncovertebral resection completing neuroforaminal decompression and avoidance of vertebral artery injury. Author designed a microsurgical technique to promote safety and efficacy of cervical neuroforaminal decompression. The aim of the present study was to localize a critical point of the resection of an uncovertebral joint by the morphologic analysis using three-dimensional CT reconstructive technique and surgical video for anterior cervical neuroforaminal decompression.
Sixty patients who underwent operations for cervical radiculopathy were classified into four groups according to surgical methods. There were four treatment groups: group 1. transuncopedicular foraminotomy and anterior interbody fusion(N=20); group 2. microsurgical anterior cervical foraminotomy(N=10); group 3. anterior cervical discectomy and interbody fusion(N=20); group 4. anterior cervical discectomy(N=10). Cervical neuroforamen was imaged in three dimensional CT reconstructive views. Comparative analysis of the preoperative and postoperative foraminal dimension and height based on the narrowest foraminal section elucidating by two and three dimensional CT reconstructive study was conducted not only for evaluating the efficacy of uncovertebral resection but also for verifying statistic significance. The critical point completing uncovertebral resection for the neuroforaminal decompression was established by comparative analysis of surgical video and three dimensional CT reconstructive image. The percentage increment of foraminal dimension and height measured 138.8%, 42.2% in group 1; 85.2%, 8.0% in group 2; 31.1%, 9.5% in group 3; 1.3%, 1.3% in group 4. The narrowest foraminal section was identified at the oblique sagittal section through the top of the pedicles. Uncopediculotomy and interbody distraction revealed contributing effect of foraminal decompression about 85% and 31% respectively. Statistic significance for the percentage increment of foraminal height and dimension between all groups were accepted. The critical points of complete uncovertebral resection for the cervical neuroforaminal decompression were the superior portion of the pedicle and the transitional zone between posterior longitudinal ligament and epivascular and periradicular sheath. Transuncopedicular foraminotomy and anterior interbody fusion is more effective surgery for cervical neuroforaminal decompression in comparison to the others.

P 32

COMPLICATIONS OF PEDICLE SCREW FIXATION OF THE CERVICAL SPINE

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Objective: Dorsal stabilisation of cervical spine is done most frequently using lateral mass screws. This technique does not provide sufficient stability in all cases, so often an anterior fusion is added. Our aim is, to prove whether a cervical pedicle screw insertion is possible with low risk and to work out risk factors..
Methods: All patients, who were stabilised by cervical pedicle screw fixation from the year 2000 to 2002 were included in this prospective study. Indication for instrumentation were degenerative instability with cervical myelopathy in 11 patients, rheumatoid arthritis in 4 cases and trauma in 5. In most cases additional decompression and bony fusion was performed. Pre and postoperatively there was done a CT-scan (2mm cuts) and plain X-rays. Furthermore the clinical outcome was examined in all cases.
Results: In 25 patients there were 90 pedicle screws implanted in the cervical spine. Most sites were C3 with 26 pedicle screws and C4 with 17 pedicle screws. Radiologically 63 screws or 70% showed a correct placement in the pedicle (Maximal breach 1 mm). Further 19 screws or 21% showed an obviously displacement of screws with reduction of mechanical strength, slightly narrowing the channel of the vertebral artery (<50%) or affecting the lateral recess slightly without compression of neural structures. These malplacements were all without signs and symptoms. Eight more screws or 9% had a critical breach. 4 of them showed a narrowing of the vertebral channel of more then 50%, in all cases without vascular problems. Three screws passed through the intervertebral foramen, in one case with temporary progress of paresis and in an other with new sensory loss. In this patient there was done a revision surgery: The screw was loosened and had to be corrected. The most significant risk factor was the level of surgery: All critical breaches were from C3 to C5. Furthermore an percutaneously assisted application of the screws showed a significant reduction of risk for malplacement. Only a little influence showed the use of neuronavigation and the learning curve of the surgeon.
Conclusion: Instrumentation with cervical pedicle screws is very stable. But even by use of new techniques like percutaneously assisted application of the screws or neuronavigation there is a little risk for damaging nerve roots or the vertebral artery. So this technique should be reserved for selected circumstances with clear indications.

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SOMATOSENSORY AND MOTOR EVOKED POTENTIALS IN SPONDYLOTIC CERVICAL MYELOPATHY AFTER ANTERIOR-POSTERIOR DECOMPRESSION

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Introduction: Somatosensory and motor evoked potentials (SEPs, MEPs) are widely used in CSM for early detection of spinal cord involvement. However, there are controversial reports in predicting and monitoring the effect of surgical therapy. The aim of the study was to evaluate clinical and electrophysiological findings before and after combined anterior-posterior decompression.

Methods: Eighteen patients (16 men, 2 women, mean age 52,6 yrs) with radiological evidence of absolute multilevel spinal stenosis and clinical signs of cervical myelopathy were surgically treated in two stages with 2-4 months interval. Disectomies, uncusosteophytectomies and foraminotomies were performed from anterior approach followed by tricortical graft spondylodesis and titan plate stabilization. Posterior approach included open-door laminoplasty at 3 to 5 levels. Somatosensory and motor evoked potentials (SEPs and MEPs) were performed before the operation, after the operation and one year later. JOA score was used to measure clinical outcome.
Results: All patients had at least one abnormal results of SEPs and/or MEPs before the operation. Eleven patients clinically improved, 6 patients remained unchanged and one patient deteriorated. Slight functional motor improvement accompanied by an increase of central motor conduction time occurred in 6 patients one year after surgery. No significant changes concerning SEPs and MEPs were observed in 9 patients. Three patients showed slight prolongation of central motor and somatosensory conduction without a clinical correlate.
Conclusions: Long-term monitoring of SEPs and MEPs for assessment of surgical therapy seems to be of a limited importance. However, improved central motor conduction time was correlated with good surgical outcome one year after anterior-posterior decompression.

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EXPANSIVE MIDLINE T-SAW LAMINOPLASTY WITH CORAL BONE SPACERS FOR THE MANAGEMENT OF MULTILEVEL SPONDYLOTIC MYELOPATHY. CLINICAL OUTCOME, COMPLICATIONS, CT-SCAN AND MRI EVOLUTIVE STUDY

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Hypothesis: To evaluate the clinical outcome and complications of expansive midline T-saw laminoplasty in patients with multilevel spondylotic myelopathy. Cervical spine was monitored through CT-scan and MRI studies during follow-up with a maximun of 4 years. This series comprises only European population where the results of this techniques are not well known.
Methods: A total of 24 patients with spondylotic myelopathy were operated on according to the technique described by Kurokawa in 1982. Spinous process splitting was performed using a T-saw and coral bone trapezoid spacers (15 to 20 mm) were use to maintain the canal expansion. All patients had multilevel cord compression at least in three intervertebral discs. None had either cervical kyphotic deformity or segmental instability. CT-scan and MRI studies were performed every 6 months after surgery. Measures included cord compression index, sagittal and transverse diameter of the spinal canal, posterior displacement and distraction of the spinal cord. Clinical parameters such as strength, dexterity, numbness, pain, walking capacity, range of cervical motion and Nurick score were evaluated. Special attention was paid to the register and analysis of complications.
Results: Progression of myelopathy was arrested in all patients. Patients reported improvement in strength in 75%, dexterity in 65%, and numbness in 80%. Walking capacity improved in 65% of patients. Pain was not deteriorated in any case, and 30% experienced improvement. Mean Nurick score improved from 3.1 to 2.1. Cervical range of motion showed a 25% restriction at follow-up. The mean cord compression index improved from 0.48 to 0.62. There was no significant spinal cord streaking. Posterior spinal cord displacement was observed in all cases. No significant lost of spinal canal expansion was found using the coral bone spacers. There were complications related to surgery: two breakage of laminae at the hinge gutter, one dermal sinus track, two cases of C5 radiculopathy due to excessive traction, and one case of transitory segmental motor paralysis with T2 high signal intensity zone in the spinal cord just after surgery. All these complications resolved completely without sequel during the first month after surgery. Short temporary postoperative axial symptoms such as radiated shoulder pain and paraspinal muscles spasm were refer by 72% of patients. There were no development of kyphotic deformity and segmental instability after surgery.
Discussion: Expansive midline T-saw laminoplasty with coral bone spacers is a attractive technique for the management of multilevel spondylotic myelopathy, specially when cervical spine is stable and lordosis is maintained. The surgical procedure do not reduced notably the cervical range of motion, do not increase previous neck pain, and prevent degeneration of the adjacent levels.
Conclusions: In this series, laminoplasty had lower complications rate than that reported in the literature for multilevel anterior corpectomy. The main drawback is the higher incidence of short temporary postoperative axial symptoms and the risk of transitory segmental motor paralysis.

P 35

EFFECT OF POSTURE AND CO-CONTRACTION OF LUMBAR STABILIZING MUSCLES ON CERVICAL STABILIZING MUSCLE CONTROL

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Background and Purpose: Postural re-education and training of the deep neck flexors, by some therapists combined with lumbar segmental stabilization, are recently used as treatment modalities for patients with cervical disorders. As currently no information on the relationship between lumbar and cervical segmental stabilization is available in healthy subjects, the present study aims to verify what effect co-contractions of the lumbar stabilizing muscles have on cervical local stabilizing muscle control and to examine whether this effect is related to postural corrections.
Relevance: Identifying links between the functioning of the cervical region and other parts of the spine in healthy subjects might have important implications for the rehabilitation of patients with cervical spine disorders.
Subjects: Nine healthy subjects participated in this study. Exclusion criteria were a history of low back and/or neck pain, neurological and vestibular dysfunctions. Based on clinical tests of lumbar and cervical stabilizing muscle control, three categories could be made: no, moderate and good control.
Materials and Methods: Each subject had to perform upper cervical flexion holds of 10 seconds with and without co-contraction of the lumbar stabilizing muscles. These trials were performed in a slouched and a corrected upright sitting posture without back support. Electromyography recordings were collected from several muscles in the neck and lumbar region, head position and arm movement were registered with accelerometers. Descriptive statistics were calculated. Analysis of variance was used to assess differences between trials, positions and subjects.
Results: In the corrected sitting posture, the subjects with moderate and good control had increased activity in the cervical stabilizing muscles and they were able to perform a larger upper cervical motion with less activity of the cervical global mobilizer muscles. In addition, all subjects could better recruit lumbar stabilizing muscles. In subjects with no control of lumbar and cervical stabilizing muscles, the co-contraction conditions seem to result in a

"stiffening strategy", i.e. increased activation of the cervical and lumbar global mobilizer muscles.
Conclusions: A corrected sitting posture enhanced the control of the cervical stabilizing muscles. These improvements in muscle control might result from biomechanical optimization and/or neurophysiological facilitation from the lumbar stabilizing muscles.

P 36

COMPLICATIONS OF 278 CAGES IN ANTERIOR CERVICAL FUSION (ACF).

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Objective: The prospective nonrandomized single-center trial assessed the efficacy of titanium cages filled with hydroxyapatite (A) and of PEEK cages filled with tricalcium phosphate (B) as bone graft substitutes in ACF. Complications are reported. Method: Between 05/95 and 12/01, 211 patients affected by spondylotic myelopathy (n=133) and radiculopathy (n=78) underwent ACF. 174 patients (77 f, 97 m) were treated with 222 implants type A and 37 patients (18 f, 19 m) with 56 implants type B. Both graft substitutes were loaded with bone marrow aspirated from a vertebra adjacent to the fusion site. Single-level (163), two-level (39) and three-level (9) procedures were performed. Anterior plating was added in 17/23/7 cases respectively. Independent observers assessed the follow-up (minimum 10 months, mean 39 months). Complications were classified as related to 1) the approach 2) the graft substitutes 3) the plate and screws and 4) neurological worsening.
Results: 1) Wrong level fusion in 2 patients and 2 cases of esophageal perforation complicated by mediastinitis accounted for the 4 revision surgeries of the whole series. Temporary laryngeal nerve dysfunction (5%) was observed: whenever possible, the levels below C6 were approached from the left side. Postoperative sore throat decreased by maintaining endotracheal tube cuff pressure at 20 mmHg during surgery. 2) The degree of subsidence of the implants (2mm/34, 3mm/12) in the adjacent vertebrae correlated with the height of the graft substitutes. The initially used 7mm tall implants caused overdistraction of the level along with interscapular pain. The currently inserted 5 or 6mm implants are well tolerated. No cage dislocation occurred. 3) No plating hardware failure became clinically relevant. 4) Two patients with severe myelopathy worsened following three-level ACF. One of these died 2 months after the procedure because of pulmonary embolism. Although neither implant dislocation nor spinal cord encroachment could be shown on MRI, a marked medullary edema was highly suspicious of surgically induced microtrauma. Since then, surgery on risky myelopathy patients has been performed with MEP and SSEP monitoring. Conclusions: Bone graft substitutes proved to be safe. Due to the avoidance of graft-related complications and of harvesting site morbidity they are to be recommended as the first choice for ACF.

P 37

RESULTS OF POSTERIOR FORAMINOTOMY AND ANTERIOR DISCECTOMY WITH PMMA FUSION FOR PATIENTS WITH CERVICAL DISC DISEASE AND RADICULOPATHY

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Cervical disc disease can lead to morphologic different disc lesions, which again may differ in clinical presentation, operative treatment and outcome. Considering the current literature engaged with this topic, there is still no consensus, which is the ideal approach and operative management in each constellation. We retrospectively analysed all patients which were treated operatively for single-level cervical disc disease in our institution between 1993 and 1998 and excluded those patients with myelopathy, traumatic or recurrent discopathy. Of the remaining patients with pure radiculopathy, which were either treated with anterior microdiscectomy and PMMA fusion (Group A/177 patients) or foraminotomy (Group B/132 patients), the charts and neuroradiological findings were analysed and the outcome was evaluated via questionnaire. Follow-up was possible in 241 patients (78.1%), and the observation time ranged from 3-10 years (mean, 4.6 years). The mean age of the 142 male and 99 female patients was 47.2 years (range, 26-78 years). Mean preoperative duration of symptoms was 11 months (A) and 3.6 months (B), with existence of motor deficits in 55% (A) and 66% (B). Pure soft discs were found in 27% (A) and 87% (B), pure hard discs in 33% (A) and 7% (B), whereas a combination of hard and soft disc was found in 40% (A) and 6% (B). Distribution of affected levels were similar. Of all 241 patients, 51% of group A and 56% of group B were without any symptoms with excellent outcome, 42% of group A and 39% of group B had good outcome, and 7% in group A as well as 5% in group B had fair outcome. Excellent and good results were obtained on long-term follow-up in 93% after anterior microdiscectomy with PMMA interbody fusion and 95% after posterior foraminotomy, in cases of various different morphologic cervical disc diseases. Although different in various basic properties, both procedures were successful for treatment of cervical radiculopathy caused by monosegmental cervical disc disease. Both methods are safe and reliable, with few complications and comparable outcome, but each indication has still to be done individually under consideration of symptoms, radiological findings and the patients needs.

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CERVICAL INTERBODY FUSION CAGES: A MINIMUM 4-YEAR PROSPECTIVE FOLLOW-UP

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Introduction: Lumbar interbody fusion cages have been shown to increase spinal stability and promote fusion. This technology has seemingly been successfully extrapolated to the cervical spine. However, cervical fusion cages have received FDA approval only recently thus there is limited information on long-term outcomes. The current study prospectively examines long-term pain and function outcomes following cervical interbody fusion with cages.
Methods: This study cohort consists of 93 patients who underwent anterior discectomy and fusion with cervical interbody fusion cages (BAK/C Interbody Fusion Systemô) and were followed a minimum of 4 years postoperatively. Patients were diagnosed with discogenic radiculopathy at no more than 2 contiguous levels from C3 to C7. Demographics and surgical details were collected. Fusion was independently assessed. Outcome measures including VAS (neck and arm pain), SF-36, work status and patient perception were collected preoperatively and 3, 6, 12 months post-operatively and then yearly following. The last follow-up was a minimum of 4 years post surgery (mean: 4.4 yrs; max 6.25yrs.).
Results: The patient cohort consisted of 46 males and 47 females with a mean age of 45.2 and mean symptom duration of 34.8 months. Tobacco use was reported by 42 patients and 38 had ongoing compensation claims. A total of 118 levels were fused, (68 1-level, 25 2-level). Mean surgery duration, EBL, and median hospitalization were 97min., 80cc and 1 day. Adverse events included 9 procedure related events (9.7%) and 4 implant related events (4.3%).

Fusion rates were 92.7% at 12 months and increased to 97.5% at last follow-up. Both right and left arm pain were significantly improved from preoperative levels at all post-surgical time points. The SF-36 summary scores were significantly improved at all postoperative time points. Over 70% of patients rated the results of their surgery Good or Excellent at all postoperative time points. Patients working increased from 47% presurgery to 61% at the last follow-up.
Conclusions: Cervical fusion with interbody cages has been shown to be safe and effective. This procedure yields high fusion rates, significantly improved clinical measures and a large return to work percentage. These improvements are maintained at least 4-years.

DEFORMITIES

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THE COURSE OF SAGITTAL PLANE ABNORMALITY IN THE PATIENTS WITH CONGENITAL SCOLIOSIS MANAGED WITH CONVEX GROWTH ARREST

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Summary of background data: Patient age; localization, length and magnitude of the curve; and sagittal plane alignment are reported to be the major determinants in the selection of patients for convex growth arrest. Although the existence of sagittal plane abnormality (kyphosis or lordosis) is accepted as a contraindication for convex growth arrest, this issue has not been discussed in detail.
Objectives: The purposes of this study are to investigate the effect of sagittal plane abnormality on the control of coronal plane deformity, and to evaluate the course of sagittal plane abnormality of the congenital scoliosis patients who were satisfactorily managed with convex growth arrest.
Study design: Retrospective analysis.
Materials&Methods: Inclusion criteria are: 1) A diagnosis of congenital scoliosis in a patient younger than 6 years of age 2) Treated with convex growth arrest 3) Followed-up for a minimum 2 years 4) Abnormal sagittal plane alignment within the scoliotic segment preoperatively. The patients were evaluated with AP and lateral X-rays preoperatively and at the final follow-up. Sagittal plane abnormalities were analysed both segmentally and globally according to the age-specific normals.
Results: 38 congenital scoliosis patients treated with convex growth arrest were reviewed. Among 13 patients with segmental sagittal plane deformity, 2 girls had an insufficient control of scoliosis (15%). 11(8 girls, 3 boys) patients with a mean age of 35(6-72) months and mean follow-up of 40(24-76) months had a satisfactory control of coronal plane deformity (85%). With a detailed analysis of these patients, coronal plane deformities were found to be 58°(36-105) preoperatively and 52°(13-107) at the final follow-up. While six of the curves improved coronally, the remaining ones were found to be stabilized. Sagittal segmental alignments within the scoliotic segments were hyperkyphotic in 9 patients and hypokyphotic in 1 and lordotic in 1. At the end of the follow-up, sagittal Cobb angle of the abnormal segments remained stable in 7 patients while deteriorated in 4. However, none of the 4 patients required any reconstructive spine procedure for kyphosis during follow-up, yet.
Conclusion: Sagittal segmental abnormality does not have a negative effect on the control of scoliosis in the majority of the patients (11 out of 13). If the coronal curve stabilizes or improves then sagittal segmental abnormality could also be stabilized (in 7 of 11 patients) contrary to the previous reports. The presence of sagittal plane deformity, either global or segmental, might not be considered as an absolute contraindication for congenital scoliosis patients who are going to be treated with convex growth arrest if other prerequisites are properly adhered to or other surgical alternatives are found to be too complicated.

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OPERATIVE TREATMENT OF NEUROPATHIC SCOLIOSIS. A COMPARISON STUDY LUQUE VERSUS ASHER

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The aim of the study was to determine the advantage and disadvantage of the Luque and Asher technique in the operative treatment of neuropathic scoliosis. In a retrospective study 52 patients with neuromyopathic scoliosis were treated with Lauque or Isola instrumentation. Patients were devided in two groups. Group L: Patients were treated with a Luque instrumentation. There were 18 patients with a average age at operation of 12 years (range, 8-32). The follow-up time was 40 months (range from 23-62). Group A: Patients were treated with a Isola instrumentation according to Asher technique. The were 34 patients with a average age at operation of 14 years (range 9-21). The average follw-up time was 36 months (range from 23-62). The scoliosis could be corrected in group L from 90 degrees Cobb to 41 degrees (54 % correction). The loss of correction was 7°. The pelvic obliquity could be corrected from 26 degrees to 9 degrees (54%), loss of correction was 2 degrees. Scoliosis in Group A could be corrected from 88 degrees to 38 degrees (57% correction). Loss of correction was 7 degrees. The average pelvic obliquity was 22 degrees and could be corrected to 8 degrees. In group L we found in 8 patients a complication (45%) like neuroparalysis, pleura contusion, suture deficiency, infections, broken rods, and one patient died. In group A in 19 patients a complicaten assist. The complication rate was 56%, like neuroparalysis, infection, suture deficiency, broken rods and a intraoperative cardiac arrest (without consequence). The results of two questionnaires, which complied following the FAM and FIM scala, were positive. 70% in boths groups felt more confortable after surgery. The sitting was improved in 70% in Group L and in 83% in group A. 91% of all patients would decide in favour of operation again. Luque Galveston instrumentation seems as safe and effective as Isola instrumentation. There was no significant difference in correction, loss of correction and complication rate.

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ECG OF SURGEONS DURING SCOLIOSIS SURGERY

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Objective: To assess the cardiology of continuous ECG of Spinal Surgeons performing complex spinal deformity surgery.
Design: Spinal surgeons were attached to 24 hour tape ECG monitors while performing spinal deformity surgery. Pre op, intra-op and immediate post op assessment were performed.
Subjects: 4 Consultants 1 Spinal Fellow
Outcome measures: ECG changes, Heart Rate variance and Heart Rate
Results: Variability in Heart rate was related to the experience of the surgeon and the case performed.
Heart rate variance was highest in the Consultant with the most recent appointment. Heart rate variance in the Trainee was the lowest. The highest heart rate was achieved when scrubbed supervising the surgical trainee. The surgeons with the highest deformity work load had the lowest intra-operative heart rate

Conclusions: Spinal deformity surgery is stressful to the Consultant performing the case. Experience and case mix affect these findings. The highest stress rate occurs with supervising trainees.

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ADOLESCENT IDIOPATHIC SCOLIOSIS DURING THE YEAR PRECEDING MENARCHE: EVOLUTION AND OUTCOME

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To investigate the outcome of adolescent idiopathic scoliosis during the pubertal growth spurt, girls who had been diagnosed with AIS during the year preceding menarche, and who had at least two years' follow-up, were identified. Starting and latest values (age, height, Cobb angles), menarche, and non-operative treatment were considered for progression of Cobb angle =>10° and the incidence of surgery. 50 girls fulfilled the criteria. 9 were braced of whom 3 continued to progress and 4 subsequently had surgery. Of 41 not braced, 10 progressed and 6 had surgery. Fisher's exact gives p=0.679, not significant, that bracing had an effect, and p=0.065, not significant, for those going on to surgery. Progression of at least 10° was observed in 13 (26%), of whom 6 (46.2% of those progressing) underwent surgery. A further 4 had surgery without further progression, giving an incidence for surgical correction of 10 (20%). Of those who progressed, 14 were 40° or more at final review, 3 of whom had been above that angle at diagnosis and 1 of whom was less than 20°. The difference between the initial Cobb angles for the stable group (21.38°+10.11) and the progressive group (28.62°+14.00) was not quite statistically significant (t=-2.003, p= 0.051). Age at diagnosis (12.83+0.78 vs. 12.66+0.61) and last review (17.3+3.35 vs. 16.75+1.27), height at diagnosis (157.6+3.05 v.s. 153.2+7.12), at last review (161.9+5.27 vs. 163.47+8.83), age at menarche (13.3+0.80 vs. 13.14+0.61) and time to menarche (0.45+ 0.27 vs. 0.48+0.0.32) were not significantly different. In the progressive group, latest Cobb angle was 44.38°+16.16 vs. 21.84°+ 11.73 in the stable group. The apex of the scoliosis correlated negatively (r=-0.301, p=0.035) with the incidence of progression, indicating greater probability of progression for curves with a thoracic apex. Menarche occurs 9 months into the pubertal growth spurt and 3 months after peak growth velocity and this group must be presumed to be at maximum risk for progression. Nevertheless, not all did progress and a smaller proportion had surgery. Reports of outcome in non-operative treatment could be usefully re-evaluated in light of these findings.

