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Spine

1. Physical characteristics and workload exposure in 45–55-year-old men with and without low back pain

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Material: 149 men (129 from a manufacturing industry, Stockholm and 21 from the outpatient clinic of the Department of Orthopedic Surgery, Karolinska Hospital) were included in the study. The men were divided in three groups according to results from a screening formula, physical files and information from Social Security General Sicklisting. Group 1 = backhealthy men (n 36), Group 2 = men with recurrent LBP but free from LBP >2 months prior to the evaluation (n 91), Group 3 = men with chronic LBP, sicklisted >3 months the year prior to the evaluation (n 21).

Method: Height, weight, body composition (calipers), spinal configuration and flexibility (kyphometer), straight leg raising (Myrin's inclinometer), isokinetic and isometric trunc strenght (Cybex II+), trunc endurance (mod Biering Sorensen) were measured. Information about work load exposure during all working life was gathered through questionnaire and evaluated through a workload score built on the NYK-codes (Nordisk Yrkesklassificering)). A rating scale (Borg) was used to measure the subjects perceived work load exposure. The questionnaire also included questions about present work concerning working postures, material handling and psychological work load parameters such as work satisfaction, locus of control and feelings of comfort at work.

Results: There were no differences between the groups considering anthropometry (height, weight, body composition). Group 1 (backhealthy men) had the highest values concerning configuration, flexibility, strength and endurance. Group 3 (chronic LBP) had the lowest values and Group 2 (recurrent LBP) had values in between. The differences were statistically significant between Groups 1 and 3 in all variables except degree of lordosis and abdominal trunk strength. The differences between Groups 1 and 2 were significant only when it concerned degree of lordosis and endurance of abdominal muscles. Both Groups 2 and 3 had significantly higher scores and perceived physical workload than Group 1 throughout their working lives. Groups 2 and 3 stated that they spent significantly more time in stooped and twisted postures and had significantly less influence on their working situation than Group 1.

2. Surgical treatment of chronic low back pain and sciatica—psychological aspects

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Follow-up was performed by an unbiased observer of 50 patients operated with decompression and fusion by one orthopedic surgeon for adult spondylolisthesis (22) or chronic low back pain and sciatica (28). The history of pain was not less than 2 years and the average sick leave 3 years. The overall success rate was found to be 82%. The result of the operation was not correlated to radiographic findings, nor to the MMPI scales hypochondria or hysteria. As a matter of fact both groups of patients showed the same personality profile corresponding to that of chronic idiopathic pain syndromes. The only factor in this study correlating to outcome of surgery was the simple Wadell signs.

3. Symptoms and signs in degenerative lumbar spine disorders

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Introduction: Regarding lumbar disc herniation, signs and symptoms have been well described in retrospective studies (Hakelius, Spangfort and others) while corresponding descriptions concerning lateral and central stenosis of the lumbar spine are not as thorough. In a prospective study we have determined the frequency of some common symptoms and signs in patients with lumbar nerve root compression syndromes.

Patients and methods: In a prospective and consecutive study, 100 patients with lumbar disc herniation (age 43 (20–81) years, 44% women), 100 with lateral stenosis (age 41 (23–75) years, 68% women) and 100 patients with central spinal stenosis (age 65 (37–83) years, 46% women) were included.

The diagnoses were established by means of one or more of the following examinations: myelography, CT, MRI and nerve root block, and were confirmed at a subsequent operation. On admission, a standardized protocol regarding patient symptoms and signs was completed.

The following symptoms were registered: pain at rest, pain at night, pain on sneezing/coughing, consumption of analgesics and walking capacity.

Objective variables studied were: spinal mobility, SLR-test, crossed SLR-test and motor and sensory affection.

Results: Symptoms and signs are presented in the two tables below in percent.

Symptoms and signs	Disc herniation	Lateral stenosis	Central stenosis
Pain at rest	85	86	63
Pain at night	71	79	55
Pain on coughing	68	51	25
Analgesics regularly	54	37	42
Walking capacity <0.5 km	41	14	66
Spinal mob –	96	81	78
SLR test +	88	51	35
SLR <30° +	43	9	4
Crossed SLR +	23	6	2
Quadr refl –	11	13	42
EHL power –	50	55	42
Ankle reflex –	49	37	65

Conclusions: Among the parameters studied, certain differences between the disease entities exist. Pain seems to be a more prominent feature in disc herniation and lateral stenosis, while a serverely reduced walking capacity signifies central stenosis. Objective signs of root tension are common in disc herniation while central stenosis often is associated with multiple motor deficits.