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ADOLESCENT IDIOPATHIC SCOLIOSIS: EVOLUTION AND OUTCOME FROM 1 YEAR BEFORE MENARCHE

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To investigate the relationship between immaturity and prognosis in adolescent idiopathic scoliosis, 58 girls diagnosed at least a year before menarche and followed until at least a year after were identified. Starting and final values (age, height, Cobb angles), menarche, surgery and non-operative treatment were considered. Progression of at least 10° was taken as clinically significant. 9 were braced of whom 7 continued to progress and 4 subsequently had surgery, while 7 of 49 not braced had surgery as their only treatment. Fisher's exact gives p=0.026, that a statistically significant number braced continued to progress, but p=0.056, not quite significant for surgery. Progression was observed in 24 (41.4%), of whom 11 (45.8% of those progressing, 19% of the study group) underwent surgery. Of those who progressed, 14 were 40° or more at final review: 2 had been above that angle at diagnosis and 5 less than 20°. The only statistically significant differences between stable and progressive groups were initial Cobb angle (14.4°+5.2 vs. 21.2°+11.1, t=2.681, p=0.010) and height at last review (160.3+ 6.98 vs. 164.3+4.3, t=2.107, p=0.041). Age at diagnosis (11.6+1.1 vs. 11.7+0.99) and last review (16.9+2.9 vs. 17.9+2.13), height at diagnosis (146.6+9.0 v.s. 147.3+6.9), age at menarche (13.52+1.1 vs. 13.93+0.84) and time to menarche (1.95+0.76 vs. 2.26+0.98) were not significantly different. In the progressive group, final Cobb angle was 41.4°+11.28 vs. 12.4°+7.67 for the stable group. The apex of the scoliosis did not correlate with progression. While progression did occur, it was not general or universally severe. Orthoses did not effect the outcome (78% progressing in a brace). The risk factor of a high initial Cobb angle is confirmed, while the finding of greater height at maturity in the progressive group, suggesting a faster growth rate during puberty, re-affirms a similar observation by Loncar-Dusek et al (1991). Because only half the patients showed progression, and only half of these came to surgery in this high-risk group, it would appear that aggressive intervention in many cases of AIS is not appropriate and treatment protocols could be modified accordingly.

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C7 PEDICLE SUBTRACTION OSTEOTOMY AND DECANCELLISATION FOLLOWED BY CERVICO-THORACIC SEGMENTAL FIXATION IN ANKYLOSING SPONDYLITIS

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Introduction: Cervicothoracic extension osteotomy for severe cervical fixed flexion deformity in ankylosing spondylitis is traditionally performed without internal fixation. We describe a modified osteotomy technique supplemented by segmental fixation, which provides immediate spinal stability and reduces the risk of neurological injury.

Methods: In a retrospective case series and radiological review of 8 patients (6M, 2F), average age 56 years (range 39 - 74), minimum 12 month follow-up, 3 patients had psoriatic spondyloarthropathy whilst 3 had previous lumbar osteotomies. All have cervical fixed kyphosis causing marked restriction in forward gaze and "chin on chest" impingement, feeding difficulties and personal hygiene. Somatosensory evoked and motor evoked potential monitoring was used. The head was immobilised using clamps to hold the halo ring. The senior author (JKW) added a C7 pedicle subtraction osteotomy and decancellisation as a modification to the routine C7 laminectomy, C6 and T1 hemilaminectomies, which allows complete visualisation of exiting bilateral C7 and C8 nerve roots. Additionally, during controlled halo manipulation, the pivot point of the closing osteotomy occurs at the anterior longitudinal ligament. When reduction is achieved, segmental fixation was employed using a combination of cervical lateral mass screws and thoracic pedicle screws. All patients were immobilised for up to 3 months in a halo-jacket.

Results: All patients had restoration of their normal forward gaze. Mean preoperative kyphosis of +17 degrees was corrected to lordosis of -36 degrees (mean total correction 53 degrees). There were no spinal cord injuries or nerve root palsies whilst 3 patients had mild sensory radiculopathies lasting a few weeks. There was no loss of correction, no pseudarthrosis and 1 patient had 50% anterior subluxation that later united. 2 deep infections cleared with a wound washout and antibiotics.

Discussion: Cervico-thoracic osteotomy in ankylosing spondylitis continues to be challenging and hazardous. The modified technique described resulted in no major neurological complications and few transient radiculopathies. This was achieved via a C7 decancellisation and extension osteotomy supplemented with segmental internal fixation, which provides immediate spinal stability, reduces saggital spinal translation and associated high risk of neurological injury, whilst maintaining correction until bony union.

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EVALUATION OF POSTERIOR CORRECTIVE FIXATION FOR IDIOPATHIC SCOLIOSIS USING TEKMILON TAPE

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Purpose: To evaluate the usefulness of and problems with spinal fixation using Tekmilon tape(ultra high molecular weight polyehilen)in posterior corrective fixation (Isola procedure) for idiopathic scoliosis.
Subjects: The subjects were 20 patients with idiopathic scoliosis over 2 years after operation. They consisted of 2 males and 18 females aged 12-22 years (mean 17 years) at the time of surgery. The Cobb angle was 54°-72°(mean 66°).
Methods: Surgery was carried out by the Isola procedure under spinal cord monitoring after storing 1,200 ml of autologous blood. In patients with thoracic curves, 1-2 vertebrae at the lower end of fixation were fixed with pedicular screws, a claw hook was placed at the upper end of the concave side. Tekmilon tape 5 mm wide was passed under a mean of 7 vertebral arches around the apical vertebra. Tekmilon tape was tied with a special tightening gun.
Results: The postoperative Cobb angle was 9°-25° (mean 17°), and the correction rate was 64-87% (mean 75%). The mean operation time was 5 hours, and the mean volume of hemorrhage was 1,010 ml. Tekmilon tape broke in 2 vertebrae of 2 patients, but it could be readily re-applied.
Discussion: In posterior corrective fixation for scoliosis, correction by sublaminar wiring around the apical vertebra is frequently performed, but great attention not to damage nerve tissues was always needed during passage of a metal cable under the vertebral arches and subsequent maneuvers. Although similarly careful maneuver was necessary in passing Tekmilon tape under the vertebral arches, to its greatest advantage, its withdrawal or manipulations after its passage were extremely safe for nerve tissues. The problems of this tape are 1) the optimum tightening level has not yet established, 2) the tightening gun needs to be improved so that it can be more easily. 3) the current tape is radiolucent. This feature needs to be modified to allow easier checking of of the tape after surgery.
Conclusions: In posterior corrective fixation for scoliosis, safe and satisfactory correction could be achieved using Tekmilon tape.

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DIAGNOSTIC AND CLINICAL MANAGEMENT IN CONGENITAL SCOLIOSIS CAUSED BY SPLIT CORD MALFORMATION

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Introduction: The essence of split cord malformation (SCM) is congenital structure defect of spinal cord results in prevelence of spinal crevice accompanied by bone or fibrous spur dividing spinal cord into two parts. SCM may cause scoliotic deformity of the spine and neurological deficits.
Objectives: To present our diagnostic and clinical management and assess efficacy of operative treatment.
Material and methods: 23 patients (16male, 7female) underwent diagnostic and treatment procedures in our department.18 patients were diagnosed by CT, 14 by MRI. There were 16 cases of mix SCM, 5 cases of type-I SCM, 2 cases of type-II SCM. On admition the neurological condition was assessed according to clinical examination and SEP. 13 patients had neurological deficits: 10 motor, 3 sensor, disturbances. Additional deformation occured in 11 patients: foot deformation in 8 cases, inequality of lower extremities in 3 cases. Preoperative scoliotic Cobb angle averaged 65o (range16o-154o). There were 14 thoracolumbar and 9 thoracal scoliosis. Intercanal spur occured in: thoracolumbar part in 10 patients, thoracal part in 8 patient, lumbar in 5 cases. 17 patients with mean age was 11 years (range 2-19) underwent different operative procedures. We divided patients into 2 groups:

1) non/instrumented procedures with anterior or posterior fusion were performed in 6 patients
2) excision of intracanal spur and instrumented correction with posterior spinal fusion was performed in 11patients

Results: Among non-operated patients 5 presented stable scoliosis due to skeletal maturity, in 2 cases scoliosis progressed due to bone immaturity. The mean Cobb angle was 50° (range22°-94°) postoperatively and 49°(5°-120°) at 3 years follow-up (range1-11years). In 7 patients postoperative complications were observed: 1 paraparesis, 5 cerebrospinal fluid leakage, 1 respiratory tract insufficiency. Deformity stabilization was obtained in 8 patients, whereas it was still progressive in 2 patients, in 7 cases decrease of deformation was observed. Regression of neurologic deficits was observed in 1 patient.
Conclusion: Progression of scoliotic deformation caused by SCM in most cases leads to neurological deficits. Early diagnosis by means of MRI may prevent sceletal and neurological disturbances due to proper and accurate clinical decision including operative management - resection of spur followed by correction of scoliotic deformation.

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SEGMENTAL INSTRUMENTATION IMPORTANCE IN REDUCTION THE INCIDENCE OF SPINAL PSEUDOARTHROSIS IN SURGICALLY MANAGED SCOLIOSIS.

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Introduction: To achieve a solid bone fusion is the main goal in surgical management of scoliotic spinal deformities. The incidence of the pseudoarthrosis is the late complication, which usualy needs additional reoperation and prolong the healing time. In this contribution we present our experiences with prevention and treatment spinal pseudoarthtrosis after scoliotic surgery.
Purpose of the study: The main purpose of our study is retrospectively evaluate the role of segmental instrumentation in reduction of incidence the late spinal pseudoarthrosis. The second purpose is to maintain and evaluate the risk of pseudoarthrosis incidence in non-idiopathic scoliotic deformities.
Material and methods: Since 1975 the total amount of 1150 scoliotic deformities were surgically managed and evaluated in our Orthopaedic Department. Since 1992 to 2002 the segmental instrumentation were applicated in 723 patients with scoliotic deformities, and 652 of them were the idiopathic deformities.

Results: In period of the distraction methods the incidence of spinal pseudoarthrosis in surgically managed idiopathic scoliosis was about 7%.The incidence was reduced to about the 0,65 % in evaluated patiens, which were surgically managed with using the segmental instrumentation. The incidence of spinal pseudoarthrosis in non-idiopathic scoliosis was in the range from 18% to 43%, in depending on character of deformity (neuromuscular, paralytic, myelodysplastic, neurofibromatosis or congenital scoliosis with defect of posterior spine elements).
Conclusions: Good surgical technique with quality posterolateral decortication and fusion, segmental instrumentation, using the autologous bone grafts and enough postoperation bracing are the main factors in prevention of the spinal pseudoarthrosis incidence. Preventive fusion reexploration in risk scoliotic types is standard treatment procedure. Changing of the type instrumentation from distraction to the segmental instrumentation led to the considerable reduction of the spinal pseudoarthrosis incidence in our patients group.

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SPONDYLOCOSTAL DYSOSTOSIS. 13 NEW CASES TREATED BY CONSERVATIVE AND SURGICAL MEANS

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Study design. A prospective assessment of a cohort of patients affected by Spondylocostal Dysostosis (SCD).
Objective. To report on the results of both conservative and operative management of this rare condition and, based on this, to propose an assessment and treatment protocol for SCD.
Summary of Background Data. SCD and Spondylothoracic Dysostosis (STD) are subtypes of the Jarcho-Levin Syndrome, a hereditary condition manifested by vertebral body and related rib malformations. SCD features an autosomal dominant or recessive pattern of inheritance, vertebral body malformations and rib anomalies including absence and/or malformations. STD has an autosomal recessive inheritance, vertebral body malformations and deformed ribs flaring in a crab-like pattern. Mortality prevails in STD due to more severe respiratory compromise.
Methods. The details of prenatal and postnatal diagnosis, history and management of 13 patients with SCD are presented. All patients were treated post-natally with continous chest physiotherapy. Two patients refractory to conservative treatment underwent surgical intervention: one had chest wall reconstruction via a latissimus dorsi flap, the other posterior spinal instrumented fusion for progressive scoliosis.
Results. Prenatal ultrasound, done in 4/13 cases, showed full details of both vertebral and rib anomalies. Thoracic and lumbar hemivertebrae were the most common skeletal abnormality, leading to congenital scoliosis in 10/13 cases; unilateral (10/13) rib defects were mostly identified. A number of extra-skeletal abnormalities were also identified. At an average follow-up of 3 years, the survival rate was 100% with a remarkable decrease of the rate of respiratory complications. Surgical treatment led to satisfactory results without significant complications.
Conclusions. Prenatal diagnosis of SCD makes genetic counselling an important issue. Post-natally, prompt management of these patients with physiotherapy leads to long term survival. Surgical intervention may then be indicated to stabilize chest wall or spine deformities, with promising results.

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THE RESTORATION OF THORACIC KYPHOSIS IN THE SURGICAL TREATMENT OF A.I.S.: SCREWS VERSUS HOOKS

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Introduction: Pedicle screw instrumentation as a part of scoliosis surgery, have been shown to provide better correction in lumbar deformities. The goal of this retrospective study was to verify if segmental screw fixation had the same efficacy in correcting thoracic deformities and restoring the thoracic sagittal balance in the presence of hypokyphotic deformities.
Methods: Forty-nine cases with AIS were reviewed: they had undergone posterior surgery by segmental instrumentation, such as CDI or similar devices, from 1987 to 2000. All patients presented with a predominant thoracic curve associated with sagittal imbalance (hypokyphosis) and were divided into two groups according to the fixation technique selected: 24 were treated by multiple hook fixation (MHF) and 25 by segmental pedicle screw fixation (SPSF). In the SPSF group, the pedicle screws were inserted at every other or every third vertebra in lumbar and thoracic areas, and correction was achieved by translation technique and derotation manoeuvre without distraction on the concavity and compression on the convexity of the curve. All patients were followed-up by surgeons both clinically and radiographically.
Results: At a follow-up longer than 2 years in all cases, the average frontal correction decreased from 65.3° to 24.8° in the PSF group, and from 54.5° to 27° in the MHF group; the average thoracic kyphosis value changed from 10.9° to 25.6° in the PSF group, and from 12.3° to 18° in the MHF group. There were no major, visceral or neurological complications related to hook or pedicle screw placement.
Conclusions: According to the present results, segmental pedicle screws are more effective than multiple hooks in restoring thoracic hypokyphosis in AIS, whereas they appear to be similar in terms of frontal correction of scoliosis deformity.

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THE INFLUENCE OF POSTERIOR FUSION ON THE FORWARD BENDING OF THE TRUNK AFTER SCOLIOSIS SURGERY

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The purpose of the paper: The forward bending after scoliosis surgery is a frequent concern of the patients and their parents. Our goal was to assess to what extend the fusion can impair the ability to make a forward trunk bending and what is the influence of the caudad level of the instrumentation - fusion. We also discuss the biomechanics of the trunk flexion in accordance to the spine and hips mobility.
Material: One hundred consecutive patients aged 12 - 17 years operated on with CD instrumentation because of the right thoracic scoliosis.
Method: The forward bending of the trunk was measured as a distance from the tips of the fingers to the floor when flexing with straightened knees. The results before the surgery and after one year follow-up were compared.
Results: Before the surgery 36 % of the patients were not able to perform full forward bending it is to touch the floor with finger tips. The average fingers - floor distance in this group was 9.9 cm (2.5 cm to 26 cm). The remaining 64 % could easily perform the full bending reaching up to 18 cm beneath the floor level. After the surgery there was a worsening of the forward bending in 85 %

fused to L3 and in 74 % fused to L2. The average bending deficit was 12.4 cm compared with 9.9 cm preoperatively. None of the patients showed any complications immediately after the surgery and after the one year follow-up.
Conclusions: 1. The majority (64%) of the scoliotic patients can perform a full forward bending of the trunk before the surgery. 2. The surgery reduces the ability to bend forward for but the average loss of flexion is clinically not important - 2.5 cm. 3. Patients can be assured that the fusion of the spine does not influence much the total trunk movement despite regional stiffness in the fused area.

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CLINICAL EVELUATION AND TREATMENT STRATEGY OF SCOLIOSIS ASSOCIATED WITH CHIARI MALFORMATION AND/OR SYRINGOMYELIA

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Objective To evaluate the treatment strategy of the scoliosis associated with Chiari malformation and /or syringomyelia.
Methods A total of 52 cases suffered from scoliosis with Chiari malformation and /or syringomyelia were divided into three groups for surgical treatment. (1) Group 1: 18 cases had scoliosis with Chiari malformation or syringomyelia without obvious neurologic impairment, their scoliosis was corrected with posterior instrumentation, but their Chiari malformation and syringomyelia were left untreated surgically. (2) Group 2: 12 patients, whose scoliosis wasn't indicated for surgery but whose Chiari malformation was associated with syringomyelia, underwent posterior suboccipital craniectomy C1 posterior arch decompression and dural plasty no matter whether neurologic deficits were present or not. (3) Group 3: 22 cases not only whose scoliosis needed operative treatment, but whose Chiari malformation or syringomyelia caused neurologic deficits, had two-stage surgery: firstly, they were operated on with posterior suboccipital craniectomy C1 posterior arch decompression and dural plasty, 6 months later, they underwent the scoliosis correction with instrumentation.
Results In 34 patients who underwent craniovertebral decompression, only 6 of the 24 cases with preoperatively neurologic deficits achieved mild improvement within 6 months postoperatively. In 40 patients who were treated with posterior correction for scoliosis, the average frontal correction was 63% and the average sagittal correction was 80% for scoliosis less than 90°, the average frontal correction was 49% and the average sagittal correction was 74% for scoliosis more than 90°. At a 19-month follow-up, the average loss of the frontal correction was 6%.
Conclusion Scoliosis associated with Chiari malformation and /or syringomyelia can be treated satisfactorily, with the similar results for adolescent idiopathic scoliosis. Accurate diagnosis and proper treatment for Chiari malformation or syringomyelia before scoliosis surgery will improve the rate of scoliosis correction, decrease the surgical complications and the potiential complications of Chiari malformation and syringomyelia.

DISC DISEASE

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DISC CHONDROCYTE TRANSPLANTATION IN A CANINE MODEL: A TREATMENT FOR DEGENERATED OR DAMAGED INTERVERTEBRAL DISC

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As yet there are no effective therapies to retard or reverse disc degeneration. With this in mind, we designed a study (using the dog as our model) to investigate the hypothesis that 1) repair of the damaged disc is technically feasible, 2) autologous cells can be reproducibly cultured under defined and controlled conditions, 3) percutaneous delivery is possible, and that 4.) disc chondrocytes will integrate with the surrounding tissue, produce the appropriate intervertebral disc extracellular matrix, and provide a functional as well as formative solution to disc repair. In the context of degenerative changes in an injury model we were able to show the following: 1) Autologous disc chondrocytes could be expanded in culture and returned to the disc by a minimally-invasive procedure after 12 weeks. 2) Disc chondrocytes remained viable after transplantation as shown by BrdU incorporation and maintained a capacity for proliferation after transplantation as depicted by histology. 3) Transplanted disc chondrocytes produced an extracellular matrix that displayed elements similar in composition to normal intervertebral disc tissue. Positive evidence of proteoglycan content was supported by accepted histochemical staining techniques such as Safranin O-Fast Green. 4) Both Type II and Type I collagens were demonstrated in the regenerated intervertebral disc matrix by immunohistochemistry following chondrocyte transplantation. 5) When the disc heights were analyzed for variance according to treatment, a statistically significant correlation between transplanting cells and retention of disc height was achieved. In summary, autologous chondrocyte transplantation is technically feasible and biologically relevant to repairing disc damage and retarding disc degeneration.

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DIAGNOSTIC CRITERIA FOR THE INTERNAL DISC DISRUPTION IN THE LITERATURE: IS IT RELIABLE?

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A new disease, called as internal disc disruption (IDD), is a matter of great debate. Some insist that the discography is an accurate diagnostic tool for IDD, while others dispute. Before a scientific verification, some doctors already have performed invasive operations for this uncertain disease. It is necessary to explore the diagnostic criteria and characteristics of IDD. We investigated the background, history, diagnostic methods and criteria of this new disease by a review of the literature. The review included literature on the words internal disc disruption of lumbar spine in MEDLINE. Similar disc disorders such as internal disc derangement, internal disc disorder, painful disc, chronic disc disease, lumbar disc disease, or degenerative disc disease were excluded, since the exact distinction of theses similar words was virtually impossible. The criteria for the diagnosis of IDD are diverse. Minimum requirements for the diagnosis were the pain and the shape of the discography. Interpretation of the discography becomes complicated considering the volume and pressure. The pain pattern is a key element for the correct diagnosis, which depends on the subjective re-

port of the patient. The diagnosis is up to the patient's response, and the examiner alone cannot make it. The IDD is not a real disease but a hypothetical one at present. If we perform unsolved therapies before scientific verification, IDD will be a doctor-made disease.

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DISC DISTRACTION REDUCES APOPTOTIC CELL NUMBER IN DEGENERATED DISCS IN THE LUMBAR SPINE: AN IN VIVO STUDY ON NEW ZEALAND WHITE RABBITS

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Introduction: Disc degeneration associated with increased cell death has been previously reported. However, the effects of disc compression combined with disc distraction on disc cell apoptosis, related to disc degeneration have not yet been investigated. Temporary dynamic disc distraction on a single degenerated intervertebral disc segment is thought to either prevent further disc degeneration or stimulate disc regeneration, yet the mechanism remains unclear. To quantitatively investigate the biomechanical and biological response of the intervertebral disc to hyper- and hypo-physiological spinal loading, we have developed an in vivo rabbit model. This model provides a defined and precisely controlled loading of a single disc segment. The purpose of this study was to use this model to determine whether controlled dynamic disc distraction is effective in decreasing apoptosis of disc cells in previously loaded intervertebral discs.
Methods: Eighteen New Zealand white rabbits were used for this study. In each animal the intervertebral disc L4/L5 were studied. The discs in six animals remained unloaded and served as controls. In twelve animals the discs were axial compressed (2.5Mpa) using an external loading device. After 28 days of loading six animals were sacrificed and the segments L4/L5 were harvested. In the remaining six animals the previously loaded discs were distracted for 28 days using a modified external distraction device. After 28 days of distraction the six animals were sacrificed and the segments were harvested. Apoptosis of disc cells were measured by In Situ Oligo Labeling (ISOL), a technique that specifically distinguishes apoptotic from necrotic cells. Two sections were counted in the annular layers and nucleus pulposes of each animal.
Results: Involuting mammary tissue was used as positive control for both apoptotic and non-apoptotic cells. Few apoptotic cells were noted in control discs. 20% of cells were apoptotic in the loaded disc. However, the percentage of apoptotic cells exposed to 28 days dynamic distraction reduced the percentage of apoptotic cells to 5 % in (annulus, nucleus).
Discussion: The results demonstrate a reduction in the percentage of apoptotic cells after distraction of previously compressed discs versus compressed discs without distraction. These findings suggests that temporary dynamic distraction of degenerated discs could prevent programmed cell death through reduced intervertrebral disc pressure leading to increased diffusion of oxygen, nutrients, and waste products resulting in improved intervertebral disc environment. The application of a controlled temporary dynamic disc distraction may have future therapeutic potential in stimulating disc regeneration.

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MECHANISMS OF DISC DEGENERATION: ROLE OF TNFA, IL-1A, IL-6, MMP-3, TGF-B 1,2,3 AND SUBSTANCE P.

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Background: Mechanisms of disc degeneration have been evaluated primarily under biomechanical aspects. However, the discrepancies between morphological disc degeneration and neurological symptoms suggest that in addition to mechanical, biochemical parameters are involved. The alterations and dynamics of the cytokine profile associated with painful disc degeneration especially the role of pro-inflammatory proteins such as Tumor Necrosis Factor (TNFa), Interleukin -1 and 6 (IL-1a, IL-6) and Substance P are not well understood. Also, the sequential alterations of matrix-metalloproteinase-3 (MMP-3) and Transforming Growth Factor (TGF-b 1,2,3) expressions levels during disc degeneration are not apparent.
Methods: Annulus fibrosus and nucleus pulposus were obtained from patients with chronic discogenic low back pain (LBP) who underwent anterior lumbar interbody fusion (ALIF) and from patients receiving correction of traumatic and idiopathic scoliosis. Herniated disc tissue was obtained from patients undergoing discectomy for sciatica. Tissue samples were immediately frozen in liquid nitrogen and stored at -80°C until further analysis using standard Western blot protocols.
Results: TNFa was significantly higher in annulus compared to nucleus in patients with LBP. TNFa was also elevated in herniated tissue. Yet, in opposite to patients with LBP, patients with herniated discs treated with non-steroidal inflammatory drugs (NSAID) had significant lower TNFa levels compared to patients without NSAID. IL-1a, IL-6 and Substance P were significantly elevated in patients with LBP. There was a trend of elevated MMP-3 levels in herniated discs, though this was not significant compared to nucleus of patients with LBP. Interestingly TGF-b 1,2,3 was significantly higher in annulus of patients with LBP.
Conclusions: Increased TGF-b levels in the annulus of patients with LBP might be the result of triggered repair mechanisms. While patients with acute discogenic pain likely profit from NSAID therapy by decreasing TNFa levels, patients with chronic LBP might fail to profit due to unaffected TNFa levels despite NSAID therapy. Supposed the increased levels of Substance P play a role in chronic LBP, therapies targeting Substance P related toxicity on inhibiting interneurons might be beneficial for non-surgical therapy of discogenic LBP. Further studies have to proof such a beneficial therapy.

P 56

HISTOLOGICAL COMPOSITION OF EXTRUDED LUMBAR DISK MATERIAL CORRELATED TO CLINICAL SYMPTOMS, OPERATIVE FINDINGS, AND OUTCOME

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Background: Previous studies have investigated the histological composition of herniated lumbar disk fragments. However, few publications examined correlations with clinical data.

Objectives: To investigate possible correlations between the histological composition of the herniated disk fragments and pain, disability, clinical signs, operative findings, and outcome.
Study Design: 55 consecutive patients undergoing microdiskectomy due to lumbar disk herniation were included in this prospective clinical study over 12 months. No patient was lost to follow-up.
Methods: Before and 3 months after treatment, patients were examined by an independent investigator using a standardized clinical protocol; subjective disability and pain were assessed by the Oswestry Disability Questionnaire and the McGill Pain Questionnaire. The herniated disk fragments were examined semiquantitatively for the percentages of nucleus pulposus, anulus fibrosus, and cartilaginous endplate. All data were recorded on SPSS for Windows 8.0 and statistical analyses were performed with that software.
Results: Age of the patients correlated with the histological composition of the herniated fragments. In patients less than 30 years of age, significantly higher percentages of nucleus pulposus were found than in the older group, while anulus fibrosus was found in significantly higher percentages in patients older than 30 years. Both higher percentages of cartilaginous endplates and nucleus pulposus correlated with increased pain intensity values from the McGill Pain Questionnaire. Impaired reflexes before surgery occurred significantly more often in patients with >20% of cartilaginous endplates in the herniated fragment. When nucleus pulposus was <30%, sensory impairment tended to be more severe both before and after surgery, and correlated with impaired reflexes at follow-up.
Conclusion: The histological composition of the herniated disk fragment affects pain, clinical symptoms, and outcome after surgery.

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IMMUNOHISTOCHEMICAL STUDY OF MATRIX METALLOPROTEINASE-3 (MMP-3) AND TISSUE INHIBITOR METALLOPROTEINASE-1 (TIMP-1) IN INTERVERTEBRAL DISC

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The aim of this study is to evaluate the collagen type I, collagen type IV, and the enzymes MMP-3 and TIMP-1 of the material obtained peroperatively during single-level disc hernia operations by immunohystochemical methods and is to compare the results with the Thompson disc degeneration classification on MRI examinations of the patients.
Materials and methods: Thirty patients, 25-45 years old (young age group) who had been operated on the diagnosis of single-level lumbar disc hernia were included in the study. The patients were examined neurologically and their disc degenerations were classified according to Thompson disc degeneration classification of their MRI findings. The disc tissues obtained preoperatively were taken into investigation together with discs of 5 cadavers of the same age group, which had been the control group. Collagen type II, collagen type IV and the enzymes MMP-3 and TIMP-1 in the disc material were examined by immunohystochemical methods. The data obtained were compared statistically.
Results: Thirty patients, 25-45 years old were included in the study. Sixteen of the patients (53.3%) were female, 14 (46.7) of them were male. The duration of their complaints were ranging between 12 -120 months. According to classification of Thompson disc degeneration in the MRI, the degeneration identified in 9 patients were Class I (30%), 9 were Class II (30%), 8 were Class III (26.6%), 2 were class IV (6.7%), 2 were Class V (6.7%). Collagen type II in the discs obtained preoperatively were increased in 25 patients (83.3%), whereas collagen type IV were present in only 10 patients (33.3%). MMP-3 activity was either positive or increased in 24 patients. TIMP-1 activity was not identified in 9 patients (30%). The correlation between collagen type IV which is accepted as the phenotypical marker of degeneration and the Thompson degeneration classification in MRI were statistically significant (p 0.076). There was statistically significant correlation between the existence of collagen type IV and the increase in immunoreactivity of MMP-3 (p 0.076). There was a statistically significant correlation between the increase in the scores MRI Thompson degeneration classification and the positive immunoreactivity of MMP-3 ($p<0.01$). When the degeneration in MRI was high, the immunoreactivity of MMP-3 was also high. The MMP-3 was positive in 84% of the discs, immunoreactive TIMP-1 was positive in 75% of them. MMP-3 and TIMP-1-negative discs, which could be in normal, healthy discs, were only 2(6.6%). The equilibrium was changed in favor of MMP-3 in 94% of the discs. Both MMP-3 and TIMP-1 were positive in 56.7% of the discs. MRI degeneration scores were also higher in this group. In the control group that was constituted from 5 cadavers, all collagen type IV, the MMP-3 and TIMP-1 activities were negative. It was concluded that the change in MMP-3 and TIMP-1 equilibrium showed degeneration. Any agent that could decrease the synthesis of MMPs or inhibit the activities of MMPs like TIMP-1, were assumed to inhibit the degeneration in the discs or generation of disc hernias.

EXPERIMENTAL

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VARIATION AND DESIGN CONSIDERATIONS REGARDING POSTEROLATERAL BONE FUSION MASS

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Introduction: In the evaluation of surgical procedures, bone graft substitutes and growth factors the posterolateral spinal fusion model has been found useful. Many of the methods for quantifying the fusion mass (DEXA- and CT-scanning and histology/histomorphometry), however, still needs validation. It could be hypothesised that the variation between individuals is small compared with the variation within individuals. The aim of this study was to evaluate the correlation between the posterolateral fusion mass on the right and left side, by use of histomorphometry.
Methods: 24 adult mini-pigs underwent posterolateral spinal fusion with pedicle screw devices at L3-L4. 8 g autogenous iliac crest graft was applied on each side of the spine. The postoperative observation time was 3 month. The sections were randomly chosen for evaluation of histomorphometry. Blinded quantitative evaluation of the bone fusion mass was performed using linear intercept technique.
Results: There was a relative poor correlation between the bone mass % on the right and left side ($R=0.384$) and the bone mass % was significant different between sides ($p<0.0001$). The intra observer variation was excellent ($R=0.99$). The variation in bone mass between different levels in the same block was found to be mean 4.8%.
Discussion: This study identifies a serious problem by using a study design where the right and left side are controlling for each other. We recommend that different levels or different animals are used as random controls. The bone volume analyzed on both the left and right side should be presented as a sum.

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VERTEBRAL END PLATE ROLE IN THE BONE GRAFT CONSOLIDATION.

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The surgical technique of anterior vertebral arthrodesis has been modified by the introduction of cages in spinal surgery. The classical technique recommends removal of the vertebral endplate and exposure of bleeding cancellous bone. However, after the observatin of cage subsiding during postoperative follow-up, the vertebral endplate is no longer removed, due to its greater mechanical resistance which prevents cage subsiding. The mechanical characteristics of the vertebral endplate are well known, in contrast to their osteogenic potential, which was investigated in the present experimental study. The study was conducted on mongrel dogs of both sexes which were submitted to anterior corpectomy at the cervical spine level. A cortico-cancellous bone graft removed from the tibia was used for the reconstruction of the vertebral segment, which was stabilized with ostheosynthesis plate. At site of contact between the surface of the vertebral body and the bone graft, the vertebral endplate was completely removed and cancellous bone was exposed in the inferior vertebra, whereas in the superior vertebra of the arthrodesed vertebral segment only curettage was perfomed and the vertebral endplate was preserved, as recommended for cage implantation. Twenty adult dogs of both sexes were divided into 4 experimental groups according to time of sacrifice (15, 30, 90 and 180 days). The consolidation of the bone graft with the vertebral body was evaluated by histology using HE and Gomori trichrome staining. In the interface between the bone graft and the vertebral body surface in which the vertebral endplate was not removed, graft conslidation was not observed in any of group 1 animals (sacrificed after 15 days), and was observed in 1 animal (20%) of group 2 (30 days), in 2 animals (40%) of group 3 (90 days), and in 4 animals (80%) of group 4 (180 days).
In the interface between the graft and the vertebral body in which the vertebral endplate was removed, bone graft consolidation was observed in all animals of all experimental group (15,30,90 and 180 days). Bone graft consolidation with the surface of the vertebral body was influenced by the removal or maintenance of the vertebral endplate. Due to the importance of this structure in current surgical procedure, this phenomenon deserves to be studied in more detail in order to understand the basic events involved in this process.

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BIPHASIC CERAMIC LOADED WITH BONE MARROW IN LUMBAR ARTHRODESIS: COMPARISON OF 2 TYPES OF INTERCONNECTION

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Introduction: The biphasic type of calcium phosphate ceramics with bone marrow added is one of the most common type of bone substitute used. Within the family of biphasic differences remain as the diameter and the rate of interconnection of macropores. The purpose of this study was to compare the rate of bone ingrowth produced by 2 different commercially available biphasic ceramics as regards mainly the interconnection in a rabbit intertransvere fusion model.
Materials and Methods: The common characteristics of the 2 ceramics were their composition (60% hydroxyapatite, 40% tricalcium phosphate) and their total porosity (about 80%). In one material the interconnexion was partial and of few microns of diameter and connected macropores ranged from 150 to 300 microns. In the other, interconnection was total and of 100/150 microns of diameter and connected macropores ranged from 400 to 600 microns. Ceramic blocs with and without bone marrow were implanted in 2 independent intertransvere sites and associated with an instrumentation in 20 rabbits. The rate of bone ingrowth was quantified after 6 weeks of implantation on Electronic Scanning Microscopy images.
Results: New bone formation was significantly higher with the total interconnected ceramic in comparison to the partially interconnected: 151% of increasing within the blocs with bone marrow and 80% without bone marrow. Furthermore, distribution of bone ingrowth inside the ceramic was more homogeneous with total interconnexion. Bone formation benefit due to the addition of bone marrow was in absolute value similar between the 2 types of ceramic and in relative value of 35% in the case of total interconnexion and 87% in the case of partial interconnexion.
Discussion: The rate of new bone formation was greatly different between the 2 types of ceramic despite some common characteristics. The interconnection as a main difference has likely influence the osteo-integration. The supplementary new bone formation benefit due to the addition of bone marrow was independent of the type of ceramic.
Conclusion: This preclinical study suggests that within the family of biphasic ceramics interconnection differences have to be to take into account as regards clinical applications.

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CT- NAVIGATION WITH A NEW AIMING DEVICE EXEMPLIFIED BY THE TRANSLAMINAR FIXATION OF LUMBAR FACET JOINTS - AN EXPERIMENTAL STUDY

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Introduction: Modern navigation systems are expensive and not everywhere available. To enable percutaneous application of screws or pins and to enhance the precision of punctures or biopsies, an aiming device was developed, which can be used together with conventional CT-systems. In order to get information on the safety and precision of the new technique a study was undertaken by using the translaminar fixation of lumbar facet joints of fresh human cadavers as an technically demanding example
Methods: Carbon fiber PEEK Pins were used instead of titanium screws. Using the new aiming device, 32 translaminar pins were inserted under CT-control in 16 segments (L1/2 - L5/S1) of 6 fresh human cadavers. Neither the body nor the lumbar spine was fixed in this series. In L5/S1 the chest of the body had to be elevated in two cases in addition to tilting the CT gantry to achieve the obliquity, necessary for placing the pins. 28 pins were inserted ideally or safely. Four pins missed the lamina caudally because the pressure of the drill bit caused the vertebra to give way. No pin entered the spinal canal.
Conclusions: Percutaneous translaminar fixation of lumbar segments by CT-navigation is feasible and promising. The CT-navigation with the new aiming device seems to be safe when carried out according to the precise rules which were established following this study. E. g. Fixation of the body or movable bony element is essential to prevent the target structure from giving way during the procedure and the use of a sharp drill bit which does not slip off the bone is mandatory. A major advantage of this kind of CT-Navigation is, that from the positioning of the guide wire to inser-

tion of the implant every step of the procedure can be controlled instantly. The technique may also be used for other percutaneous screw or pin fixations, as well as for biopsies and punctures. This study will be completed by another series which will be finished during the next months. In the new series other indications for percutaneous screw application as e. g. pedicle screws or ilio-sacral screws will be examined additionally.

FRACTURES

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KYPHOPLASTY FOR OSTEOPOROTIC VERTEBRAL FRACTURES - RESULTS AND STABILITY AFTER ONE YEAR

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Minimal-invasive augmentation techniques of vertebral bodies have been advocated to treat osteoporotic vertebral body fractures (VBFs). As opposed to vertebroplasty, kyphoplasty is designed to address both fracture-related pain as well as the kyphotic deformity usually associated with the fracture. Previous studies have indicated the potential of the technique for immediate pain relief and reduction of vertebral height, but whether this is a lasting effect, has not been well investigated. The current prospective study reports on our experience and the one-year results in 27 kyphoplasty procedures (Kyphon Inc., Wezembeek-Oppem, Belgium) in 24 patients with PMMA (Palacos E-flow, Essex Chemie, Switzerland) for osteoporotic VBFs. Indications were painful osteoporotic vertebral body fractures with a kyphosis of 10° minimum or an increase of deformity under initial mobilisation. Pain was assessed on a 0-10 VAS. Deformity and reduction of the vertebral body was measured as the angulation between the two endplates on standing lateral radiographs. All parameters were taken pre-operatively, one day and two months post-operatively and after one year. Multiple regression analysis was conducted to determine the relative importance of possible independent factors as predictors of the achieved fracture reduction. Statistica 6.0 software (StatSoft Inc., Tulsa, OK, USA) was used with a significance level set at $p = 0.05$. There were no device related complications with clinically insignificant local cement leaks in nine vertebrae. All but one patient experienced pain relief directly following the procedure with a lasting effect after 2 months and also one year in 25 cases. An average vertebral kyphosis reduction of 47.7% was achieved with no loss of reduction after one year. Pain relief was not related to the amount of reduction. The potential for reduction was statistically related to pre-operative kyphosis ($p<0.0001$), level treated ($p=0.035$), and fracture age ($p=0.046$), but not with age of the patient ($p=0.279$). One new fracture adjacent to a treated level was observed, necessitating further intervention (vertebroplasty). In this series, kyphoplasty was an effective treatment of VBFs in terms of pain relief and durable reduction of deformity. However, whether spinal realignment results in an improved long-term clinical outcome remains to be investigated.

IMAGING

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DIAGNOSIS OF SPINAL ARTERIOVENOUS MALFORMATIONS: CAN MR SPINAL ANGIOGRAPHY BE USED AS AN INITIAL SCREENING TEST?

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Objective: To investigate the role of spinal MR angiography using a breath-hold 3D contrast-enhanced technique as a screening test for the diagnosis of spinal AVM, instead of conventional myelography.
Design: A prospective radiological study over 4years. Patients were screened with either a full spinal myelogram, and/or spinal MR/MR angiogram using a breath-hold contrast-enhanced technique.
Subjects: We investigated 25 consecutive patients clinically suspected to have a spinal AVM(male:n=16 female:n=9).
Outcome measures: The MRA scans and myelograms were reported independently by 2 neuroradiologists who were unaware of the findings of the alternative investigation.
Results: A total of 16 patients underwent myelograms; 17 had MR scans, 15 underwent MRA scans and 6 had spinal angiograms. There were 6 positive AVM cases and in this group, 1 patient had a myelogram only as a screening test, 5 patients had MR scans and a further 2 had MRA scans only.Only 1 patient had both myelography and MRA. In the 15 patients with negative results, 12 had myelograms, 11 had MR and 11 had MRA. In this group, 11 patients had both myelograms and MR/MRA scans.In summary,in the positive group, 5 of the 6 were diagnosed using MRI and MRA scans. In the negative group, both MRI and MRA correlate with myelographic findings in 11 cases. MRA was able to correlate well with the findings of the nidus and feeding vessels in the positive AVM cases.
Conclusions: We recommend MRA using the new 3-D breath hold technique as initial screening in patients suspected of having a spinal AVM. Myelography should only be considered if both MRI and MRA initial screening tests were negative and if there was a strong suspicion of a spinal AVM.

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DIURNAL VARIATION IN INTERVERTEBRAL DISC HEIGHT IN NORMAL INDIVIDUALS USING STAND-UP POSITIONAL MRI

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Introduction: Circadian variation in human stature was first reported in 1726. Diurnal height changes result from gravitational forces. Most previous MRI studies of the lumbar spine have been in the supine position with a few in a sitting position
Materials and methods: 15 volunteers, without LBP and sciatica were studied with a pMRI in the supine and standing postures, at controlled times in the morning and evening. On sagittal images, disc heights were measured at L1/2 - L5/S1 using (a+p)/2, and (a+m+p)/3 where a, m and p are the anterior, mid and posterior disc heights respectively. Measurements and interobserver reproducibility were performed independently by an orthopaedic surgeon and radiologist. The lowest vertebral body separated from the sacrum by a complete intervertebral disc was designated at L5. Measurement results were analysed with one-way ANOVA and multiple comparison posttests.
Results: The mean percentage loss of height for the supine examinations was 7.70-7.09 and for the erect examinations 7.29-7.52.

Discussion: The length of the spine is almost one third of the total body height and the IVDs provide 25% of the spinal length. Various studies have shown that in the upright posture the lumbar spine supports 50% of body weight The IVD is an osmotic system. Pressure dependent fluid exchange in the IVD takes place through a pumping mechanism, in which the proteoglycans also serve to increase the osmotic pressure thus driving fluid into the disc. This current study, is unique, in that the pMRI scanner allows one to assess the spine in a 'naturally loaded' position.. Given that the normal diurnal loss is about 17mm.one would expect that the loss over the lumbar spine would be about 8.5mm. Another factor that has been proposed to be relevant when measuring variation in IVD heights is that shortening of the lumbar spine in the upright posture may result from a combination of increase in lordosis and shrinkage of IVDs.

INFECTION

P 65

POST-OPERATIVE INFECTION AFTER SPINAL INSTRUMENTATION. A RETROSPECTIVE ANALYSIS OF TWENTY-ONE CASES

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Purpose: The incidence of the postoperative infection following fusion with instrumentation is about 1-6%. The current study was designed to analyze the frequency, nature, predisposing factors and treatment of postoperative wound infection instrumented spinal fusion.
Subjects and Methods: We retrospectively reviewed 850 consecutive instrumented spinal fusions, from 1981-2001, in order to express a single surgeon's experience with postoperative infection. The indications of fusion were, scoliosis (198 cases), kyphosis (50 cases), fractures (397 cases), spinal stenosis (103 cases), spinal instability (53 cases), and tumors (49 cases). The overall rate of postoperative infection was 2.47% (21 patients) after elective posterior or combined anterior and posterior spinal instrumentation. The mean age of the 9 men and 12 women included in the study, was 49 years of age (range of age 23-76 years old). The diagnosis of the infection was based on clinical presentation associated with significant wound drainage (90.47%) and inflammatory indexes. Deterioration of the neurological status was present in two patients (9.52%). A single organism was cultured in seven patients (33.3%). Staphylococcus aureous, with resistance to methyciline, was the most common organism cultured (42.85%, three out of seven patients). Therapeutic management, conservative or surgical, was determined by clinical and laboratory criteria. Repeated debridement followed by delayed closure was performed in seven patients (33.3%). Instrumentation removal was performed in three patients (14.28%) with late infection but only two of them had solid fusion at operation. Bone allograft was removed in the majority of the cases. The surgical treatment was followed by a 6-week course of postoperative antibiotics.
Results: Eighteen of patients (85.71%) were relieved of pain and 50% (one out of two) of patients had neurological amelioration. One patient was re-operated for fusion due to spinal instability and pseudarthrosis, which was attributed to the removal of the implants. The average time of fusion following infection control, was 12.3 months (range 8-23 months), in 97% of patients (20 patients).
Conclusions: The early diagnosis of the infection after spinal fusion with instrumentation, followed by aggressive surgical approach including repeated debridement and delayed closure is recommended. Maintaining the instrumentation in situ is safe and can provide stability. Removal of the implantation is recommended in cases that fusion has occurred.

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ANTIBIOTIC PROPHYLAXIS IN SPINE SURGERY - EVALUATION OF CEFOTIAM PENETRATION INTO THE HUMAN INTERVERTEBRAL DISC

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Objective and Importance: The intervertebral disc is one of the largest avascular structures in the human body. Antibiotics must enter discs by way of passive diffusion through the adjacent bony and cartilagenous endplates and surrounding annulus fibrosus. Spondylodiscitis after lumbar disc surgery is a well-known complication with a frequency of 0 % to 3.7 %. Postoperative spondylodiscitis is the result of intraoperative contamination and can be prevented by treating these patients with prophylactic antibiotics. Antibiotics used for surgical prophylaxis should therefore reach a sufficient concentration in the operation area. The efficacy and distribution into the tissues muscle, ligamentum flavum, bone and disc of a single-shot dose of cefotiam (second generation cephalosporin) as prophylaxis against infections was analyzed.
Methods: We investigated the penetration of cefotiam into human intervertebral discs in correlation to serum level during lumbar and cervical disc surgery in 80 patients so far (ongoing study). All patients received a preoperative intravenous bolus infusion of 2 g cefotiam over a 15 minute period. Intradiscal samples were collected intraoperatively in a bloodless manner, serum was asservated simultaneously. Antibiotic concentrations were analyzed by bioassay.
Result: High cefotiam blood levels were present in all patients. We found a correlation between serum concentration and intradiscal concentration. The concentrations of cefotiam in the discs reached antibacteriological levels (range: 2 - 38 mg/l).
Conclusion: This study demonstrates that cefotiam does penetrate the human intervertebral disc after systemic application in sufficient concentrations. Our results suggest that cefotiam may be a good choice for antibiotic prophylaxis in spinal operations.

LUMBAR SCOLIOSIS

P 67

THE BEHAVIOR OF LUMBAR MODIFIER TYPE C THORACIC SCOLIOSIS IN SELECTIVE ANTERIOR CORRECTION AND FUSION OF THE THORACIC CURVE

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Purpose of the study: Radiometric curve analysis of primary and spontaneous secondary curve correction after anterior instrumentation in idiopathic thoracic scoliosis of only lumbar modifier type C curves.
Methods: 22 patients with idiopathic thoracic scoliosis Lenke lumbar modifier type C were prospectively evaluated. All patients had a selective anterior fusion of the thoracic curve from end- to end-vertebra. Follow-up averaged 32 months. Cobb angles of pri-

mary and secondary curves, the apical vertebral rotation and the deviation of the lumbar apex vertebra of the Center Sacral Vertical Line (CSVL) were measured as well.
Results: There were 13 patients with Lenke Curve Type 1, two with Curve Type 2 and seven with Curve Type 3. 16 patients had a normal (N) sagittal alignment modifier, five had a hypokyphosis (-) and one patient a hyperkyphosis (+). The Cobb angle of the primary curve ranged from 50° to 82° (averaged 66.1°) and was corrected to 23.9° (8-40°). Loss of correction averaged 5.8°. Apical thoracic vertebral rotation was corrected from 25° to 13°. The secondary lumbar curve measured 48.9° (33-64°) preoperatively (62% correction on the bending films) and was corrected spontaneously to 25.2° (10-44°) without relevant loss of correction during follow-up. Apical vertebral rotation averaged 22.3° in the lumbar curve and corrected spontaneously to 16.3°. Lumbar apex vertebra deviation from CVSL was corrected minimal from 3.0 cm to 2.8 cm postoperatively and to 2.4 cm at the latest follow-up on average. The lumbar modifier type C remained unchanged in 20 patients, only in two cases the lumbar modifier type C was corrected spontaneously to a lumbar modifier Type B. There was no case of distal decompensation in the frontal plane.
Complications: Implant related complications were observed in 4 patients (rod breakage), but no pseudarthrosis occurred.
Conclusion: Selective anterior correction and fusion in idiopathic thoracic scoliosis with Lenke lumbar modifier type C enables a satisfactory correction of both primary and lumbar secondary curve when preoperatively Cobbangle of the lumbar curve is smaller than 65°. However, spontaneous derotation and correction of deviation from CSVL of the lumbar curves was minimal.

MINIMALLY INVASIVE

P 68

HIGH THORACIC KYPHOPLASTY

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Introduction: Kyphoplasty is increasingly becoming a recognised minimally invasive treatment op-tion for osteoporotic vertebral fractures and neoplastic vertebral collapse. The technique of Kyphoplasty has been shown to reduce the rate of epidural cement leakage and to restore height in dependance of fracture age.
Since the introduction of Kyphoplasty in 1998 there have however been very few re-ports of treatment of vertebrae of higher thoracic levels.
Material and Methods: Nineteen patients (16 female; 3 male; average age: 68,3) with a total of 25 fractures from T2 to T8 were treated with the extrapedicular Kyphoplasty technique using biplanar fluoroscopy (T2x1; T3x1; T5x2; T6x9; T7x8; T8x4). Twenty fractures were osteoporotic and 4 were due to metastatic collapse (breast-CA, gastric-CA, cervix-CA, plasmocytoma). One type B fracture (T3) required additional internal fixation.
Results: The average augmentation volume was 3,2 ml (2-5ml). Average operation time was 54 minutes and average fluoroscopy time was 3,3 minutes (1,8-7,2 minutes). Blood loss was less than 50 ml in all patients with exception of the patient with the additional internal fixation (250 ml). All but one patient were mobilised on the first postope-rative day and all patients reported significant pain relief. On follow-up (range: 1 week - 1 year), pain relief was maintained.
Complications: There was epidural cement leakage in one patient (Gastric-CA meta-stasis) without neurological deficit and one deep vein thrombosis.
Conclusions: Kyphoplasty in mid- and high thoracic levels can be performed safely. Pain relief is as efficient as in lower levels. With regard to cement leakage, Kyphoplasty in the mid- and high thoracic levels offers a high degree of control.

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PERCUTANEOUS DECOMPRESSION STIMULATES REPAIR IN INJURED PORCINE INTERVERTEBRAL DISCS

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Background: Discectomy is an effective treatment for radiculopathy due to an extruded disc. Although success rates are not as high, individuals with contained herniations without frank neural compression, can also be effectively treated. This may be due to subtle changes in pressure on the nerve that accompany removal of disc. Alternatively, it may be caused by changes in disc biology. Consequently, whether the therapeutic effects of discectomy are mechanical (relief of pressure) or biological (decreased inflammation and/or synthesis of matrix) is unresolved.
Purpose: Determine the effect of percutaneous decompression on the histologic, morphologic, biochemical, and biomechanical features of degenerating intervertebral discs.
Study design: A porcine model of disc degeneration was utilized to establish a degenerative baseline against which to evaluate discectomy efficacy.
Outcome measures: Histology and morphology images were rated for degenerative findings (of cells and matrix) in both the nucleus and annulus. Cytokines IL-1, IL-6, IL-8 and TNF-_ were measured from tissue samples using ELISA. Intact specimen stiffness was measured biomechanically. MRI images were collected for biomechanical specimens.
Methods: Utilizing a retroperitoneal surgical approach, stab incisions were made in 4 or 5 lumbar discs per spine in twelve pigs. Animals were allocated into one of three groups: 6 week recovery, 12 week recovery, and percutaneous decompression utilizing an electrosurgical device at 6 weeks with recovery for 6 additional weeks. Four animals served as controls.
Results: Discs treated with discectomy had a significant increase in IL-8 and a decrease in IL-1 as compared to the 12-week, non-treated discs. On morphological grading treated discs were less degenerated than time-matched, non-treated discs.
Discussion: The temporal pattern of cytokine production initiated by discectomy may have important implications for disc healing. Discectomy appears to stimulate a healing response, mediated by IL-8, which can mitigate the progression of degeneration initiated by acute trauma. Thus, the clinical efficacy of discectomy may due to more complex mechanisms than reduction of disc pressure. Methods for treating painful discs may be enhanced by improved awareness of disc healing mechanisms, which may be dysfunctional in LBP patients. Pharmacologic manipulation of cytokine networks is an especially promising avenue for research.

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MINIMAL INVASIVE INTERLAMINAR ENDOSCOPIC LUMBAR DISC SURGERY. RESULTS AND COMPLICATIONS OF 125 PROCEDURES

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Summary: Minimal invasive surgery is an important means of reducing tissue trauma and patient mobidity.

The advantage of posterior interlaminar endoscopic disc surgery is that almost all pathologies including spinal stenosis and stenosis of the lateral recessus can be treated.
By using a very limited approach the scar formation can be minimized. Results and complications of this exciting technique shall be analysed.
Methods: Prospective studie of 125 patients (78male, 47 female, average age 45 years) with herniated lumbar disc (8 L3/4, 62 L4/5 and 63 L5/S1) who underwent endoscopic disc sugery with the Metrxâ System (Medtronic Sofamor Danek). Complications and results after at least 3 months were noted.
Results: Mean surgical time was 42 minutes, mean surgical time for the first 25 patients 79 minutes. Most complications occurred during the first 30 procedures. Dural tear 5 cases, aseptic discitis in 2 cases, early recurrent disc herniation in 2 cases. 11 patients needed therapy due to edema of the nerve root. No complications occurred in our last 50 cases. After at least 3 months excellent results were noted in 22,5%, good results in 57%, moderate results in 10% and bad results in 10% of the patients. Endoscopically operated patiens could be mobilized very early after surgery compared to "conventional" microscopical cases, the use of additional pain medications was significantly reduced. Due to preexisting osteochondrosis in 3 patients a fusion was performed in these cases after 9 months.
Conclusions: Our results are at least as good as in –conventional microsurgical surgery. Most complications occured during our first surgerys, the endoscopic technique is technically demanding a learning curve of about 30- 40 cases is necessary. The postoperative pain is significantly reduced compared with open microsurgical techniques. Due to our results endoscopic interlaminar disc surgery is our method of choice in herniated lumbar discs, microsurgical procedures are reserved for cases with known spinal varicosis or old patients with a very narrow interlaminar space and hypertrophic facet joints.

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A COMPARISON OF EARLY EXPERIENCE OF MICRO ENDOSCOPIC DISCECTOMY TO STANDARD MICRO SURGICAL DISCECTOMY

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Aims: The aim of this study was to undertake a prospective evaluation of the results and complications of Micro Endoscopic Discectomy (MED) and Micro Surgical Discectomy (MSD).
Methods: 30 Patients in total were recruited over a 28-month period. This included the first 15 patients who underwent MED and 15 patients who underwent MSD. There was no significant difference between the two groups concerning age and sex distribution, occupation, preoperative time of work and clinical symptomatology. The disc herniations were located at either L4-5 or L5-S1 in all patients. All Patients were followed prospectively up for an average of 9 months (Range 2-22 months). Outcomes were measured using the Oswestry Disability Index (ODI) and the Greenough and Fraser Score (GFS).
Results: Similar improvements in ODI and GFS were observed in both groups. However, the MED group appeared to require less postoperative analgesia in particular opioid based preparations. In addition patients undergoing MED tended to be discharged earlier. The only complication was in the MED group where one patient required conversion to MSD due to a dural tear.
Conclusion: Our results indicate that MED is at least as effective as MSD, although it initially takes longer to perform due to the learning curve. However, the decrease in post operative analgesia requirements and earlier discharge is beneficial. Overall, we feel it has advantages over other minimally invasive techniques such as the percutaneous posterolateral discectomy for nerve root compression, which cannot treat sequestrated discs, or patients with disc herniations associated with recess stenosis.

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A PROSPECTIVE STUDY OF PERIRADICULAR INJECTION FOR PAIN IN HERNIATED LUMBAR DISC AND UNILATERAL SPINAL STENOSIS

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Objectives: To investigate the therapeutic value and prognostic factors associated with periradicular infiltration for radiculopathy in patients with either lumbar disc herniation (LDH) or spinal stenosis.
Methods and results: To date, no studies have investigated the therapeutic value of a single periradicular infiltration for radiculopathy in spinal stenosis. There is only one double blind RCT of periradicular injection in sciatica due to herniated nucleus pulposus. 55 patients with LDH and 62 patients with spinal stenosis with leg dominant pain who met the strict inclusion criteria received fluroscopically guided periradicular infiltration of local anaesthetic and steroids at the site of their documented pathology. All the patients were followed up for 3 months. The outcome measures included the change in Oswestry disability index score (ODI), Low back outcome score (LBOS) and visual analogue scale (VAS) for radicular pain. Clinical improvement is defined as a reduction in ODI by 10%. The prognostic value of the duration of symptoms, psychological measures, age, gender, occupation and neurological signs were investigated using multiple regression analysis and Chi-square analysis. The mean change in ODI for LDH group was 12.9% compared to 5.6% in the spinal stenosis group. The post-injection change in VAS for LDH and spinal stenosis were 20mm and 12mm respectively. There is a statistically significant difference in the outcome between the two groups. 58% of the patients with LDH have a significant clinical improvement compared to only 37% of the patients with spinal stenosis. Pre-injection Modified Somatic Perception, Modified Zung Depression and age have prognostic value for LBOS. Only age has predictive value for change in ODI and post-injection VAS. We have not found a predictive value for the duration of symptoms, age, gender, occupation, Lasegue and cross Lasegue sign.
Conclusion: There is a significantly better response to root block for radicular pain for patients with LDH than spinal stenosis. We do not know if this is treatment effect or natural history of the pathology.

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ENDOSCOPIC ANTERIOR DECOMPRESSION OF THE SPINAL CANAL IN SPINAL TRAUMA - TECHNIQUE AND RESULTS OF 34 CASES

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Objectives: Anterior decompression of the spinal canal via conventional approach requires extensive surgical exposure. Attempting to reduce morbidity associated with thoracotomy, we used minimal invasive thoracoscopic technique for anterior decompression of the spinal canal in thoracic and thoracolumbar injuries. The purpose of this retrospective study is to demonstrate the standardized

operation technique and the effectivity of the endoscopic procedure.
Material and Methods: Since February 1997, 34 patients with fractures of the thoracic and thoracolumbar spine and significant narrowing of the spinal canal underwent thoracoscopic spinal surgery. Resection of retropulsed vertebral fragments and protruded intervertebral discs were performed endoscopically. followed by vertebral body replacement and anterior instrumentation with locked-screw-plate. Pre- and postoperatively, conventional X-ray and CT-scan were obtained to control complete clearance of the spinal canal and correct placement anterior instrumentation.
Results: 34 patients, 7 female, 24 male underwent endoscopic anterior decompression of the spinal canal. The average age was 42 years (21-71 years). Mean follow-up was 39 months (6 -72 months). 3 patients (9%) has been lost to follow-up. Most injuries occurred at the thoracolumbar junction (30/34 patients). In 15 patients (44%), a detachment of the diaphragm was performed endoscopically to gain approach to the upper lumbar spine. The average operative time was 260 minutes. Mean preoperative narrowing of the spinal canal was 55% (44% to 71%). A complete clearance could be achieved in 97% (33/34 patients). In one patient with primary hemilaminectomy the retropulsed anterior fragment has been incompletely removed. Postoperatively no additional neurological deficit occurred except of one patient with transitory worsening of the preoperative status.
Conclusion: Anterior decompression of the spinal canal and anterior instrumentation of the thoracolumbar spine can safely and effectively be performed using minimal invasive thoracoscopic technique. Clearance rates are comparable to open technique and morbidity associated with conventional thoracotomy and thoracolumbar approaches is reduced

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INFLUENCE OF CAGE GEOMETRY ON SAGITTAL ALIGNMENT IN INSTRUMENTED SHORT-SEGMENT PLIF

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Introduction: Purpose of this study was to determine whether rectangular and wedge shaped cages have a different influence on sagittal alignment of the lumbar spine in short-segment instrumented PLIF.
Patients and Methods: Forty two patients having undergone instrumented short-segment posterior lumbar interbody fusion between L3 and S1were reviewed retrospectively. Twenty-two patients (12 women and 10 men, 38 - 78 years) had PLIF with rectangular cages (RC): 13 single- and 9 double-level fusions. Twenty patients (8 women and 12 men, 34 - 81 years) had PLIF with wedge shaped cages (WSC): 10 single- and 10 double-level fusions. All patients had additional pedicle screw fixation, the operative technique was standardized. Pre- and postoperative standing lateral radiographs were assessed for segmental and lumbar lordosis as well lumbar and sacral tilt.
Results: Mean follow-up was 18 months. Mean segmental lordosis of fused segments showed significant differences (P<0,05): Segmental lordosis decreased in the RC group from 10° to 2° at L3-L4, from 10° to 5° at L4-L5 and from 9° before to 6° after fusion surgery at L5-S1. In the WSC group segmental lordosis increased from 4° to 7° at L3-L4, from 2° to 8° at L4-L5 and from 9° to 17° at L5-S1. Analysis of changes in lumbar lordosis, lumbar and sacral tilt did not show significant differences though opposite trends: Lumbar lordosis decreased from 55° to 48° in the RC group and increased from 45° to 53° in the WSC group. Lumbar tilt measured 98° prior to and 102° after surgery in the RC group and 97° before and 94° after surgery. Sacral tilt measured 44° prior to and 40° after surgery in the RC group and measured 42° prior to and 45° after surgery in the WSC group.
Conclusions: The cage geometry has a significant impact on the alignment of the lumbar spine after instrumented PLIF. With rectangular cages lumbar lordosis and segmental lordosis of the segments fused decrease, sagittal balance is maintained by compensatory changes of the sacral tilt. Wedge shaped cages significantly increase segmental lordosis, enhanced lumbar lordosis and therefore should be preferred for restoring sagittal alignment in instrumented PLIF procedures.

NAVIGATION TECHNIQUE

P 75

THE PLACEMENT OF PERCUTANEOUS SPINAL INSTRUMENTATION USING THREE-DIMENSIONAL FLUOROSCOPY

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Purpose: Three-dimensional fluoroscopy uses a 2-D isocentric C-arm fluoroscope to intraoperatively generate a 3-D data set that can be used for navigation when coupled with an image guidance system. The authors sought to evaluate the accuracy of 3-D fluoroscopy, and investigate a method for the placement of percutaneous spinal instrumentation in a human cadaver model.
Methods: An isocentric C-arm was used to obtain CT images of the spines of 3 intact cadavers. A percutaneous dynamic reference array (DRA) was attached to the C2 spinous process of each specimen for the cervical instrumentation. The DRA was attached to the spinous process immediately cephalad to the three levels to be instrumented in the thoracolumbar region, then moved as necessary. Light-emitting diodes attached to the C-arm were tracked with an electro-optical camera. The image data set was then transferred to the image-guided workstation, which performed an automated registration. Using the workstation, trajectories were planned for bilateral C1-2 transarticular, C3-6 lateral mass, and C7-L5 pedicle screw placement. Thoracolumbar screws were placed in all pedicles ç› 4mm diameter. Through 1.5 cm incisions a drill guide fitted with light-emitting diodes was used for sequential, image-guided drilling, tapping, and placement of cannulated 4.0åC6.5 mm screws at each level. Post-procedure, the specimens were assessed with thin-cut CT scanning to determine the accuracy of screw placement.
Results: A total of 36 cervical and 94 thoracolumbar screws were placed (8 thoracic pedicles were < 4mm diameter). 124 of 130 screws (95%) were placed accurately, completely within the cortical margins. This included 35/36 (97%) in the cervical region, 59/64 (92%) in the thoracic region, and 30/30 (100%) in the lumbar region. One of the C7 pedicle screws had a minor (< 2mm) cortical wall violation. Two of the thoracic pedicle wall violations were < 2 mm outside of the cortex and the three others were between 2 and 3 mm.
Conclusions: This study demonstrates the feasibility of performing completely percutaneous image-guided spinal instrumentation procedures. Three-D fluoroscopy generates intraoperative CT images that can be automatically registered with an image-guided surgery system. The combination of these technologies enables accurate, percutaneous spinal navigation.

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COMPUTER ASSISTED POSTERIOR INSTRUMENTATION OF THE CERVICAL SPINE - PEDICLE CREWS AND TRANSARTICULAR SCREWS C1/2

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Purpose of Study: Transarticular C1/2 screws are widely used in posterior atlanto-axial instrumentation. Pedicle screws in the cervical spine are uncommon until now. Due to improved biomechanical stability compared to lateral mass screws pedicle screws could be used, especially for patients with poor bone quality or defects in the anterior column. Nevertheless there are potential risks of iatrogenic damage to the spinal cord, nerve roots or the vertebral artery related to posterior cervical spine instrumentation techniques. Therefore the aim of this study was to evaluate whether C1/2 transarticular screws as well as transpedicular screws can be applied safely intraoperatively and with high accuracy using a computer-assisted surgery system.
Materials and Methods: 22 consecutive patients with post. occipito-cervical, cervical or cervico-thoracic instrumentation with transarticular screws C1/2 or pedicle screws operated by one surgeon were evaluated prospectively. In 12 patients 24 transarticular screws C1/2 and in 10 patients 58 pedicle screws were used. Indications were instabilities due to rheumathoid arthritis in 6 patients, rupture occipito-cervical instabilities due to rupture of the alar ligaments in 4 patients and dens non-union in 2 patients for transarticular instrumentation as well as cervical spinal stenosis in 3 patients, cervical spine fractures in 3 patients, spinal metastasis in 4 patients for transpedicular instrumentation. In 6 patients the occiput was included in the instrumentation. The patients were instrumented with the neon occipito cervical systen, for computernavigation the Brainlab System with the Spine 5.0 software was used. The registration of the vertebra was done with surface matching algorythms after fixing a dynamic reference base with a clamp at the spinous proces of the instrumented vertebra. Registration was done for each instrumented vertebra. The mean additional instrumentation time due to the use of the comuternavigation system was 10 minutes per vertebra. The mean age at operation was 48.3 years (32-78). For evaluation a postoperative CT with multiplanar reconstructions in the screw axis was done to evaluate the position of the screws.
Results: No implant related complications were observed. No neurological or vascular complications were found related to pedicle screws or transarticular C1/2 screws. The malplacement rate of the pedicle screws was 3.5% (2 screws) and in all cases below 1 mm displacement, no malplacement of transarticular C1/2 screws was found.
Discussion: This study showed that transpedicular screws as well as C1/2 transarticular screws can be applied safely and with high accuracy using a CAS system

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A PERCUTANEOUS TECHNIQUE FOR PEDICLE INSTRUMENTATION USING IMAGE GUIDANCE

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Hypothesis: Image guided surgery offers enhanced accuracy in percutaneous spinal procedures.
Methods: An experimental study on a pig cadaver model.A 4mm diameter(10cm long) screw was inserted transversely into the spinous process of a pig cadaver spine through a 2cm midline skin incision using fluoroscopy.A bicortical purchase was necessary.The dynamic reference base of the image guided system was attached to the screw superficial to the skin. Using navigation techniques, 3.2 mm diameter guide-wires were inserted into both pedicles at each level.Real Trajectory was confirmed with fluoroscopy in AP and Lateral views and printed as a hard copy.Hard copy X-rays were then compared to the virtual trajectory saved on the navigation system hard drive.Accuracy of wire placement was calculated.In order to quantitatively assess the spatial accuracy of this approach the X-rays were registered with the virtual representation produced by the planning system. This was accomplished in an automated way by minimization of linear correlation between the corresponding images.
Results: In total,20 pedicles were instrumented at 10 levels from Dorsal 7 to lumbar 4

Mean estimate of accuracy for dorsal levels-AP and Lateral:(mm)
D7 = 2
D8 = 1.5
D9 = 1.5
D10 = 2.33
D11 = 1.75
D12 = 0.5
Standard Deviation = 1.857
Mean for all Dorsal = 1.452(mm)

Summary of lumbar levels:(mm)
L1 = 1.25
L2 = 2.25
L3 = 0.75
L4 = 0.5
Standard Deviation = 1.187
Mean for all Lumbar = 1.047(mm)

Discussion: Small incisions at each spinous process (2cm) were made. Three pig cadaver spines were used. The accuracy of Dorsal levels=1.45mm (SD = 1.86). The accuracy of lumbar levels = 1.05mm (SD = 1.19). Lumbar pedicle instrumentation showed more accuracy when compared to dorsal pedicle instrumentation. The error of navigation that was accommodated by the image guidance system was = 2mm. Overall X-ray radiation was reduced for each level. There was correlation between X-ray copies vs virtual trajectory.
Conclusions: Our data indicates that a safe percutaneous technique using navigation can be developed. This has potential benefits in vertebroplasty, pedicle, and upper cervical fixation, by minimising soft tissue dissection.

NEW TECHNIQUES

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PLIF TECHNIQUE IN THORACOLUMBAR SPINE FRACTURES: AN ALTERNATIVE TO COMBINED PROCEDURES

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The different treatment options of dorsolumbar spine fractures are still discussed very controversially. The aim of any procedure - either conservative management or surgical technique - is the improvement of neurological symptoms, restoration of anatomy and painfree clinical stability of the spine. Therefore solid bony fusion of the injured segments in proper balanced position is supposed to be mandatory. Classical posterior instumentations and fusion tech-

niques have proven very valuable in clinical praxis but are frequently afflicted with a remarkable loss of correction resulting in secundary kyphotic deformity. Anterior intersomatic strut grafts and/or cages have proven to be superior and can prevent major deformities in most cases. Nevertheless in comparison of both methods combined procedures are more effortsome, the rate of complications and the morbidity in general is reported to be significantly higher than in single posterior procedures. A modified PLIF procedure allows the clearance of the spinal canal, the resection of the damaged intervertebral disc under visual control and also an anterior repair by cortico-cancellous bone grafts in a pressfit technique by a single posterior approach.
Surgical technique: The injured segment is distracted by a spreader and a one side flavectomy is performed. After partial resection of a hemifacet the posterior wall fragment as well as the intervertebral disc easily can be reached by the transforaminal access. The torn disc and bony fragments can be removed and the defect can be filled with matching strut grafts. Taking away the distraction device and by additional posterior shortening with the implants the grafts are squeezed in between the vertebral bodies. Additional posterior bone grafting is obligate. Up to now 48 patients with dorsolumbar spine fractures have been treated by hemifacettectomy and this PLIF technique in the last 2,5 years. There was no intraoperative complication, especially no neurological deterioration. In 28 patients at least 12 month results are present. In 19 patients the loss of correction was less than 5 degrees and in only two patients the loss of correction was more than 10 degrees. In 27 of 28 patients a CT scan one year after surgery confirmed an anterior fusion of the grafts. During implant removal in one patient a pseudomeningocele was found but without any clinical correlation or consequence. The procedure is effective and reliable and can lead to excellent radiological and clinical results. The repair of the anterior column of the spine by the posterolateral approach - especially in cases when a clearance of the spinal canal seems to be necessary - can be a valuable alternative to combined procedures.

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E.L.I.F. FOR TREATMENT OF L5-S1 PATHOLOGY. (EXTRA-FORAMINAL LUMBAR INTERBODY FUSION)

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A lumbar interbody fusion of L5-S1 using an extra-foraminal approach was performed on 23 patients. The technique and results are presented below.
Background: Our previous series demonstrated the quality and low morbidity of the extra-canalar and extra-articular E.L.I.F. approach. Until recently, the extra-foraminal route was only possible for disks L4-L5 and above. At the L5-S1 level, a 30 degree access is blocked by the iliac alae. Furthermore, L5-S1 is accompanied by a large L5 transverse process and the sacral alae which further diminishes the inter transverse space where the surgeon would like to pass.
Surgical technique: Bilateral incision on the posterior iliac crest. The lumbar aponeurosis is resected down to the iliac crest. The internal iliac wing then the sacral alae are followed up to the L5-S1 articular mass. At this level, the approach regains the intermuscular plane of the E.L.I.F., between the longissimus and the multifidus, freeing the L5 transverse process. Approaching the disk requires a resection of the external part of the articular mass and especially of the sacral alae. In the first eight surgeries, this partial resection was not done, causing a transient foraminal radiculagia for these cases. The L5 root, thus freed, is gently inclined without tension laterally to perform discectomy. The insertion of bilateral interbody cages in carbon composite are impacted according to the usual E.L.I.F. technique. Cages were filled with autograph from the iliac crest. Addition bone was placed between the cages. No pedicle fixation was added.
Material and methods: Twenty three patients presented degenerative discopathy with leg and back pain. In twenty patients the associated lesions were isthmic spondylolisthesis (7 patients), degenerative retrolisthesis (9), disk herniation of small volume (4) Patients presenting spinal stenosis within the canal, or central disc herniation, were excluded from the series. These cases were treated with a P.L.I.F., pedicle fixation and surgical decompression. Patients were examined post-op, at 1, 3, and 6 months intervals, using the Lickert scale. Plane radiography, flexion-extension, myelography, MRI or CT scan were performed. Prior to surgery, fusion was accessed at 6 months using sagittal CT reconstruction.
Results: Radiological fusion was observed in the 23 cases. One cage required re-implanting by anterior approach following an accidental perforation of the anterior longitudinal ligament when inserting the cage. No vascular, visceral or other neurological complications were observed except one transient SPE.

Clinical outcome:

	Pre op N=23	3 months N= 23	6 months N=23	12 months N=13
Back pain	4.21	1.85	1.4	1.45
Leg pain	3.73	0.78	0.52	0.38
Medication				
- No			14	12
- Paracetamol			9	1
Normal daily activity	0		19	

AT 6 months 11/14 patients returned to work. All except 4 patients were improved.
Conclusion: The L5-S1 extra-foraminal approach (E.L.I.F) facilitates a good-quality interbody fusion with few complication. These early results can be compared to those obtained for the same indications by other approaches, P.L.I.F. or A.L.I.F. Further study of the E.L.I.F. at L5-S1 is warranted.

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NEW INDICATIONS FOR THE POSTEROLATERAL SUBMUSCULAR APPROACH TO THE LUMBAR SPINE

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Introduction: Commonly used posterior approaches to the lumbar spine involve the risk of injury to the erector spinae muscle with serious consequences. This is minimized with the posterolateral submuscular approach (PSA) (Watkins 1953, Ray 1983). This report should call the approach to mind and show its usefulness for two new indications: Pedicle fixation and extraforaminal PLIF (EPLIF).
Technique: (1) Short Bilateral incision, 2 cm medial to the lateral border of the erector spinae. (2) Incision of the superficial fascia medial to its fusing with the deep aponeurosis lumbalis. (3) Blunt dissection below the muscle and along the aponeurosis down to the transverse processes and facet joints. The next steps depend upon the purpose of the procedure: (a) Posterior fusion and/or pedicle fixation; (b) removal of an extraforaminal disc herniation; (c) EPLIF. Procedure (a) only requires steps 1, 2, and 3. In (b) and (c) the intertransverse structures are resected. The exiting nerve root is identified and the foramen exposed. For an EPLIF the annulus is exposed, the disc is curetted and the intervertebral prosthesis implanted into the disc space from outside the intervertebral foramen.

The EPLIF can be performed bilaterally or unilaterally as well as through a keyhole approach.
Material: Since June 2000 the PSA has been applied in 44 patients for foraminal and extraforaminal disc herniations (30 patients), EPLIF (12 patients), and elastic pedicle fixation (2 patients). 6 EPLIF were performed biportally and 6 uniportally. 4 types of intervertebral prostheses were used. 11 patients had EPLIF at one level (L3/4, L4/5) and one at two levels (L3/4/5). 2 patients underwent ALIF L5/S1 and one L4/S1 with EPLIF at the adjacent level. 11 EPLIF were stabilized by pedicle fixation and one by translaminar pin fixation. No approach-related complication occurred.
Conclusions: The need of two incisions is offset by significant advantages: No or minimal destruction of posterior vertebral elements; minimal injury to the erector spinae muscle; less postoperative pain. The PSA is well suited for the new indications. Its oblique direction facilitates the insertion of pedicle screws, the removal of disc material as well as the insertion of intervertebral prostheses.

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INTERBODY FUSION: T.L.I.F. VS. P.L.I.F. WITH IMPACTED CAGES POSSIBILITIES AND LIMITS FOR THE RESTORATION OF DISC SPACE HEIGHT. A COMPARATIVE STUDY.

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Introduction: The TLIF (Trans Foraminal Interbody Fusion) is growing in popularity with the hope that a unilateral approach will reduce morbidity as compared to a bilateral PLIF approach. But can similar segmental corrections be achieved with a TLIF, as compared to the PLIF, which are so important to a successful clinical outcome? During an interbody fusion, the following things contribute to neurological decompression and spinal balance:

- restoration of the disc height, and consequent opening of the foramen
- correction of rotation in the coronal plane.
- correction of lordosis in the sagittal plane.
- possible reduction of a slip

The purpose of the study was to determine if the TLIF construct achieved similar correction as compared to the PLIF.
Materials and Methods: From 1992 to 1996, 120 PLIF interventions were performed on 150 levels. All patients had bilateral pedicle fixation and impacted cages. Between 1997 to 1993, 170 patients received a TLIF with impacted cages for 200 levels, in association with unilateral and at times, bilateral pedicle fixation. However, in these cases the spinal canal was left untouched on the side opposite the Transforaminal approach. All interbody fusion was performed with impacted cages and patient autograft. The author performed all cases. This is a retrospective study. The patient radiographs were evaluated pre-op, post op and at 1 year. The following parameters were evaluated from the radiograph:

- the general quality of the vertebral endplates pre op,
- interspace height and lordosis, at pre-op, immediate post op and at 1 year
- the height, length, angle and positioning of the impacted cages,
- the contribution that pedicle fixation made upon the lordosis of the segment fused.

Results: Overall, corrections for the PLIF and TLIF series were quite similar pre-op, immediate post-op and at 1 year. There were some circumstantial differences that will be presented.
Conclusions: In this series the similar radiographic results lead us to conclude that the TLIF and PLIF assure similar biomechanical and biological correction. However, the TLIF can still be improved and this series has lead us to modify our technique and instrumentation to facilitate the placement of the cages.

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COMPARISON OF TRADITIONAL ILIAC CREST BONE GRAFT HARVESTING WITH INTRAFASCIAL APPROACH

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Introduction: The amount of graft harvested and the donor site complications were compared with traditional posterior iliac crest bone graft harvesting (Group1) versus intrafascial bone graft harvesting technique (Group 2).
Methods: Beginning in February 1999, a prospective, randomized clinical study was made with a minimum of 2 year follow-up and a mean of 33 months. A prospective chart review and interview was performed on 117 adult patients that underwent low back posterolateral spinal fusion with iliac crest bone graft. Group 1 had 59 patients (27M, 32 F; mean age 51) and Group 2 had 58 patients (24M, 34 F; mean age 48).
Results: The mean amount of graft obtained with traditional graft harvesting (17.22 cc) was more than the technique obtained with intrafascial approach (14.71 cc) ($p<0.05$). None of the patients in Group 1 had sacroiliac joint penetration during surgery. 15 patients had pain at donor site at 6th month follow-up. At 12th month follow-up 10 patients complained of iliac crest pain on a scale of 1-10, ranged from 1 to 7 with a mean of 4.5. Eight of them were in the need of NSAID medication. 14 patients were complaining of numbness on the scar. A patient in Group 2 had sacroiliac joint penetration that caused pain. 8 patients in Group 2 complained of iliac crest pain 5 resolved by the 3rd postoperative month. The pain in three patients left was not interfering daily activity. At last follow-up the self reported pain on a scale of 1-10, ranged from 2 to 4 with a mean of 3. Two of them were taking NSAIDs for pain. In Group 2 no patients were complaining of numbness.
Discussion: The intrafascial graft harvesting technique minimizes the morbidity (hematoma formation, iliac crest pain) compared with traditional harvesting. Another advantage of intrafascial graft harvesting is the no requirement for a second skin incision. The inner and outer cortices of the ilium were preserved. The cluneal nerves were not in the risk of damage with intrafascial approach. Due to its lower complication rate the intrafascial graft harvesting should be preferred to traditional iliac crest harvesting.

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TREATMENT OF RECURRENT HERNIA BY ANTERIOR APPROACH AND LUMBAR DISC PROSTHESIS: RESULTS ON 21 PATIENTS WITH A MINIMUM OF TWO YEARS FOLLOW-UP

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Purpose of the study: Is there a place for anterior approach and lumbar disc prosthesis avoiding fusion in the treatment of patients with chronic low back pain and acute sciatica due to a recurrent hernia some years after one posterior surgery?
Material and methods: 21 patients had severe sciatica with a recurrent hernia two years later (in average) a posterior surgery for disc hernia at the same level.They all had chronic low back pain with fair result after the first surgery.MRI and discography-CT

confirm the hernia sometimes through the posterior ligament but not extruded ; 9 patients had some bone reaction (Modic sign).To avoid a new posterior surgery increasing scarr tissue around the root, we did an anterior extra-peritoneal approach with complete excision of the pathological disc including the hernia and implantation of a lumbar disc prosthesis SB Charité Link*: 14 in L5S1 and 7 in L4L5.They were 12 male and 9 female,age 37, operated between 1993 and 2001.

Results: With an average follow-up of 4 years, we deplore very few complications:one epidural veins bleeding and one case of incomplete peripheric ossifications and no secondary fusion. Only one patient have moderate radicular pain in the long term which is much less than after recurrent posterior surgery. All prosthesis were mobile with (in average) 12°5 on flexion_extension films and 5° on bendings. All the patients had excellent (9) or good (12) results among the Stauffer-Coventry-Cauchoix classification and 19 among 21 recovered the same job.

Conclusion: Anterior approach and lumbar disc prosthesis is a good choice for recurrent hernia and chronic low back pain some years after the posterior surgery. Morbidity is low, functionnal results are better than after a new posterior surgery with or without fusion. SB Charité Link* prosthesis is still efficient in the long term and 90% of the patients did recover the same job.

OSTEOPOROSIS

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THE EFFECT OF VERTEBROPLASTY ON THE LOAD TRANSFER IN AN OSTEOPOROTIC FUNCTIONAL SPINAL UNIT

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As life expectancy increases, age-related disorders and the search for related medical care will expand. Osteoporosis is the most frequent skeletal disease in this context with the highest fracture risk existing for vertebrae. Osteoporotic compression fractures are increasingly treated by vertebroplasty, resulting in immediate, reliable pain relief and a low complication rate. Experimental studies have shown significant increases of stiffness and strength for single treated vertebral bodies. However, the consequences of vertebroplasty for the adjacent, non-treated levels are unclear, as fractures may be facilitated by the rigid cement augmentation. The purpose of the presented finite element analysis was to determine changes in the load transfer due to vertebroplasty. 3D finite element models of healthy and osteoporotic L2-L3 functional spinal units (FSU) were developed. The geometry was based on reconstructed CT scans. Osteoporosis was modelled by decreasing the material properties of all bony structures. Uni- and bipedicular cement filling with PMMA was modelled. The following loading conditions were simulated: pure compression, flexion and lateral bending. The results of the treated FSU were compared to those of non-treated FSUs.

Vertebroplasty changed the overall displacement behaviour of the FSU, increased the pressure in the nucleus pulposus and the deflection of the adjacent endplate. The stresses and strains in the vertebral body next to an augmentation were increased and their distribution changed. Larger areas were subjected to higher stresses and strains. The treatment clearly altered the load transfer within the FSU. Unipedicular augmentation decreased the overall amount of changes, whereas the osteoporotic bone definition increased the differences. Vertebroplasty restores the strength of treated vertebrae, but leads to decreased failure load of FSUs, increased stresses and strains in adjacent vertebrae and an altered load transfer through the whole functional spinal unit. The increased endplate deflection may lead to endplate fracture and in consequence provoke further changes in the load transfer promoting the complete failure of the vertebral body. These findings support the hypothesis that rigid cement augmentation may facilitate the subsequent collapse of adjacent vertebrae. Further study is required to determine the optimal reinforcement material and filling volume to possibly minimise this effect.

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FACTORS AFFECTING A POSITIVE CLINICAL RESPONSE TO PERCUTANEOUS VERTEBROPLASTY

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Objective: To determine the factors affecting the outcome of percutaneous vertebroplasty (PV) for the treatment of persistent painful osteoporotic fractures.

Methods: A retrospective review of 212 patients who underwent PV for osteoporotic fracture at 325 levels. Age, sex, level of fracture, number of vertebrae treated, bone mineral density, duration of symptoms, vertebral body height, MRI imaging, bone scan imaging, preprocedural ASA staging and the presence of cement leaks at post procedural CT were analyzed as parameters for prognosis significance by univariate analysis. Multivariate analysis with logistic regression was employed in 127 patients with only one level affected, to estimate the strength of influence of each variable. Excellent outcome was defined as subjective decrease in pain severity below 3 in a visual analogue scale (VAS). VAS between 4 and 6 was considered as a good result, and VAS above 7 was considering a poor result.

Results: Preprocedural VAS was 8,65 (range 6-10), decreasing to 2,93 (range 0-8) after the vertebroplasty. VAS scale decreased to less than 3 in 66% of the patients and to 4-6 in 25% of the cases. The female sex ($p=0,045$), the presence of less than 2 symptomatic vertebrae ($p<0,01$), the age of fracture less than 5 months ($p<0,01$), the ASA status of I ($p<0,01$), increased activity revealed by bone scan imaging ($p<0,01$), the presence of signal changes on MRI ($p<0,01$) and the collapse of the vertebral body less than 70% ($p<0,01$) were assessed as parameters for prognosis significance. Multivariate analysis also showed a significant correlation between MRI changes and collapse of the vertebral body and the final outcome ($p<0,01$). Patients in which both parameters were present, the VAS decreased to less than 3 in 84% of the patients and to 4-6 in 16% of the cases.

Conclusions: Percutaneous vertebroplasty is a very efficient procedure for pain that is refractory to conservative treatment due to osteoporotic vertebral fracture. Appropriate patient selection is essential to achieving clinical success. Better results can be expected when the level treated is confirmed by MRI and/or bone scan and the vertebral body height lost is less than 70%.

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PULMONARY EMBOLISM OF POLYMETHILMETHACRILATE AFTER PERCUTANEOUS VERTEBROPLASTY

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Objectives: Vertebroplasty is a minimally invasive technique that is useful for handling pain in vertebral fractures due to osteoporosis and vertebral metastases. Nevertheless, this technique is not exempt of serious complications, and among them pulmonary thromboembolism (PTE) stands out. The objective of this work is to analyse the incidence of cement leaks to the lungs after carrying out a vertebroplasty.
Methods: The clinical histories of 239 patients treated with vertebroplasty due to osteoporotic vertebral fracture (212) or vertebral metastases (27) were revised. In 29 of these patients a thoracic CT scan was performed after the procedure. The CT images are revised searching for the presence of cement, as well as the radiographic and CT images of the treated vertebrae.
Results: Of the 29 patients, there were 18 women and 11 men, with an average age of 61 years (range, 33-81). Vertebroplasty was performed in 19 osteoporotic vertebrae and in 21 due to metastases. In none of the cases specific vertebroplasty cement from those actually available was used. In the postprocedure vertebral CT scans cement leaks were observed in 63% of cases. In pulmonary CT scans the presence of cement was observed in a patient treated at three levels due to osteoporotic vertebral fractures. The CT scan was performed 4 months after the procedure due to an exacerbation of heart failure and respiratory failure.
Conclusions: Cement leaks during vertebroplasty are frequent (up to 72%) and are generally asymptomatic. PTE due to cement can be a very serious complication. In none of the cases described in the literature specific vertebroplasty cement was used. Of the results found in this study it seems that the incidence may be higher than previously described in the medical literature, since on occasions it can pass unnoticed. Proper techniques and the use of new cements can decrease the incidence of this complication.

OUTCOME

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EVALUATION OF OXIPLEX®/SP GEL ON DURAL HEALING IN A MODEL OF EPIDURAL FIBROSIS IN RABBITS

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A bioresorbable, anti-adhesion gel consisting of carboxymethylcellulose and polyethylene (Oxiplex®/SP Gel) has been developed to reduce the development of epidural post-surgical adhesions and is currently marketed in Europe. A pilot human clinical study was performed to show Oxiplex®/SP Gel was safe, as determined by clinical observations, and effective in reducing pain as measured by a self assessment questionnaire administered at both 3 and 6 months post surgery. [Kim, K.D. et al. Spine: 2003, in press.] Recently, concern has been raised that a different anti-adhesion gel, ADCON®-L [Gliatech, Inc.] compromises dural healing [Le and Rogers, Spine 26:115; Hieb and Stevens, Spine 26: 748, 2001]. A study was designed specifically to look at the effect of Oxiplex® /SP Gel on wound healing in a rabbit laminectomy model with dural incision. A two-level laminectomy, including a 2-mm incision in the dura at each site, was performed on 18 rabbits. Six rabbits were treated with Oxiplex®/SP Gel, six were treated with Adcon®-L and six were untreated and served as controls. Dural healing was evaluated by gross evaluation and by histology at 14 days. The results demonstrated that both Oxiplex®/SP Gel and Adcon®-L, significantly reduced the formation of epidural fibrosis ($p<0.00l$) with no significant difference in efficacy between the two devices ($p=0.485$). Histological evaluation, however, revealed a striking difference in the healing of dural incisions. In animals treated with Oxiplex®/SP, 91.4% of histological sections were healed compared with controls of 79.4% ($p=0.282$); in animals treated with Adconâ-L, 42.9% sections were healed compared with controls ($p=0.007$). In conclusion, these results indicated that Oxiplex®/SP Gel reduced epidural fibrosis without affecting dural healing even in the presence of a large dural incision.

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RESPONSIVENESS OF INDIVIDUAL COMPONENTS OF LOW BACK OUTCOME SCORE (LBOS) IN RELATION TO THE CHANGES IN THE OVERALL CLINICAL CONDITION OF PATIENTS WITH MECHANICAL LOW BACK PAIN

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Introduction: Low Back Outcome Score (LBOS) is validated condition specific instrument that measures pain, employment, activities of daily living and utilisation of health care resources by the patients suffering from back pain.
Aim of the Study: To determine if the individual components of LBOS respond differently in relation to the extent of change in the overall clinical condition as perceived by the patients.
Materials and Methods: Postal questionnaire were sent to 300 patients treated non-operatively for mechanical low back pain and had LBOS administered before the treatment. They were asked to quantify the overall change in their clinical condition and also to complete LBOS at the same time. Changes in the individual components of the LBOS were correlated with the patient's response.
Results: Average interval between initial and second scoring was 18 months. Out of 170(62%) responses obtained, 10 patients reported no change in clinical condition (LBOS improvement = 2.8 points out of total of 75, $p = 0.485$) without any significant changes ($p > 0.05$) in the individual components of the instrument. Thirty-eight patients reported a minimal perceptible overall improvement (LBOS improvement = 7.5, $p = 0.002$) and improved significantly ($p < 0.05$) in activities of daily living (ADL) only. Sixty-one patients reported a good but incomplete overall improvement (LBOS improvement 12.37, $p = 0.001$) and demonstrated lesser utilisation of health care resources ($p<0.05$) in addition to improvement in ADL. Sixty-one patients reported complete resolution of symptoms (LBOS improvement = 17.96, $p = 0.001$) and demonstrated significant improvement ($p < 0.05$) of all the components of instrument other than return to employment ($p = 0.517$) and ability to perform sporting activities($p = 0.363$).
Conclusions: It appears from this data that minimum perceptive overall improvement results in improvement of activities of daily living only. Further clinical improvement results in lesser utilisation of health care resources but does not result in return to employment. This data will have implications in cost effectiveness of health care services.

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FEASIBILITY OF A GLOBAL INTERNET DATABASE AND OUTCOMES SYSTEM FOR SPINAL DISORDERS

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Hypothesis: A global web based outcomes database system for spinal disorders was developed.This study explores the validity and accuracy of using this system to do research studies and comapre treatment outcomes for different procedures, by surgeons in different parts of the world.
Methods: The highest level of security is used. Clinicians register online.Each patient is given an ID and a password.The patient enters pre and post-treatment information online, on web based questionnaires. The data is stored on an internet based database.Standard outcome measures like the Oswestry score, the SF-36 are used. Surgeons enter treatment information online.They can collaborate with other clinicians online. The following information can then be accessed:outcomes for a particular patient, outcome for aparticular procedure, compare outcomes between the clinician and the database, share information and collaborate with other surgeons, participate in multi-centre trials. This study was designed to test the online system and the reporting tools. 10 clinicians in different cities participated. A total of 100 patients information was entered.The clinicians then accesssed the system and used the reporting tools. The feasibility of many clinicians sharing information, the accuracy of the data and patient compliance was assessed.
Results: All 100 patients completed the initial quesionnaire. 90 completed the follow-up questionnaire. Clinicians entered data on all 100 patients. Data accuracy as far as calculating the outcome scores was 100%.All clinicians were able to extract outcomes data on their patients. All the system tools worked satisfactorily.
Discussion: This sytem allows colleagues from all over the world to collaborate using standard outcome measures.The system was tested and found to be accuarte. System tools worked as designed. It allows large trials to be conducted, world wide. All clinicians have exclusive access to their data. Clinicians can constantly audit their outcomes and compare with the online database.
Conclusions: We present a feasibility study of a global database and outcomes system for spinal disorders. It was found to be accurate and all the system tools worked satisfactorily. It offers the potential to continuously monitor patient outcomes and compare these with colleagues from across the world.

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PROSTHETIC DISC NUCLEUS IMPLANTS: RANGE OF MOTION IS MAINTAINED AT SIX-YEAR PATIENT FOLLOW-UP

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The PDN® prosthetic disc nucleus device was first used in 1996 to treat eleven patients suffering from symptomatic degenerative disc disease. Six-year clinical follow-up data, including range-of-motion (ROM) measurements, are now available and have been analyzed to help determine the long-term efficacy of the device. Eleven patients in a German feasibility study were implanted with PDN devices. The first patient was implanted via a bilateral hemilaminotomy, with device components situated in a direction parallel to the sagittal plane. Subsequent patients were implanted using a unilateral microdiscectomy approach, with the device components situated perpendicular to the sagittal plane. Clinical outcomes were measured via Oswestry and Prolo scores, as well as disc-height and segmental ROM measurements. Range-of-motion data was collected through flexion/extension images obtained with an open MRI (Siemens Magnetom Concerto with 0.2 T permanent magnet). Newly developed dynamic sequences were used with T1 and T2 weighted images, with patients situated in a lateral decubitus position. Of the initial 11 cases, six-year follow-up information is available for seven patients. The average Oswestry score has dropped from a preoperative rating of "severe disability" (score of 57.4) to a rating of "minimal disability" (score of 11.7), and the mean Prolo score has increased from a rating of poor (score of 4.3) to excellent (score of 9.3). Mean disc height has been maintained from a preoperative 10.4 mm to a postoperative 10.6 mm. Range-of-motion data confirms these findings and indicates that flexion and extension have not been impaired: mean postoperative flexion is 3.1 degrees, extension is 11.2 degrees, and segmental ROM is 8.1 degrees. For the seven patients with available follow-up information, the PDN device has proven effective after six years. There have been significant improvements in both Oswestry and Prolo scores, disc height has been stabilized, and range-of-motion continues to be very good. As such, the PDN device shows good long-term effectiveness in patients suffering from degenerative disc disease.

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INFLUENCE OF CAGE GEOMETRY ON SAGITTAL ALIGNMENT IN POLYSEGMENTAL INSTRUMENTED PLIF

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Introduction: The aim of the study was to determine whether rectangular and wedge shaped cages have a different influence on the sagittal alignment of the lumbar spine in polysegmental instrumented PLIF.
Patients and Methods: Forty-one patients having undergone instrumented polysegmental posterior lumbar interbody fusion between L2 and S1were reviewed retrospectively. Twenty-one patients (12 women and 9 men, 45 - 82 years) had PLIF with rectangular cages (RC): 10 double- and 11 tripple-level fusions. Twenty patients (8 women and 12 men, 52 - 79 years) had PLIF with wedge shaped cages (WSC): 9 double- and 11 tripple-level fusions. All patients had additional pedicle screw fixation, the operative technique was standardized. Pre- and postoperative standing lateral radiographs were assessed for segmental and lumbar lordosis as well lumbar and sacral tilt.
Results: Mean follow-up was 22 months. Preoperatively there were no significant differences between the two groups. Mean segmental lordosis of fused segments showed significant differences between the two groups ($P<0,05$). Segmental lordosis decreased after fusion surgery in the RC group: -1° at L2/3, -3° at L3-L4, -2° at L4-L5 and -1° at L5-S1. In the WSC group segmental lordosis increased at all levels: +2° at L2/3, +2° at L3-L4, +5° at L4-L5 and +5° at L5-S1. Analysis of changes in lumbar lordosis, lumbar and sacral tilt did not show significant differences though opposite trends: Lumbar lordosis and sacral tilt decreased in the RC group and increased in the WSC group. Lumbar tilt increased in the RC group whereas it decreased in the WSC group.
Conclusions: The cage geometry has a significant impact on the alignment of the lumbar spine after polysegmental instrumented PLIF. With rectangular cages lumbar lordosis and segmental lordosis of the segments fused decrease, sagittal balance is maintained by compensatory changes of the sacral tilt. Wedge shaped cages significantly increase segmental lordosis, enhanced lumbar lordosis and therefore should be preferred for restoring sagittal alignment in instrumented PLIF procedures.

PAIN THERAPY

P 92

LUMBAR SPINAL STENOSIS – CONSERVATIVE TREATMENT OR SELECTIVE DECOMPRESSION?

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This retrospective study will compare the results of conservative treatment for lumbar spinal stenosis (LSS) in an outpatient clinic with results of surgical decompression.
Group 1 consisted of 33 patients without manifest neurological impairment who were treated conservatively over three weeks. The treatment consisted of physiotherapy, massage, electrotherapy, sport therapy, relaxation techniques and injections (facet joint infiltrations, epi-/perineural infiltrations). Group 2 included 24 patients who had not improved following conservative treatment at other facilities, and who underwent decompressive surgery with partial facetectomy (<50%) and partial foraminotomy in our institution. Outcome assessment was performed using a visual analog scale (VAS), the Oswestry low back pain disability questionnaire (OQ) and the short form-36 (SF-36) questionnaire on admission, at discharge and three months afterwards. In conservatively treated patients at discharge a positive development regarding pain level, walking distance and self assessment was noted. Three patients with severe stenosis did not improve and reported an unchanged or increased pain level. After three months, 27% of the patients reported an increase of pain compared to the level at discharge, but in only 9% were the initial pain levels reached. 39% continued to report further reduction of the pain level, while 33% stayed at the same level as at discharge. Surgically treated patients reported a significant increase in function immediately after surgery, which did not deteriorate over the three month period. The results were comparable to those of the conservatively treated group. Complications were not experienced in either group of patients. Conservative treatment of LSS in an orthopedic outpatient clinic showed excellent and good results in the majority of patients. In particular, elderly and obese patients complained of persistent pain and impairment after conservative treatment. Patients who showed no or only brief profit from conservative treatment, did, however, show good results after selective decompression.

REHABILITATION

P 93

MOBILE WITH OTTO! A CONCEPT INCLUDING PREVENTION, EARLY TREATMENT AND REHABILITATION IN AN INDUSTRIAL AND CLINICAL SETTING TO REDUCE LOW BACK PAIN IMPACT ON WORKLOSS: DESCRIPTION AND PRELIMINARY RESULTS

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Introduction: Can a concept of progressively more demanding, goal oriented treatment including integration of stake-holders reduce work loss and cost due to Non Specific Low Back Pain (NSLBP) in an industrial environment?

Background data:

1. NSLBP (Paris Task Force categories 1 – 3) is associated with an enormous socio-economic impact. NSLBP cost has remained unchanged despite effective treatment options.
2. Programs integrating stake-holders and progressively more demanding, goal oriented treatment seem to be superior.
3. Duration of pain and work loss is crucial to provide effective intervention, but not understood well by social security administration.

Objective: A concept for prevention, early treatment and rehabilitation for NSLBP in a mail-order-firm (Otto-Hamburg) with 2500 storekeeper was developed. Two guidelines were followed:

1. Evidence based and progressively more demanding, goal oriented treatment.
2. Integrate stake-holders.

The concept includes 4 groups:

Group	Criteria	Treatment	Goals
1	NSLBP in the past	Ongoing treatment in company	Prevent NSLBP
2	NSLBP today, working	Treatment in company/rehab center	Prevent work loss
3	NSLBP >6/ = 12 weeks sick listed	RTW-Program	Return to Work
4	NSLBP 12 weeks sick listed	9 – 10 weeks work-integration-program	Return to Work

Methods: This is a prospective trial with independent outcome assessment. Significance for nominal or ordinal variables are tested with Chi Square – tests and metric variables with t–tests. Data is collected pre- and post treatment, follow-up interviews are done 6, 12 and 24 months.
Results: 210 employees were included, 84 (72 % female, 28 % male, average age 44.9 (SD 7.2) years) finished treatment, 56 have been evaluated so far.

Group	1	2	3	4
n	37	13	1	5

Nil were lost to follow-up and experienced 2.8 (+/- 1.8) NSLBP episodes in the previous year. In Groups 3 & 4 all returned to work. In Group 4 the overall health status and work capacity improved significantly ($p \leq 0.01$). In all groups pain was reduced significantly ($p \leq 0.001$), coping with complaints improved significantly ($p \leq 0.01$). Changes in anxiety and depression were not significant.
Conclusions: Preliminary results indicate efficacy of the program. Long term efficacy and cost effectiveness is pursued.

SPONDYLOLISTHESIS

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SURGICAL TREATMENT OF HIGH GRADE SPONDYLOLISTHESIS BY POSTERIOR APROACH (LONG TERM FOLLOW-UP)

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Purpose: Retrospective mid to long term, clinical and X-rays study of high grade spondylolisthesis (>50%) treated surgically by

posterior approach and posterior and anterior fusion without forced reduction of the slip and reduction of L5 - S1 kyphosis.
Material: 18 patients (10 female, 8 male) had initial symptoms at a mean age of 14, diagnosis was made at 15.2 years old and surgery performed at 16.The mean time from symptoms to diagnosis is 11 months (0 to 36), and from diagnosis to surgery 11 (1 to 60) months. At surgery 50% of the patients were at the end of growth. 100% of patients had clinical signs (hamstring contracture and back pain: 100%, leg pain 45%, posture and gait problems: 40%). 50% had neurological signs. All were unsuccessfully treated by brace/medication/physical therapy. Pre-op imagings include: full spine standing films, L2- S2 MRI, functional L5-S1 X-rays.

Pre-op X-ray measurements:

slip L5-S1	mean 73,1%	(max 100%, min 56.7%)
slip angle L5-S1	mean 38°	(max 51°, min21°)
L1-L5 lordosis cobb	mean 58°	(max 80°, min 40°)

Surgical procedure: L5-S1 instrumentation: 12 patients, in case of instability or L4-L5 dysplasia, L4-L5 instrumentation: 6 patients. Prone position, flexed hips and knees, posterior mid-line approach, laminectomy L5, visualisation of L5 and S1 roots, L5 (L4) and S1 transpedicular screws, L5-S1 disk resection, sacral dome osteotomy, bone grafts +/- cage in L5-S1 interbody space, reduction only by hips extension, longitudinal rods inserted in compression, postero-lateral bone graft. Patients are protected 3 moths by a small pelvic brace,
Results: Mean follow-up 5.5 years (min 2.5, max 13)
X-ray measurement: mean (max, min)

	pre-op	post-op	follow-up
Slip L5-S1	73,1% (100 to 56.7)	42% (70,15)	44% (73,16)
Slip angle L5-S+	38 ° (51° to 21°)	5° (10,-3)	6° (11,-3)
L1-L5 lordosis	58° (80° to 40°)	47° (69,23)	45° (66,18)

Clinical results: The height gain is 2.5 cm. The waistline is restored. 13 patients return to free activities without pain. 1 patient has occasional pain at rest, 4 occasional pain during sport activities. None take medication. 2 patients have a mild L5 roots paresis one of those fully recover within 2 weeks.
Complications: 1 case of secondary L5 slip at 48h post surgery due to a technical error (screws to parallel), revision and reinstrumentation on the same level, this patient is also the one with permanent L5 mild paresis witch appeared after the secondary slip. 3 broken screws without symptoms. 2 time within 1 year with a loss of correction of 8%, 1 time after a year without loss of correction. All the case where radiologicaly fused at 1-year follow-up. No infection.
Conclusion: There is still no consensus for the indications and surgical techniques applied for the spondylolisthesis, particularly in high-grade displacement. The debate is focused around the need of correction and instrumentation. The risk of neurological damage is recorded for all the procedure even in situ spondylodesis. Our techniques by posterior approach, and anterior fusion aim at a complete correction of the L5-S1 kyphosis, and partial slip correction without forced manoeuvre. Due to the young age of our patients the balance is restored, with low risk and good clinical result at a mean follow-up of 5.5 years.

P 95

COMPARISON OF SURGERY EXTENT IN 360 DEGREE FUSION OF LUMBAR SPONDYLOLISTHESIS MANAGED BY TRANSPEDICULAR FIXATION AND PLIF OR ALIF TECHNIQUE

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Purpose. The aim of this prospective randomised study was to evaluate the surgery extent ot two groups of patients, managed for symptomatic lumbar spondylolisthesis by 360 degree fusion, after conservative treatment failure. PLIF or ALIF technique was always completed by transpedicular fixation and fusion.
Methods. The slip value ranged from 20% to 55%. Eighteen patients underwent PLIF in 360 degree fusion (mean age of 44,6 years). Radicular symptoms were present in 12 cases. Partial slip reduction was achieved in 12 cases, complete in 4, in two cases the slip remained unchanged. Sixteen patients underwent ALIF technique (mean age of 41,5 years). Radicular symptoms were present in 11 cases. Partial slip reduction was achieved in 4, complete in 12 cases. Evaluated were the time of anesthesia and surgery, intra- and postoperative blood loss and complications. The datas were statistically evaluated (t-test, Fisher test).
Results. In the PLIF group the mean anesthesia time was 221,9 minutes, SD 42,71, mean surgery time 176,9 min., SD 42,71, mean blood loss during surgery 1222,2 ml, SD 538,03, after surgery 474,4 ml, SD 234,36.
In the ALIF group the mean anesthesia time was 285,6 min., SD 29,71, mean surgery time 230,0 min., SD 29,61, mean blood loss during surgery 951,9 ml, SD 636,60, after surgery 625,4 ml, SD 404,84. Only the anesthesia and surgery time differences were statistically significant (p 0,01).
Complications: PLIF group: 4 cases (transient radicular lesion in 3 cases), ALIF group: one case - urogenitary tract infection in both groups.
Conclusion. The combined 360 degree fusion (ALIF group) for lumbar spondylolisthesis lasted significantly longer than PLIF technique. In PLIF technique higher complication rate was found (statistically insignificant). Long-term follow-up will be necessary to evaluate the long-term effect of ALIF and PLIF techniques.
Acknowledgment. This study was supported by grant ND 6852-3.

STENOSIS

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LUMBAR SPINAL STENOSIS AND DIABETIC POLYNEUROPATHY: THE DIAGNOSTIC POWER OF CONDUCTION STUDIES

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Background. Diabetic polyneuropathy (DPN) and lumbar spinal stenosis (LSS) are associated with the same patterns of non-specific motor conduction and needle abnormalities, a situation that obstructs definite diagnosis.
Objectives. To judge the diagnostic power of electrophysiological examination in differential diagnosis between LSS and DPN.
Methods. A group of 68 patients suffering from LSS, 28 patients with DPN and 32 healthy volunteers were examined and the data

from 12 electrophysiological conduction parameters were compared: radial and sural nerve sensory action potentials amplitude (SN.SA, SN.RA) and their amplitude ratio; ulnar nerve minimal F-wave latency (UL); Tibial nerve F-wave minimal latency (NTL), dispersion (NTD), and persistence; soleus muscle H-reflex latency (HRL) and amplitude; and motor evoked potentials to lower limbs, cortical latency, spinal latency (MEPL) and central conduction time (MEPC). Patients with LSS were divided into four groups with respect to neurogenic claudication and pareses in the following order: NC-/P-, <NC+/P-, <NC-/P+, and <NC+/P+. Multivariate variation of electrophysiological parameters was preliminary summarized in the principal component analysis (PCA). All examined parameters then entered multivariate discrimination analysis seeking for the most informative projections showing the associations between electrophysiology and diagnostic groups of patients. Finally, receiver-operating characteristic curves (ROC analysis) were employed in order to define the best cut-off values of single potential predictors and their multivariate combinations.
Results. Both multivariate discrimination analysis and ROC analysis confirmed three diagnostically valuable levels of sufficiently effective discrimination between LSS and diabetic neuropathy: Discrimination level I. the most desirable overall separation of LSS and DPN: UL in contrast to SN.RA and SN.SA. Discrimination level II. LSS patients without pareses vs. DPN patients: contrast between amplitude values (SN.RA, SN.SA) and latency values (namely UL, NTL) with partial contribution of MEPL and HRL. Discrimination level III. Separation of patients without pareses and neurogenic claudication from patients with pareses: H reflex amplitude in contrast to MEPC and NTD.
Conclusions. The strongest diagnostic power between DN and LSS was given by conduction studies from the upper extremities. In examination of the lower limbs, electrodiagnostics reflect above all the severity of LSS and only combination of the parameters can separate both diseases reliably.

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CORRELATION BETWEEN THE DEGREE OF NARROWING AND WALKING ABILITY IN PATIENTS WITH LUMBAR SPINAL STENOSIS

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Background Data. There is general agreement that the degree of narrowing of the lumbar spinal canal does not correspond with the clinical severity of the disease.
Objectives. The aim of the study was to compare a history of neurogenic claudication, physical examination, and a ten-metre walking test with the radiologically established severity and extent of lumbar spinal stenosis (LSS).
Methods. A group of 68 patients suffering from LSS underwent physical examination and were given a simple ten-metre walking test. Mean age was 55 years (43-67), neurogenic claudication was present in 57%, weakness of lower limbs in 32%. The clinical data, including walking time, were compared with an axial CT scan of the lumbar spine. The number of stenotic levels and the narrowest transversal and sagital values. as well as the presence of scoliosis, were evaluated. (Normal transversal value >16.0 mm, normal sagital value >11.7 mm).
Results. The number of stenotic levels was not significantly associated with decreased ability to walk (OR 1.58, CI (0.52; 4.79)*). The same result was found for the relation between ability to walk and narrowest sagital diameter (OR 1.28 (0.46; 3.55) or presence of scoliosis OR 0.93 (0.16; 5.3). The ability to walk was significantly ($p < 0.05$) influenced by transverse reduction of the spinal canal at the narrowest level OR 2.89 (1.43; 4.13). (Odds ratio (OR) expressing risk of decreased walking ability (10-m test performed in >15 s) associated with above mentioned radiological risk factor, univariate logistic models, RR expressed with 95% confidence interval in parenthesis.)
The number of stenotic levels and narrowest sagital canal diameter did not correlate with the presence of neurogenic claudication or lower limb weakness. The transversal narrowing of the spinal canal correlated with pareses of lower limbs ($p < 0.05$). (Mann-Whitney test for quantitative parameters, binomial test for relative frequencies.)
Conclusions. We were not able to document any association between the extent of lumbar spinal canal stenosis and restriction of walking capacity.
Only the severity of the transversal stenosis at the narrowest level predicts restriction of walking capacity and presence of lower limb weakness.

SURGERY

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TRANSFORAMINAL APPROACH AND CIRCUMFERENTIAL LUMBAR FUSION USING FEMORO-CORTICAL ALLOGRAFT

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Recent studies, including randomized clinical trials, suggest that circumferential fusion provides better clinical outcome than posterolateral fusion when treating chronic low back pain. The obliged use of interbody cages significantly increases the cost of circumferential fusion. Many surgeons have bone allografts at their disposal with minimum cost. Several reports describe the use of femoral allografts as ALIF interbody spacers, but none describe their use as TLIF interbody spacers.
Aim: To analyze the efficacy of TLIF femoro-cortical allografts as interbody spacers in terms of segmental anatomic reconstruction and fusion.
Material and Methods: We evaluated 50 lumbar segments from 41 patients, 25 women and 16 men, mean age 47.05 years (range 27-68), in whom circumferential lumbar fusion had been performed using custom-made femoro-cortical allografts as TLIF interbody spacers, associated with autologous bone graft and pedicular instrumentation. Using the validated "Distortion Compensated Method" and digitized preop, postop, 6-month and 1-year postop radiographs, an independent observer compared lordosis and disc-height of the femoro-cortical TLIF segments with 36 segments in which titanium mesh cages had been used as TLIF spacers. Using CT scanning and plain radiography, fusion was assessed by two independent observers and one of the surgeons at two years of follow-up.
Results: Analysis of surgical and postoperative changes showed no significant differences in lordosis between lumbar segments with femoro-cortical allografts and segments with titanium mesh cages. A significant intra-operative increase in disc-height ($p<0.00$) followed by a significant decrease ($p<0.01$) in the first 6 postoperative months was found in the femoro-cortical segments. Comparison with the titanium mesh segments showed no significant differences. No significant changes in disc-height were observed between the 6-month and 1-year controls.
Two years after surgery, 38 segments (76%) showed circumferencial fusion, 6 (12%) posterolateral fusion without interbody fusion, 4 (8%) isolated interbody fusion and 2 (4%) pseudoarthrosis.

Conclusions: Femoro-cortical TLIF spacers provided segmental reconstruction and first-year stability similar to that attained with TLIF titanium mesh cages. The 2-year follow-up fusion rate using femoro-cortical TLIF spacers was similar to reported rates for other circumferential constructs. Custom-made femoro-cortical TLIF spacers constitute an excellent and less costly alternative to currently-used standard TLIF interbody devices.

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EFFICACY OF LONG-SEGMENT STRUCTURAL ALLOGRAFTS IN ANTERIOR COLUMN RECONSTRUCTION

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Purpose: To evaluate the safety and efficacy of solvent dehydrated structural allografts (Tutogen Medical GmbH, Germany) as an anterior structural support in the treatment of bone defects after corpectomies.
Materials and Methods: Sixteen among 22 consecutive patients treated with anterior corpectomies due to several diseases were included in this retrospective study. Six patients with metastatic tumours who died before completion of two years follow-up (f/up) were excluded. The diagnoses were vertebral tuberculosis in seven, burst fractures in four, carcinoma metastasis in one, primary malign tumours in two and post-traumatic deformity in the remaining two. Anterior column defects due to corpectomies were reconstructed by solvent dehydrated structural allografts (fourteen femoral and two humeral shaft) in all patients. X-ray analysis included measurement of pre-operative, post-operative and f/up local kyphosis angle (LKA) and evaluation of graft incorporation, resorption and subsidence. Fusion and incorporation of the grafts were evaluated by using the 4-point grading system proposed by Bridwell et al.
Results: There were 7 male and 9 female patients with a mean age of 40.6 (Range 15 to 64) years. Mean duration of f/up was 50 (Range 24 to 86) months. All patients underwent corpectomies (two levels in 2 and one level in 14) and allograft reconstruction to manage either the tumour, infection, deformity or mechanical instability. None of the allografts were packed with autogenous bone. The level of corpectomies were between T9 and L4. Additional anterior short segment (one above, one below) instrumentation was performed in four patients while 10 patients were stabilized with short segment posterior instrumentation. Three patients initially treated with single level corpectomy without any stabilization, had to be stabilized later due to gradual displacement of the allografts. One of them underwent an early revision anterior procedure followed by posterior short segment instrumentation. Slight displacement of the grafts in the remaining two patients could be controlled by external immobilisation. Mean pre-operative LKA of 12; (±15.1) was corrected to 2.5; (± 14.8) postoperatively. LKA at the final f/up was 5; (±17.6). Only three patients had more than 5 degrees of correction loss due to slightly impacted grafts into the upper vertebral bodies. There was no graft collapse or fracture. Fourteen grafts demonstrated evidence of incorporation and fusion(Grades I or II). Only two allografts were classified as having grade III (graft intact, potential lucency) fusion. None of the grafts were classified as grade IV(no fusion).
Conclusions: In the literature, the small number of reports studying allograft bone in anterior spine are mainly based on interbody reconstruction using fresh-frozen bones. In the current study however, the solvent dehydrated allografts replacing one or two vertebral bodies were evaluated. Our data suggest that long-segment anterior allografts are efficient and safe in maintaining vertebral height and structural integrity in numerous pathological deformities.

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INJECTABLE BIOMATERIALS FOR AUGMENTATION OF THE NUCLEUS PULPOSUS

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Introduction: Discectomy is the most common spinal surgical treatment. Substantial disc height reduction following discectomy may occur and is evident soon following the discectomy procedure. Changes in disc height can have both local and global effects. On the local (or cellular) level decreased disc height may lead to a decrease in cell matrix synthesis and an increase in cell necrosis and apoptosis. Decreased disc height also results in significant changes in the global mechanical stability of the spine. The facet joints bear increasing loads [1]. There is increased range of motion resulting from loss of disc height [2]. Adjacent segment loading increases as the disc height decreases at a given level[3]
Objective: The objectives of augmentation of the nucleus pulposus following disc removal are to prevent disc height loss and the associated biomechanical and biochemical changes resulting from reduced disc height and volume. Flowable biomaterials may be injected via a small incision, can interdigitate with the irregular surgical defects and may, depending on the material used, physically bond to the adjacent tissue. Our work involves the evaluation of a recombinant protein copolymer consisting of amino acid sequence blocks derived from silk and elastin structural proteins as an injectable biomaterial for augmentation of the nucleus pulposus (Injectable Disc Nucleus - IDN, SpineWave, Shelton, CT).
Methods: Synthetically designed protein polymers consisting of repeated blocks of amino acid sequence are produced using gene template directed synthesis (Protein Polymer Technologies, San Diego, CA)[4]. The protein polymer used in the Injectable Disc Nucleus (IDN) is a copolymer of silk and elastin. One of the elastin blocks is modified to provide for chemical cross-linking. The IDN material is comprised of a solution of the protein polymer and a small volume of polyfunctional cross-linking agent. The material closely mimics the protein content, water content, pH and complex modulus of the natural nucleus pulposus. Testing in cadaveric human spinal motion segments compared the axial strain during mechanical loading of native segments with those augmented with the IDN material [5]. The testing involved cyclic loading between 35 kg and 75 kg at 1 HZ for 20 cycles, followed by static loading with 5 kg (30 minutes), 75 kg (60 minutes) and 5 kg (30 minutes). Maximal strain during the creep test was calculated. IDN injected specimens were compared to native specimens using one-way ANOVA. Finally, a failure test in axial compression was conducted on the IDN and the discectomy specimens by ramping the load up to 200 kg. After testing, the specimens were dissected to observe the state and location of the IDN. In addition to mechanical evaluation, extensive biocompatibility and toxicology testing has been performed on the IDN material.
Results: The IDN material integrated extensively with the surrounding disc tissue and did not extrude during any of the testing. While the maximum strain under axial load for the IDN injected segments (21.9±6.4%) was greater than for the native segments (14.8±4.6%), the difference was not statistically significant ($p > 0.05$, $n=5$). The maximum strain of the discectomy segment without IDN injection (34.6%) was substantially greater than the IDN injected specimens. Acute and chronic biomaterial testing have demonstrated that the material is non-cytotoxic, non irritating and non-toxic. Chronic toxicity and neurofunctional testing is being conducted in a rat model. A sheep model is being used to assess the IDN placed within the intervertebral disc following discectomy. Biomechanical testing and histological analysis is being performed at various time points after implantation.
Conclusions: The IDN appears suitable to replace the natural nucleus pulposus following a discectomy procedure. Extensive bio-

material characterization shows the material to be non-toxic and biocompatible. The mechanical properties of the material mimic those of the natural nucleus pulposus. Preclinical testing is underway in a variety of animal models, while benchtop testing is characterizing the mechanical properties and durability of the material in a spinal application. Pilot human clinical studies are anticipated in the future.

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SURGICAL OUTCOME

P 101

REMOVAL OF LUMBAR INSTRUMENTATION FOR THE TREATMENT OF RECURRENT LOW BACK PAIN IN THE ABSENCE OF PSEUDARTHROSIS

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Introduction. Removing spinal instrumentation in the absence of pseudarthrosis for the treatment of recurrent low back and leg pain is controversy discussed. This study compared two groups of patients who either had a solid or loose instrumentation for spinal fusion at the time of removal and the absence of pseudarthrosis and evaluated their outcome postoperatively, to determine if instrumentation removal is beneficial for patients with recurrent low back pain following lumbar fusion.
Patients and Methods. 45 patients underwent an anterior and posterior lumbar spinal fusion. The removal of metalwork was performed by the same surgeon and senior author of this paper (MRP). The reason for the revision surgery was recurrent low back and leg pain. All patients had based on a thorough surgical exploration of the fusion mass a solid fusion. Instrumentation was deemed either solid or loose at time of removal based on the purchase at the screw-bone interface. Final outcomes were determined using a functional and satisfactory questionnaire and related to the two groups.
Results. The majority of the patients in both groups would recommend the surgery to a family member, would have the surgery again themselves and consider the surgery a success. The group of patients with loose instrumentation were significantly more likely to have a successful outcome than the group without loose instrumentation.
Conclusions. This study indicates that the removal of instrumentation in the absence of pseudarthrosis is beneficial in the relief of low back pain and leg pain symptoms. Increased success rates were noted in patients with loose instrumentation. However, this classification was based on inter-operative inspection. Further studies of the ability to diagnose and predict success prior to surgery needs to be done.

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RESULTS OF POSTERIOR FUSION IN THE TREATMENT OF SEVERE IDIOPATHIC SCOLIOSIS

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Study design: a retrospective study of patients with severe idiopathic scoliosis who underwent spinal surgery from posterior approach.
Objectives: to analyze and compare radiological outcome of posterior fusion with different instrumentation.
Summary of background data: the treatment of idiopathic scoliosis with Cobb angle over 80° is difficult and connected with significant percentage of complications. Various distraction and derotation instrumentations are used for posterior fusion, sometimes preceded by skull femoral traction.
Material and methods: a total of 378 patients were included in this study. They were divided into 4 groups. Group I consisted of 43 patients who underwent posterior fusion with Wisconsin instrumentation, the mean patients' age during surgery was 14 years. Before operation the mean curve angle was 95° and follow-up period was 4.5 years. Group II consisted of 240 patients who underwent posterior fusion with Wisconsin instrumentation, preceded by skull femoral traction. The mean patients age during surgery was 16 years. Before operation the mean curve angle was 104° and follow-up period was 4.5 years.Group III consisted of 43 patients who underwent posterior fusion with derotation instrumentation. The mean patients' age during surgery was 13 years. Before operation the mean curve angle was 86° and follow-up period was 3.5 years. Group IV consisted of 52 patients who underwent posterior fusion with derotation instrumentation, after skull femoral traction. The mean patients' age during surgery was 15 years. Before operation the mean curve angle was 101° and follow-up period was 4 years.
Results: For group I obtained mean postoperative curve angle was 52° with correction of 46.2%. During last examination the mean curve angle was 57° with average loss of correction 8.6%. For group II obtained mean postoperative curve angle was 55° with correction of 47.3%. During last examination the mean curve angle was 57° with average loss of correction 4.3%. For group III obtained mean postoperative curve angle was 38° with correction of 55.4%. During last examination the mean curve angle was 41° with average loss of correction 9.2%. For group IV obtained mean postoperative curve angle was 52° with correction of 48,7%. During last examination the mean curve angle was 54° with average loss of correction 2.7%. The smallest amount of all complications was in groups III and IV (7% and 9.6% respectively).
Conclusions: The amount of correction was comparable in all groups but group III, in which the mean preoperative angle was significantly smaller. The loss of correction was bigger after posterior fusion without traction. The rate of complications after the use of derotation instrumentation was lower.

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COMPLICATIONS AND LONGTERM OUTCOME OF HIND BRAIN DECOMPRESSION FOR ARNOLD CHIARI MALFORMATION: A NINE YEAR EXPERIENCE

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Aim of the study: The aim of this study is to present our complication rate and the longterm outcome of patients with Chiari malformations after undergoing hind brain decompression.

Patients and methods: We retrospectively analysed the results of patients who underwent hind brain decompression between 1994 and 2003. There were 70 cases with a mean age of 32 years with a range of 6 to 62 years. Follow-up was done with repeated MRI scans and clinical examination in the outpatients clinic.There was a mean follow-up of 4.7 years with a range of (1-9 years). The presenting symptoms included headache in 44 patients, dysasthetic arm pain and weakness in 30 patients, drop attacks in 7 patients, ataxia in 9 patients, cranial nerve dysfunction in 8 patients and scoliosis in 9 patients.Radiologically 61 patients were classified as having a Chiari I malformation and 9 patients had Chiari II.36 patients had associated syringomyelia.All patients underwent hind brain decompression through a small posterior fossa craniectomy, opening of the foramen magnum with or without removal of arch of C1.In 12 patients the dura was not opened.
Results: We had no mortality in our series and one patient had a stroke which resolved except for mild facial weakness.7 of our patients had a post operative CSF leak. 8 patients developed meningitis postoperatively, which resolved completely with antibiotics.Only 2 patients had a wound infection.Long term follow-up revealed that 50% of the patients were asymptomatic following the surgery and another 27 % had marked improvement in their symptoms.Only one patient (0.01%) deteriorated postoperatively and the rest (23%) had unchanged condition.Of the patients presenting with scoliosis 67% (n=6) had no further progression in their curve while 22% (n=2) progressed despite good radiographic appearance of the syrinx.One patient had complete correction of his scoliotic curve postoperatively.
Conclusion: Our series is the largest from a single centre with pre and postoperative MRI folow up and our results compare favourably with previously published literature.The clinical features, surgical findings and clinical outcome will be presented.Factors predictive of a poor outcome will also be discussed.

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IMPLANT REMOVAL AFTER POSTERIOR STABILIZATION OF THE THORACO-LUMBAR SPINE

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Introduction: Implant removal because of pain after posterior stabilization of the spine is a widely performed operation. However, there is a lack of data concercing the indication and the patients outcome after this procedure. We conducted this retrospective study to proof if patients do benefit from implant removal.
Methods: Included were patients with removal of pedicle screws because of pain and discomfort. They were interviewed 6-24 months after implant removal. We evaluated patients satisfaction and outcome after the operation, operative data, hospital stay and complications. Not included were patients with routine implant removal after temporary bisegmental stabilization of fractures.
Results: 62 patients fulfilled the inclusion criterias. 58 (93.5%) of them could be interviewed, 30 males and 28 females with a mean age of 46.5 years. Original diagnoses were fractures in 23 patients (40%) and degenerative spine diseases in 35 (60%) patients. 35 patients (60%) had additional degenerative alterations like arthritis of facet joints and/or disc protrusions at other levels. Indication for implant removal was pain at the implant site in 56 (96%) patients and pedicle screw failure with pain in 2 patients. 13 patients (22%) had have diagnostic infiltrations before implant removal. Mean hospital stay was 7.1 days. 5 patients (8.6%) had a complication (infection, plexus lesion, hematoma at psoas muscle). Pain decreased on VAS from 6.2 preoperatively to 4.8 postoperatively. 36 patients (62%) stated they had some benefit from the operation, but only 7 patients (12%) were painfree completely. Only in 4 cases (31%) the preoperative diagnostic infiltration correlated with the postoperative outcome. 37 patients (64%) would undergo the same procedure again.
Conclusion: Removal of pedicle screws because of back pain leads only in 12% of patients to a complete remission of symptoms. However, 62% of patients have some benefit and 64% would undergo the same procedure again. Complications occur frequently (8.6%). Preoperative diagnostic infiltration does not help predicting the outcome. Surgeons should consider these results when planing routine implant removal and patients should be informed thoroughly to avoid too high expectations.

P 105

EXPANDABLE CAGES FOR ANTERIOR STABILIZATION OF FRACTURES IN THE THORACO-LUMBAR SPINE. A PROSPECTIVE CLINICAL STUDY.

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Introduction: Expandable titanium cages are in use for anterior stabilization of the vertebral column in patients with complete burst fractures. No clinical or radiological data concerning the outcome are available currently. The purpose of this study was to evaluate the clinical and radiological results of expandable titanium cages in a prospective clinical trial.
Methods: Between 04/1999 and 03/2003 81 patients with thoracolumbar burst fractures underwent posterior stabilisation followed by anterior internal vertebral body augmentation using expandable titanium cages filled with cancellous bone graft. Pre- and postoperatively at 3, 6, 12 and 24 months evaluation was performed using the parameters pain, range of motion, subjective improvement and SF-36. Plain radiographs including lateral flexion and extension views and two-dimensional quantitative CT-scans were obtained to assess stability and fusion.
Results: To this date, 49 patients had a one year, and 22 patients a two year follow-up. Pain decreased significantly from 62 to 25 on VAS. ROM increased and preoperative neurologic deficit improved in 25% of patients after surgery. Average subsidence of the cages was 4.5 mm and average postoperative loss of lordosis was 5.5 degrees. Flexion/extension views and CT scans showed a solid bony fusion in 25%, an incomplete fusion in 35% and a non-fusion in 40% after two year. One of the first patients with severe osteoporosis had significant subsidence of the cage and had to be revised. One patient suffered of left sided paralysis of the diaphragm. There were 9 cases of post-thoracotomy-syndrome.
Conclusion: Expandable cages offer the option of direct internal reposition of the anterior column with a very exact adaptation to the height of the defect. A gradual press fit of the cage and endplates can be achieved. The clinical outcome after one and two years is similar to operative techniques using tricortical iliac crest bone graft or non-expandable cages. However, fusion could not be achieved in 40% of patients and little loss of reduction occurs despite the fact of anterior and posterior stabilization and without signs of instability. Expandable cages are suitable for internal augmentation of fractures in the thoraco-lumbar spine. Since fusion can not be achieved in all cases, expandable cages should not be used as a stand-alone device currently.

P 106

NEUROMUSCULAR SCOLIOSIS TREATED BY SEGMENTAL, THIRD GENERATION INSTRUMENTED FUSION

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Introduction: Second generation instrumented spinal fusion (e.g., Luque-Galveston) has been the standard in Neuromuscular Scoliosis (NMS) surgery. We aim to provide current data on the results of NMS surgery with segmental, third generation instrumentation.
Methods: Inclusion criteria for this retrospective study were progressive NMS treated by segmental third generation instrumentation at a minimum follow-up of 2 years. All patients were instrumented with either Colorado, or Synergy, systems by one surgeon, from 1995 to 2000. Clinical and radiological follow-up was done at 3, 6, 12 months and yearly thereafter. A published follow-up outcome questionnaire was administered to patients' parents or carers.
Results: 59 (29 females, 30 males) patients were included. Mean age at surgery was 14 (range, 8-21) years. Mean follow-up was 53 (range, 24-85) months. Aetiologies of spinal deformity were mainly Cerebral Palsy (31 patients) and Duchenne's Muscular Dystrophy (8). The choice of procedure depended on patients' general health, maturity, degree and flexibility of spinal deformity and intraoperative conditions. On average, 6 levels were operated on the 39 anterior procedures, and 15 levels on the 59 posterior procedures. 15 procedures were staged (1 week apart, anterior and posterior), 24 combined (single stage, anterior and posterior) and 20 posterior only. Average surgical time was 390, 345 and 255 minutes respectively. Average circulating blood volume loss was 73%, 68% and 58% respectively. Correction of coronal deformity averaged 71%, 65% and 59% (loss of correction at follow-up: 4%, 4% and 6%) respectively. Correction of sagittal deformity averaged 48%, 48% and 38% (loss of correction at follow-up: 3%, 5% and 7%) respectively. Correction of pelvic obliquity averaged 71%, 65% and 59% (loss of correction at follow-up: 5%, 5% and 7%) respectively. Major complications affected 11.8% of patients including deep infection (4 cases), implant failure (3), lower respiratory tract infection (3), paraplegia (1) and pseudoarthrosis (1). Follow-up questionnaires highlighted improved quality of both patients' and families' life in 91% of cases.
Conclusions: At an average 4 years follow-up, segmental spinal fusion with third generation instrumentation provides lasting correction of spinal deformity and improved quality of life in NMS patients despite a lower complication rate than reported for second generation instrumentation.

P 107

COMPARISON OF DIFFERENT METHODS IN OPERATIVE TREATMENT OF SEVERE IDIOPATHIC SCOLIOSIS

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Study design: a retrospective study of patients with severe idiopathic scoliosis who underwent spinal surgery from posterior or anterior and posterior approach.
Objectives: to analyze and compare radiological outcome after operations in patients with severe idiopathic scoliosis.
Summary of background data: The studies on the safest et most efficient operative technique for severe idiopathic scoliosis are still conducted. The use of skull femoral traction in combination with anterior release followed by posterior fusion is advised by some authors.
Material and methods: a total of 476 patients were included in this study. All of them had preoperative curve angle bigger then 80° with significant domination of type 3 according to King classification. They were divided into 4 groups. Group I consisted of 292 patients who underwent skull femoral traction followed by posterior fusion, the mean patients' age during surgery was 16 years. Before operation the mean curve angle was 103° and follow-up period was 4.5 years. Group II consisted of 86 patients who underwent posterior fusion, without traction. The mean patients' age during surgery was 13.5 years. Before operation the mean curve angle was 90° and follow-up period was 4 years. Group III consisted of 74 patients who underwent one stage anterior release and posterior fusion. The mean patients' age during surgery was 14 years. Before operation the mean curve angle was 94° and follow-up period was 2.5 years. Group IV consisted of 24 patients who underwent anterior release followed by skull femoral traction and posterior fusion. The mean patients' age during surgery was 14.5 years. Before operation the mean curve angle was 126° and follow-up period was 2.5 years.
Results: For group I obtained mean postoperative curve angle was 54° with correction of 47.6%. During last examination the mean curve angle was 56° with average loss of correction 4.1%. For group II obtained mean postoperative curve angle was 45° with correction of 50.8%. During last examination the mean curve angle was 50.5° with average loss of correction 8.9%. For group III obtained mean postoperative curve angle was 42° with correction of 55.3%. During last examination the mean curve angle was 43° with average loss of correction 2%. For group IV obtained mean postoperative curve angle was 70° with correction of 44.6%. During last examination the mean curve angle was 70° without loss of correction.
Conclusions: combined anterior release with posterior fusion allows good and stable correction, with minimal loss of it. Anterior release with skull femoral traction and posterior fusion caused significantly smaller but stable correction in spite of bigger mean preoperative curve angle.

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HEALOS BONE GRAFT SUBSTITUTE USED IN LUMBAR SPINE FUSIONS: A CASE CONTROLLED STUDY COMPARING HEALOS USED WITH BONE MARROW ASPIRATE AND AUTOGRAFT

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The aims of spinal fusion are to achieve an arthrodesis, relieve pain and if possible, restore function of the spine. The "Gold Standard" fusion material is autograft from the posterior iliac crest. However, the morbidity associated with bone graft harvest is difficult for patients and surgeons to accept, and alternative sources of fusion material have been sought for many years. Healos is a type I collagen/hydroxyapatite matrix, that is only osteoconductive and needs osteogenic factors to make bone. These are provided by soaking Healos in bone marrow aspirate for at least 20 minutes before applying it to the fusion site. From July 2000, all patients undergoing spinal fusion in our hospital, had Healos and bone marrow aspirate used as the grafting material. They were followed prospectively using clinical and economic outcome tools, and serial radiographs. Prior to July 2000, all fusions had been carried out using autograft from the iliac crest. 49 patients (24 male and 25 female) who had been treated with Healos with at least one year of

clinical and radiological follow-up were as closely matched to historical controls, by sex, age, indication for surgery and operation as possible. All the historical controls had more than two years clinical and X-ray follow-up whereas in the Healos group only half of the patients had at least two years follow-up. 43 of the 49 patients treated with Healos had clinical and radiological fusion compared to 46 of 49 in the autograft group. There is a trend for fusion to occur later in the Healos group as the X-rays do not show the pre-existing radio-opaque scaffold of autograft which can mislead. Only one patient (2%) had a graft-related complication with Healos (temporary local inflammation at the bone marrow harvest site)compared to seven (14.3%) in the autograft group. Histology of bone retrieved at removal of metalwork (after fractures) confirms mature cortico-cancellous bone forms within one year of the index procedure when Healos is used as the graft material. The results of this study show that Healos is an effective bone graft substitute in the lumbar spine with radiological and clinical results that compare favourably with autograft. It is superior to autograft when harvesting complications are considered. Further clinical and radiological assessment will reveal in due course whether Healos exactly matches the performance of the "Gold Standard", autograft.

P 109

SELECTION CRITERIA ARE THE MOST IMPORTANT PREDICTORS OF SUCCESS IN 360 DEGREE 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 degree 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 2 years post-surgery (mean 48 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 postoperative 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.

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CORRELATIVE ANALYSIS OF THE RESULTS OF SURGICAL TREATMENT (HOOKS VERSUS PEDICLE SCREWS) OF THORACOLUMBAR INJURIES WITH TSRH-INSTRUMENTATION

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Prospective, randomized comparative clinical study to compare the efficacy of pedicle screws versus laminar hooks in thoracolumbar injuries.
Methods. Forty consecutive patients with unstable fractures in thoracolumbar spine (T11 to L1) associated with spinal canal encroachment, who underwent early operative postural reduction and stabilization with Texas Scottish Rite Hospital instrumentation were randomly sampled into two groups: 20 patients received hooks in "claw configuration" both in thoracic and lumbar spine (Group A), and 20 patients hooks in thoracic and pedicle screws in the lumbar spine (Group B). Pre- and postoperative plain roentgenograms and CT-scans were used to evaluate any changes in: Gardner kyphotic deformity; anterior vertebral body height; Posterior vertebral body height; and Spinal canal clearance.
Results. All patients were followed for an average period of 52 months, (range, 42-71 months). The correction of anterior vertebral body height was significantly more ($P<0.01$) in group B (33%) than in group A (16%), with a 11% loss of correction at the latest evaluation in group A, and no loss of correction in group B. No significant differences between the two groups were observed in the change of posterior vertebral body height restoration and Gardner angle. Spinal canal clearance was immediately postoperatively significantly ($P<0.05$) more in group B (32 %) than in group A (19 %). In the latest evaluation there was a loss of spinal canal clearance of (9 %) in group A, while it was furthermore increased at 10.5 % in group B. All patients with incomplete neurologic lesions in-group A and B were postoperatively improved at 1.1 degrees and 1.7 degrees respectively. There was no screw failure, while there was two hook dislodgements in the thoracic spine (one in each group). There was neither pseudarthrosis nor neurologic deterioration in this series.
Conclusions. This comparative study showed that the use of pedicle screws in the lumbar spine for stabilization of unstable thoracolumbar injuries restored and maintained better than the hooks the anterior vertebral body height of the fractured vertebra without subsequent loss of correction, and safeguard continuous remodeling of spinal canal resulting in increasing spinal canal clearance with time lapsed from operation.

P 111

DECOMPRESSIVE LAMINECTOMY IN TREATMENT OF DEGENERATIVE LUMBAR SPINAL STENOSIS. A RETROSPECTIVE STUDY 1990-2000 (110 CASES)

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Introduction: The goal of this study is to investigate the overall clinical outcome of surgery for degenerative lumbar spinal stenosis with evaluation of the preoperative factors affecting the outcome and to investigate radiological results and risk of post-operative developed instability in long term follow-up.
Methods: From January 1990 to December 2000, 110 patients with degenerative lumbar spinal stenosis, who had no prior back surgery, underwent decompressive surgery. The extend of surgical procedure varied from less than one laminectomy to three level laminectomy and no fusion was performed in this group. The follow-up of this study ranged between 2 and 12 years. We evaluated patients during their out-patient controls. We assessed objective neurological status, long term releasing of radicular pain, neurogenic claudication, weakness, back pain, sensory loss and atrophy. The subjective disability of patients was assessed the Oswestry score. The postoperative stability was investigated by upright flexion-extension radiographs. The patient´s estimation of the result of surgery were broken down into five groups depending on satisfaction.
Results: Age of patients ranged from 38 to 80 years, the male/female ratio was 4:1. Improvement of radicular pain revealed 86% patients, neurogenic claudication 85%, sensory loss 57%, weakness 55%, back pain 41% and atrophy 99% of patients from this group.82% of them had good outcome with either no pain or mild pain or only occasional need for pain medication, 10% was improved with chronic medication, 6% was without any change of their condition, health condition did not worsen with any patients. The mean Oswestry score in all 110 patients was 28.7%. No surgery for postoperative instability was performed in long term follow-up.
Discussion: The results suggest that pure degenerative stenosis or degenerative stenosis with disk herniation and no prior surgical intervenction, no comorbodity of diabetes and hip joints arthrosis could be relatively successfully treated by decompressive laminectomy. This surgical method has good results in treatment of radicular pain and neurogenic claudication caused by degenerative lumbar stenosis.The problem is, the relatively low number of back pain improvement. There is no significant risk of postoperative instability if there is not before surgery.

P 112

DALLAS PAIN QUESTIONNAIRE CLASSIFICATION PREDICTS OUTCOME IN LOW BACK PAIN PATIENTS UNDERGOING SPINAL FUSION

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Introduction: Ozguler et al. described a classification tool for low back pain patients using the Dallas Pain Questionnaire (DPQ) (Spine 2002). Our aim was to evaluate the ability of this classification to predict outcome in spinal fusion patients.
Methods: 578 patients (246 men, 332 women; mean age 46, range 18-81) operated between 1992 and 2001, with a complete DPQ preoperatively and after a minimum of one year follow-up, were included. They were classified preoperatively and at follow-up into four groups: Group 1 (slight disability), Group 2 (intermediate disability), Group 3 (major disability) and Group 4 (major disability and emotional distress). 250 patients with low back pain rating scale scores at follow-up were used for prediction of back and leg pain at follow-up. Using logistic regression 7 predictor variables were investigated: Age (18-59 years/60+ years), Gender (male/female), Diagnosis (listhesis/degeneration), Previous back surgery (yes/no), Work status (working/not working), Duration of pain (less than 2 years/more than 2 years) and Disability/distress (disability (group 1-3)/disability and distress (group 4)). Outcome variables consisted of disability (low=group1+2 at follow-up/high=group 3+4 at follow-up) and for the subset of patients leg pain (low/high) and back pain (low/high).
Results. Preoperative classification was Group 1: 1%, Group 2: 14%, Group 3: 36%, Group 4: 49%. Variables found to predict high disability at follow-up were female gender OR 1.39 ($p = 0.083$), previous back surgery OR 2.00 ($p<0.0005$), not working OR 2.94 ($p<0.0005$) and emotional distress OR 2.49 ($p<0.0005$). Emotional distress predicted back pain OR 2.22 (p.=0.007) and leg pain OR 2.90 (p.=0.002) at follow-up. Previous back surgery predicted leg pain at follow-up OR 1.97 (p.=0.037).
Discussion: These results show that this classification based on DPQ-scores predicts outcome in spinal fusion patients and that the largest risk factors for inferior outcome in is emotional distress, previous surgery and a status as not working.

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RESULTS OF COMBINED ANTERIOR AND POSTERIOR FUSION IN THE TREATMENT OF SEVERE IDIOPATHIC SCOLIOSIS

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Study design: a retrospective study of patients with severe idiopathic scoliosis who underwent one stage spinal surgery from anterior and posterior approach.
Objectives: to analyze radiological outcome of combined anterior release and posterior fusion in patients with severe idiopathic scoliosis.
Summary of background data: the treatment of severe idiopathic scoliosis is difficult and an achieved correction is usually smaller. Various techniques of anterior et posterior fusion are used in these cases.
Material and methods: a total of 98 patients were included in this study. All of them had preoperative curve angle bigger then 80° with significant domination of type 3 according to King classification. They were divided into 5 groups. Group I consisted of 16 patients who underwent one stage anterior release and posterior fusion with Wisconsin instrumentation. The mean patients' age during surgery was 13 years. Before operation the mean curve angle was 98° and follow-up period was 2.5 years. Group II consisted of 10 patients who underwent anterior release followed by 10-14 days of skull femoral traction and posterior fusion with Wisconsin instrumentation. The mean patients' age during surgery was 17 years. Before operation the mean curve angle was 127° and follow-up period was 4 years. Group III consisted of 19 patients who underwent one stage anterior (via thoracotomy) and posterior fusion with derotation instrumentation, the mean patients age during surgery was 14 years. Before operation the mean curve angle was 94° and follow-up period was 2.5 years. Group IV consisted of 14 patients who underwent anterior release followed by skull femoral traction and posterior fusion with derotation instrumentation. The mean patients' age during surgery was 12 years. Before operation the mean curve angle was 124° and follow-up period was 2 years. Group V consisted of 39 patients who underwent endoscopic anterior re-

lease and posterior fusion with derotation instrumentation the mean patients age during surgery was 14 years. Before operation the mean curve angle was 90° and follow-up period was 2.7years.
Results: For group I obtained mean postoperative curve angle was 51° with correction of 48.3%. During last examination the mean curve angle was 52° with average loss of correction 8.3%. For group II obtained mean postoperative curve angle was 67° with correction of 47.4%. During last examination the mean curve angle was 70° with average loss of correction 1.6%. For group III obtained mean postoperative curve angle was 38° with correction of 61.8%. During last examination the mean curve angle was 40° with average loss of correction 2.9%. For group IV obtained mean postoperative curve angle was 73° with correction of 41.8%. During last examination the mean curve angle was 70° without loss of correction. For group V obtained mean postoperative curve angle was 38° with correction of 58.9%. During last examination the mean curve angle was 37° without loss of correction.
Conclusions: There were no big loss of correction after one stage combined anterior and posterior fusion. Bigger correction was noted at patients anterior release et posterior fusion with derotation instrumentation. The type of anterior approach (thoracotomy versus endoscopy) did not influence the radiological outcome. The biggest primary curve was in group II and IV where although the correction was limited, the loss of correction was minimal.

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TIMING OF CRANIOCERVICAL FIXATION IN RHEUMATOID PATIENTS. A PHILOSOPHY ABOUT FUTURE INDICATIONS AND A COMPARITVE CLINICAL TRIAL

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Introduction: Rheumatoid atlantodental instability and secondary basilar impression will lead to serious myelopathic disability and sudden death. Population based epidemiological studies report a lifetime incidence in rheumatoid patients of 10-15%. Which proportion of radiological craniocervical pathology will develop neurological problems and in which time window? The latest results led to the establishment of another treatment philosophy, advocated by well known surgical experts. This strategy is centred around early timing of surgery based on radiological abnormalities and prevention of neurological sequels. Although attempting to follow this treatment strategy, evidence is still lacking. Critical analysis of the results and comparison with the existing literature is the basis for developing a trial.
Methods: In the LUMC(1999-2000) 82 consecutive patients with rheumatoid arthritis underwent craniocervical stabilisation. Only C1C2 instability was seen in 18 patients obviating the need for extensive craniocervical fixation. The other 64 patients were prospectively followed with a minimum of 2 year. The primary outcome measure was the Ranawat scale.
Results: A majority of 71 % Ranawat Class 3A patients did improve to Class 2, whereas only 16 % of 3B patients did improve to Class 2. The great majority of Class 3B patients (84 %) did not improve and had more complications. Two 3B patients died and a few hardware complications are reported.
Discussion: Although this is not a scientific investigation the conclusion is that current craniocervical techniques are safe to apply and result in immediate rigid fixation. Most patients were classified as Ranawat 3B. These patients do have according to Crockard an unacceptable high mortality rate of 40 % in the first six postoperative months, in contrast with Ranawat 2 and 3A (2%). Although the surgical risk seems high the complication rate is low (except 3B) in experienced hands. The proposal is an international Multicenter (Cost-)Effectiveness Clinical Trial comparing early timing of surgery with a longer wait and see policy. The Myelopathy-Disability-Index will be the primary outcome measure. This epidemiological study will be carried out following the current methods of research and will lead to a proper treatment strategy and multidisciplinary consensus in the future.

TRAUMA

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SURGICAL TREATMENT PRINCIPLES IN VERTEBRAL FRACTURES RESULTED FROM GUN-SHOT INJURIES

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Introduction: Spinal gunshot injuries are regarded as medical challenge to orthopedic surgeons because of their complex nature and associated abdominal and thorax injuries.
Material and Method: We evaluated retrospectively the results of 29 patients who had spinal fracture due to gunshot wounds in the Orthopaedics and Traumatology Department of Gulhane Military Medical Academy between January 1994 and December 2002. Average age of patients was 235 and mean follow-up period was 26 months. 22 (%75.8) of the fractures were localized in toracic region and 13 (%44.8) of the fractures were in lomber region. 3 (%10.3) of the fractures showed multiple level lesions. Surgical decompression and stabilisation were applied to to the patients with a gunshot wound to the spine who is continuing to undergo neurologic detoration. The neurologic lesion level was not found compatible with the injury level in 19 (%67.5) of the cases and it was probably due to the thermal and blast effect of the missile. Parenteral antibiotics were applied for 7 days to all patients following surgical treatment.
Results: The patients were evaluated with plain radiograms and CT scans for fracture nature and degree of neurological deficit was evaluated with MRI. While Frankel levels of 16 (%55.1) cases showed progression with our treatment. 10 cases did not showed any progression. Surgical decompression and stabilisation were applied to the patients with a gunshot wound to the spine who is continuing to undergo neurologic detoration. We observed infection in 5 (%17.2) cases with perforated discus and they responded well to surgical debridment with high dose IV antibiotic treatment However there is no indication of bullet removal in patients with complete cord lesion and who has injuries between T1 and T11 levels. The treatment covered with physical, psychological and rehabilitation components.
Conclusion: The best treatment for gunshot injuries is early surgical intervention.
Surgical decompression and stabilisation is indicated in any patient with a gunshot wound to the spine who is continuing to undergo neurologic detoration, who has proven neural compression by bone or disc fragments, large bullet fragments or hematoma, whose lesion is localized between T12 and L4 and who unstable fracture. A well done stabilization fascilitates postoperative rehabilitation program and provides early healing with a pain-free spinal column. Since this kind of patients may show motor, sensoriel and autonomic dysfunctions altogether, the treatment must cover all these requirements with physical, psychological and rehabilitation components.

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TRANSPEDICULAR BALLOON VERTEBROPLASTY AND CALCIUM PHOSPHATE CEMENT AUGMENTATION FOR TREATMENT OF BURST FRACTURES OF THE THORACIC AND LUMBAR SPINE

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Introduction: Hardware failure and reduction loss are complications of fracture treatment with pedicle screws. Studies have suggested that disc intrusion into the vertebral body is the cause of the anterior collaps. Restoring the endplate anatomy and filling of the body defect was the subject of a recent cadaveric study, showing the feasibility of anterior column augmentation by balloon vertebroplasty with calcium phosphate cement (CPC). This study describes the technique and short-term results of that procedure in the first twelve patients.
Patients and Methods: After approval by a medical-ethical committee, patients (>18 years) with an acute burst fracture but without neurologic deficits were included. Radiographs and MR-images were obtained for fracture assessment and classification. The patients were operated within a week with pedicle-screw fixation. After the reduction, cannulas were inserted transpedicularly in the fractured vertebra. Subsequently, the balloons were introduced and, after positioning under the endplate, inflated. Fluoroscopic images were obtained to assess the reduction and to monitor bone displacement. The balloons were actively deflated and removed. The cement was injected under fluoroscopy until the defect was filled completely and a posterolateral fusion was performed. The patients were mobilized wearing plaster-jackets from the third day after surgery. Cobb's angle and anterior body height were measured on the radiographs. The central vertebral body height was measured on mid-sagittal MR-images. The follow-up ranges between 3 and 15 months. Six patients have a follow-up longer than 1 year.
Results: All patients (male/female: 6/6, age 18-67 years) had traumatic burst fractures (between Th12-L3). No complications of instrumentation were seen. The balloon-pressure varied from 90 to 150 psi with a mean maximum pressure of 100 psi after "setting", in which phase the balloons actually reduced the endplate fracture. In all cases some reduction of the endplates was achieved. The amount of injected CPC varied from 12 to 36 grams. The procedure caused approximately 15-20 minutes of extra operation time and one minute of fluoroscopy. In two cases, a small amount of cement was observed in the spinal canal postoperatively. In another case cement was found anteriorly of the vertebral body. All patients recovered uneventfully and the neurological examination revealed no deficits. The postoperative radiographs and MR images demonstrated a good position of the instrumentation and CPC in situ. No reduction loss or hardware failure was observed during the outpatient visits.
Discussion: All patients have been followed long enough to detect immediate complications of surgery. The post-operative period and follow-up of these patients has not differed from that of the "usual" population of burst-fracture patients. However, only prolonged follow-up examinations can show whether this technique will prevent long-term complications and is currently under investigation.

TUMOR

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A RETROSPECTIVE REVIEW OF SPINAL INTRADURAL TUMOURS IN A SINGLE INSTITUTION

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Introduction: This is a retrospective review of the complications and functional outcome of intradural spinal tumours.
Materials and methods: Between January 1994 and April 2001, 102 patients had surgery for intradural spinal tumours. 73 patients (44 male, 29 female), mean age 53 years (range 12-87 years) underwent 76 procedures for extramedullary tumours. 12 tumours were cervical, 38 thoracic, 22 lumbosacral and 1 at multiple levels. 29 patients (15 male, 14 female), mean age 44 years (range 15-81 years) had surgery for intramedullary tumours. 15 tumours were cervical, 8 thoracic, 5 lumbar and 1 craniocervical.
Results: Operation: 66 extramedullary tumours were excised and 7 debulked. 16 intramedullary tumours were excised, 11 debulked and 2 biopsied.
Histology: There were 31 extramedullary meningiomas and 20 schwannomas. There were 15 intramedullary ependymomas and 5 astrocytomas.
Recurrences: Mean follow-up was 60 months (range 2-103 months). 4 patients were lost to follow-up. There were 8 recurrent extrameduallary tumours and 2 intramedullary.
Complications and mortality: There were 2 perioperative deaths and 2 related to disease progression. 20 % had significant complications. CSF leak (11 cases), meningitis (6 cases) and wound infection (3 cases) were the commonest.
Functional outcome: 29 patients with intramedullary tumours had useful or normal motor function pre-operatively (Frankel scale). Post-operatively 90% were unchanged/improved and 10% deteriorated. 62 patients with extramedullary tumours had useful or normal motor function pre-operatively. Post-operatively 95% were unchanged/improved, 3% deteriorated by one grade but were walking and 1 was paralysed. 11 patients with extramedullary tumours had no useful motor function pre-operatively. Post-operatively 73% were ambulant and 27% were unchanged.
Conclusions: Functional outcome was comparable to other studies and not related to extent of resection or tumour location. Mortality rate was similar to previous studies. There were 2 cases of MRSA meningitis reflecting the growing problem of MRSA in the neurosurgical population, each caused major complications. One patient died and one was paralysed after initially improving.

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VIDEO ASSISTED THORACOSCOPIC SURGERY FOR SPINAL METASTASIS: IS IT REALLY MINIMAL INVASIVE?

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This prospective study aims to assess the minimal invasive character of thoracoscopic techniques. Traditionally most of the reconstructive procedures for the management of spinal metastases are performed through open approaches. Now these procedures can be performed using VATS. However there is a great controversy about the minimal invasive character of VATS especially if the

high-risk fragile patients with spinal metastases are considered. From August 1996 till March 2001, 78 patients with spinal metastases underwent anterior thoracoscopic palliative tumour excision and reconstruction combined with posterior instrumentation. The patients were selected for this surgical regime according to Harrington and Tokuhashi scores. The following points were studied: the success and safety of the thoracoscopic techniques (blood loss, operative time, operative difficulties, ICU stay, chest tube drainage and postoperative complications), the sagittal contour analysis, and the recurrence rate. Conversion to open thoracotomy was not necessary in any case. The mean operative time of the thoracoscopic approach was 105 minutes (SD. 55 minutes) and the mean blood loss was 1540 ml (SD. 466 ml). Difficult ligature of the segmental vessel of the affected vertebral body was the most commonly encountered operative difficulty (in 10 patients). Bleeding more than 2000 ml (14 patients) and ventilatory support > 72 hours (8 patients) were the most common postoperative complications. No deaths were occurred as a result of the surgical technique. The chest tube out-put was 435.5 ml in average (SD.112 ml). The follow-up period was 41 months in average (range 24- 58 months). The mean preoperative local kyphosis angle of the affected spinal segment (s) was 22.5° (SD.16.4°) that was improved postoperatively to 8.85° (SD. 7.3°) with an average loss of correction of 6.5° at the end of follow-up. Local recurrence was encountered in only one case. Based on our results of applying the thoracoscopic techniques for potentially high-risk tumour patients, we think that the thoracoscopic anterior spinal surgery is a valuable minimal invasive technique. It combines the goals of improving visualization and minimizing the surgery-related patient morbidity with the goals of achieving efficacious, safe, and equivalent results when compared with its open surgical counterpart.

VARIOUS

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"SPINE TANGO", A NEW INTERNET-BASED SPINE REGISTRY: FEASIBILITY AND TIME-EXPOSURE IN DAILY CLINICAL USE

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Aims: In October 2002 the Spine Society of Europe in cooperation with the Institute for Evaluative research in Orthopaedic surgery of University of Berne officially released "Spine Tango", an online registry for spinal surgery. The registry is hosted by the "orthoglobe"- portal. This study was conducted on the feasibility and time exposure of internet-based documentation in daily clinical use.
Methods: Between March 2002 and January 2003 clinical data as well as patient-based questionnaires (Oswestry-score, SF-36) of patients, who underwent spine surgery (microdiscectomy, kyphoplasty, multilevel fusions, correction of scoliosis and artificial disc replacement) in our department, were collected. Those data were entered just before patients discharge via internet-connection with a data rate of 10 MBit/sec. Between April and July 2002 the system was used during its second beta-test phase. Since August 2002 an updated version was applicable, which was officially released in October 2002.
Results: We documented 23 cases in the beta-test phase of the system. The mean time exposure of data entry including the patient-based questionnaires was 20.7 (12-35) minutes per case. In the updated version we documented 111 cases. Mean time exposure decreased to 15.3 (8-27) minutes per case, mainly due to improved hierarchic submenus, which supported input-modalities.
Conclusion: "Spine Tango" in its recent version has become a feasible tool for online-documentation.

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THE EVOLUTION OF SAGITTAL SEGMENTAL ALIGNMENT OF THE SPINE DURING CHILDHOOD

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Summary of background data Although spinal column is aligned neutrally both on coronal and transverse planes, there is a physiological curvature on the sagittal plane. Ideal spinal instrumentation should neutralize coronal and transverse plane deformities while restoring the sagittal plane contour. Having normative data about the sagittal plane is an integral part in the planning of the three dimensional reconstruction of the spine. Segmental sagittal plane analysis on adults have been studied thoroughly, however, there is inadequate data on children.
Objectives The purpose of this study is to describe the normative data of the sagittal plane on pediatric age population, and to document the evolution of sagittal alignment with growth.
Study design Cross-sectional
Materials Methods 151 children (72 girls, 79 boys) without musculoskeletal abnormality between ages 3 to 15 were studied with the 36-inch standing lateral X-ray with the arms flexed at 30°. There were minimum of 10 children, at least 4 of them from one sex, in each age group. The variables measured on the radiograms were: segmental angulations from T1-2 to L5-S1; angles of global kyphosis (T1-12) and lordosis (L1-S1); segmental angulations of T2-5, T10-12, T10-L2, L4-S1 levels; T1 and L1 offsets in millimeters; location of thoracic and lumbar apices; spinopelvic alignment measurements (angles of alpha and beta, sagittal vertebral axis (SVA), and sacropelvic translation (SPT)). The measurements related to the center of the hips could only be measured after age 5 since the femoral heads could be visualized completely on the radiograms after that age. For the statistical analysis, the children were grouped in terms of ages [Group I(3 to 6 years of age), II(7 to 9), III(10 to 12), IV(13 to 15)].
Results One-way ANOVA showed significant difference between following parameters among Groups: Segmental angulations of T1-2(p=0.015), T10-L2(p=0.014), L4-S1(p=0.001); global kyphosis angle(p=0.005); global lordosis angle(p=0.000); thoracic apex(p=0.007); T1 offset(p=0.000); SVA(p=0.004); and beta angle(p=0.000). As SVA increases there found to be a higher L1 offset and lower thoracic apex, both of which results in leaning forward. With growing, total thoracic kyphosis, and total lumbar lordosis particularly due to lower 2 motion segments, were found to be increased, while thoracic apex moved upwards, T1 offset increased, and L1 offset decreased. Older children stood with a more negative SVA, and sacral inclination increased.
Conclusion Sagittal spinal alignment is found to be changing as child grows. There is a statistically significant difference among different age groups especially on cervicothoracic, thoracolumbar, and lumbosacral junctions. The position of the sacrum (inclination and translation), and both orientation in space, and global magnitude of the thoracic kyphosis, and lumbar lordosis changes with growth, as well. These findings should be taken into consideration for the young patients who require spinal instrumentation. The question "whether sagittal alignment should be restored according to the normative data for the child's age or to the normative data for the adulthood" still remains to be answered.

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EFFICACY AND COST EFFECTIVENESS OF HARMONIC SCALPEL COMPARED TO ELECTROCAUTERY IN POSTERIOR SPINAL INSTRUMENTATION

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Study Design: One hundred two patients who underwent posterior spinal instrumentation with or without the use of harmonic scalpel for the surgical approach were retrospectively reviewed.
Objectives: 1) To determine if the harmonic scalpel (HS) decreases blood loss and the need for transfusion of blood products compared to electrocautherization (EC) in patients who underwent posterior instrumentation of the cervical, thoracic and lumbar spine 2) to evaluate the cost effectiveness of harmonic scalpel compared to electrocautherization
Summary of Background Data: Although the use of harmonic scalpel, an ultrasonically activated coagulator, is described in endoscopic spinal surgery, its efficacy for the surgical approach in posterior spinal instrumentation remains unclear.
Methods: 51 Patients (group I) who underwent posterior spinal instrumentation (15 cervical, 6 thoracic, 30 lumbar) for different disease with the use of HS were compared with 51 patients (group II) in whom EC was used for surgical approach. All instrumentations were done by the same senior author (MR) at one institution. The two groups were matched in a blinded manner without knowledge about the real blood loss. The groups were similar with respect to means of age, diagnosis, localization of surgery, levels of instrumentation, levels of fusion, levels of decompression, amount of used screws and duration of surgery. The cost were analyzed using a cost comparison method.
Results: The use of HS resulted in statistically significant less blood loss (1226 ± 985 ml) compared to the use of EC (2176 ± 1763 ml; $p < 0,01$). The costs for blood products for patients operated with UC averaged 82 Euro, for patients with EC 219 Euro. The costs for operation staff with HS averaged 477 Euro, with EC 530 Euro. The material cost for HS per operation averaged 102 Euro. Thus overall costs for EC averaged 749 Euro and for HS (including depreciation of 66 and interest of 13 Euro) 740 Euro.
Conclusion: Although the Ultrasound knife is an expensive device, the overall costs remain neutral compared to electrocautery in posterior spinal instrumentation. Moreover the possibility of transfusion complications are minimized due to reduced need for blood products.

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TOTAL DISC REPLACEMENT- A PHYSIOLOGICAL RECONSTRUCTION OF THE SAGITTAL PROFILE OF THE LUMBAR SPINE? A RADIOLOGICAL STUDY

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Study Design: A retrospectiv study on lateral radiographs of patients with lumbar total disc replacement (TDR).
Objectives: Evaluation of total lumbar lordosis (LL), segmental lordotic angle (SL), anterior (AH) and posterior disc heights (PH) before and after TDR.
Summary of Background Data: Postulated basic principles of TDR are the restoration or maintenance of physiological LL and disc height. There are is a gap in the knowledge if this is also true in the clinical setting.
Methods: The average age of 22 patients with 24 TDR was 40,2 ± 6,2 years. The mean follow-up intervall averaged 14,4 months (2,8 - 23,4 months). Standard Cobb measurements were made of the operated level (OL) and the LL with a computer based evaluation system. The AH and PH of the discs in the OL were also recorded.
Results: There was no significant change in LL postoperatively (prä: 56,2°, post: 58,6°). When ≥5° was considered as a distinct change, the LL increased in 18%, decreased in 9% and remained in 73%. There was a statistically significant difference of SL at the OL (prä: 20,0°, post: 27,7°; $p<0,01$). The SL increased in 75%, remained in 25% and decreased in 0%. Postoperatively 5 of 10 "normative" SL changed to "excessive", 5 remained "normative". 8 of 12 "insufficient" SL changed to "normative", 1 changed to "excessive and 3 remained "insufficient". Both "excessive" SL remained "excessive". Thus, the SL was insufficient in 13%, normative in 54% and excessive in 33%, postoperatively. Preoperatively/postoperatively, the average heights (mm) of the anterior [posterior] disc border were 9,91 [4,83]/18,39 [9,65]. The AH/PH increased 110%/121% postoperatively.
Conclusion: 1) TDR tends to increase the SL and the disc height to unphysiological values which is probably in part due to transsection of the anterior longitudinal ligament (ALL) 2) A distinct increase in SL due to TDR does not affect the LL significantly 3) TDR did not always achieve an sufficient reconstruction of normative SL. 4) Biomechanical studies have to clarify the importance of ALL to the SL after TDR 5) The clinical relevance of these findings have to be evaluated in long term studies.

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THERMOGRAPHICALLY MONITORED SYMPATHETIC DYSFUNCTION DURING AND AFTER ALIF PROCEDURES

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Introduction: Complications after Anterior Lumbar Interbody Fusion (ALIF) ranges from vascular and neural injury to bowel injury. However, because of its close anatomical location next to the spinal column, the sympathetic trunk is more frequently affected and dominates the quantity of complications. Sympathetic dysfunctions following ALIF procedures, varies from hyperthermia to sexual dysfunction (male). Despite its frequency, only little is known about extend of hyperthermia with intact sympathetic trunk, linkage to segments fused and the course of these alterations, whether alterations occur intraoperatively and persist postoperatively or whether these alterations establish postoperatively.
Purpose of the study: Pre-, intra- and postoperatively thermographic mapping to validate thermography as a suitable and sensitive technique to evaluate sympathetic dysfunctions following ALIF procedures.
Methods: Study group was composed of 21 female and 10 male patients, with an average age of 44, treated for discogenic low back pain receiving contemporaneously dorso-ventral fusion, between January and December 2000, by the identical surgeon. Pre-, intra- and postoperative thermography was done using infrared thermography camera (ThermaCAM PM 300, FLIR). Statistical analysis was performed using the non-parametric Wilcoxon signed rank test. P values smaller than 5% were considered to be significant.
Results: Intraoperative mechanical (pressure) manipulation of the sympathetic trunk lead to reversible alterations of the temperature at the approach sided leg, with lower temperature following pressure. While these intraoperative alterations have been reversible, all patients receiving ALIF procedures at L4/5 had postoperative persisting significantly ($p<0.0029$) increased temperatures (average 3.3°C, minimum 1°C, maximum 5.1°C) at the approach sided leg compared to the opposite leg (measured 3 to 33 days postopera-

tively). Different to L4/5, ALIF procedures at L5/S1 where only in 50% accompanied with persisting increased temperatures at the approach sided leg.
Conclusions: Thermography is a suitable technique to monitor and quantify the extent of sympathetic dysfunction following ALIF procedures. The higher incidence of postoperatively persisting increased temperatures at the approach sided leg following ALIF procedures at L4/5 compared to L5/S1 might be related to the higher anatomical variability at L5/S1. Further studies have to be performed to elucidate the mechanisms of persisting sympathetic dysfunctions.

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INTERNET USE BY SPINAL OUTPATIENTS

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The use of the Internet has been on the rise over the past few years. The Internet provides a rich source of information about various aspects of life. It seems that patients are tending to access the internet more to understand and know more about their condition and treatment.
Purpose: To assess the prevalence of use of the internet by the spinal outpatients and comparison of the information to the consultation received.
Method: Data was collected from at total of 150 patients- 50 each from chronic back clinics, scoliosis clinics and pediatric outpatient clinics (comparison group for the scoliosis group). The patients and their families were asked about access to internet and the frequency of its use. They were also asked if the information provided during the consultation was satisfactory and as to how it compared to the information on the internet and as to which of the two would they rely more on.
Results: The use of the internet was more prevalent in the scoliosis group (33%) compared to the pediatric group (20%). Approximately 80% of the scoliosis clinic patients felt that they had similar information as the internet following their outpatient consultation. Nearly 96% of the chronic back clinic patients would rely on the doctor more than the internet compared to 90% of the pediatric group and 80% of the scoliosis group.
Conclusion: The clinicians should regularly update themselves as to the information available on the internet using common search engines. They should try and provide the list of useful websites to the patients to access more information of their condition.

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POSSIBILITIES FOR COST REDUCTION OF DIFFERENT IMPLANTS IN LUMBAR SPINAL SURGERY

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Introduction: To evaluate the possibilities for cost reduction in lumbar spinal surgery by analysing of the implant costs and the efficiency of each type of implant.
Methods: The costs of spinal implants are summarised according to an analysis of price lists from 2001 and 2002. The different methods are additionally evaluated with regard to the scientifically-based treatment efficiency. All prices above 100 Euro were rounded up to the closest 50. For the implants, a literature research was performed. The scientific papers were divided into groups according to their level of evidence, and then further subdivided into comparable and non-comparable categories.
Results: ventral: plates-: 1000-2800 Euro, rod-systems: 1200-2000 Euro, vertebral body replacement systems: 500-1300 Euro; dorsal: internal fixateur: 400-2500 Euro, cages: 600-1300 Euro, artificial discs: 1800-5000 Euro. For none of the implants were comparable scientific clinical publications found with a high levels of evidence.
Discussion: Costs can be reduced through a more thorough investigation and corresponding choice of implant method. The scientific cost-benefit analysis of new spinal implants must be considered more with regard to the evidence-based spinal surgery treatments. In order to sufficiently evaluate the different treatment methods, future multicenter controlled studies and meta-analyses must be undertaken.

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BIOMECHANICAL EVALUATION OF VERTEBRO- AND KYPHOPLASTY WITH PMMA OR CALCIUM PHOSPHATE CEMENT UNDER CYCLIC LOADING

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Introduction: Vertebro- and Kyphoplasty are two alternatives to augment osteoporotic vertebrae with polymethylmetacrylate (PMMA) or CaP-cements. With some limitations both methods showed promising early clinical results. However, little is known about the fatigue characteristics of the treated vertebrae under cyclic loading. The purpose of this study was to develop a new method to simulate the in-vivo dynamic loading as close as possible to compare kyphoplasty and vertebroplasty. Special interest was given to CaP-cement, which might fail due to its brittleness.
Methods: 24 intact, osteoporotic bisegmental human specimens (Th12-L2 and L3-L5) were divided into three groups (comparable mean age and BMD)

(1.) Vertebroplasty with PMMA
(2.) Kyphoplasty with PMMA
(3.) Kyphoplasty with CaP-cement
(4.) untreated control-group.

After augmentation of the middle vertebrae, all specimens underwent 100.000 cycles of excentric loading (5 Hz; 100N-600N; 30mm lever arm) while the specimen was turning around its axis (360°/min). Pre- and post loading X-rays and subsidence measurement at different sites of the vertebrae were taken. The overall height was additionally determined every 20000 cycles in the material testing machine. Finally, the specimens were cut frozen to examine the cements.
Results: The overall height change increased with strong individual differences in all groups with increasing number of load cycles up to median values of 2.8 mm for both augmented groups and 4.2 mm for the non-augmented one (Mann-Whithney, $p<0.05$). At the centre of the endplate subsidence for kyphoplasty was higher than for the vertebroplasty with little differences with respect to the kind of cement. The frozen cut did not show any signs of fatigue in the PMMA and small cracks in the CaP.
Conclusions: Vertebro- and kyphoplasty seem to be equivalent methods to strengthen the osteoporotic vertebrae. However, this results cannot be transferred to the treatment of fractures with these methods. A “physiological” loading situation was achieved by a complex motion including all combinations of flexion/extension with lateral bending during excentric cyclic loading.

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A NOVEL APPROACH TO DETERMINE TRUNK MUSCLE FORCES DURING FLEXION AND EXTENSION: A COMPARISON OF DATA FROM AN IN VITRO EXPERIMENT AND IN VIVO MEASUREMENTS

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Introduction: The spine is primarily stabilized by muscle forces, which greatly influence spinal loads. However, little information exists on the magnitudes of trunk muscle forces during postures like flexion and extension of the upper body. The goal of this in vitro study was to determine the magnitude of trunk muscle forces during flexion and extension. The loading conditions in this study accounted for body weight, local and global muscles, and forces resulting from the support of the abdominal soft tissue in different postures. Disc pressure and fixator load were compared with data from in vivo measurements.
Methods: Seven human cadaveric lumbar spines were mounted in a spine tester and adjusted to different degrees of flexion and extension of the upper body with different hip flexions. For each specimen a total of 124 load cases were studied. They included combinations of a vertical compressive load, a follower load and forces pulling with cables at a plate fixed at the cranial end of the specimen to simulate rectus abdominis, erector spinae, and a supporting force of the abdomen. Loads on internal fixators as well as intradiscal pressure and intersegmental rotation at all levels were measured. When they were close to in vivo data this muscle force combination was assumed to be the muscle forces, which can be expected in vivo.
Results: Generally, intradiscal pressure was closer to in vivo measurements than the fixator loads. The force in the m. erector spinae increased with the flexion angle but was only slightly influenced by extension. The estimated forces in the erector spinae were 100N for standing, 130N for 15° extension and 520N for 30° flexion of the upper body. Little influence was found on the intersegmental motion.
Conclusion: In vitro loading conditions can be approximated closely to in vivo conditions with the simulation of an axial preload, local and global muscles. This novel approach can help to estimate muscle forces, which can usually not be measured. The results from this study provide important input for FEM models, which may then allow the investigation of different load cases.

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