4. Experimental lumbar spinal stenosis —a new model in pigs for the study of neurogenic claudication

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Introduction: Spinal stenosis has recently been investigated in experimental models of one level stenosis in dogs (1,2). In order to investigate the etiology of neurogenic claudication, a new model of a two level spinal stenosis was developed with normal neural function at rest.

Material and methods: The material comprised six Danish breed pigs, 3 months old, weighing 29–33 kg. The care and use of the laboratory animals complied with the principles stated by the Danish law of animal experimentation.

Surgical procedure: The animals were premedicated with Midazolam and Ketamine. After orotracheal intubation the pigs were placed in prone position and ventilated mechanically with a mixture of gases containing 50% atmospheric air, 25% oxygen, and 25% N_2O. The anesthesia was continued by infusion of Ketamine, Pancronium and Pethidine. Prophylactic antibiotics were given.

The dura was exposed by partial laminectomy at the level of L5 and L7, through a posterior approach. The stenosis was induced in the two spine segments in each animal, by an ASD band, aiming at 25% reduction of the dural cross-sectional area, which previously has been demonstrated to be compatible with normal neural function for one level stenosis in other species (1,2). To prevent paraplegia, somatossensory evoked potentials (SEP) were recorded bilaterally by stimulation of the tibial nerve before, during and after induction of the stenosis. Stimuli were collected at the spine segments L2–L3 by electrodes placed in the epidural space, and in the interspinal ligament. Post-operatively cross-sectional areas at stenosis levels were determined by MRI. The animals were terminated after an observation period of 2 weeks.

Results and discussion: The pigs were ambulant from 6 hours to 6 days postoperatively in spite of no SEP amplitude change and less than 10% increase of the mean latency after induction of stenosis. In all pigs bowel and bladder functions remained normal. Adapted to adult mini-pigs the model seems valuable rendering a large segment of lumbar neural structures susceptible for pathophysiological changes. The model thus provides a large subtrate of neural structures for investigation in awake nonmedicated pigs.

References

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5. Reduction of back and pelvic problems in pregnancy

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Introduction: Back pain is often accepted as an inevitable drawback of a normal pregnancy. Previous studies have shown that 50% of all pregnant women complain of back pain and that 10–33% of all pregnant women are on sick-leave because of back pain. The aims of this study were to reduce these figures through early intervention by a physiotherapist.

Patients and methods: From August 1987 to March 1988 a total of 407 consecutive pregnant women were included in the study, randomly divided into groups A, B and C, and followed by means of questionnaires and standardized physical examinations throughout pregnancy. No treatment was given but groups B and C were given a "back-school" education. In group B two 45-minute-classes before the 20th week of pregnancy, and in group C five individual 30-minute-lessons throughout pregnancy. Group A served as controls. The differentiation between back and pelvic pain

was considered important and the information given was modified accordingly.

Results: Reduction of back and pelvic problems through applied muscle and postural training was achieved in groups B and C ($p<0.05$). Reduction through ergonomics at work was achieved in group C ($p<0.05$) where also the frequency of sick-leave was reduced ($p<0.05$).

Summary: By means of a relatively large, differentiated back and pelvic training program throughout pregnancy led by a physiotherapist, back and pelvic problems as well as the frequency of sick-leave were reduced. We recommend that all pregnant women with back and/or pelvic problems are seen by a physiotherapist with insight in the specific care of these conditions.

6. Good results after operation for lumbosacral spondylolisthesis a.m. Roy-Camille

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The optimal surgical treatment of patients with symptomatic spondylolisthesis is still under debate. Therefore, we have found it of relevance to present our early results with a recently introduced surgical technique.

Material and methods: 14 patients, 7 men and 7 women, were operated on for lumbosacral spondylolisthesis am Roy-Camille. None of the patients had received other surgical treatments. On pre- and postoperative radiographs the anterior displacement of L5 on os sacrum was measured according to Meyerding. During operation a laminectomy and facetectomy were done to decompress the L5 and S1 nerve roots. With a probe the root channels were examined to ensure that there was no root compression. Pedicle screws were inserted guided by an image intensifier. The plates were first fixed to the sacrum, then pedicular screws in L4 and L5 accomplished the reduction.

After the plates were positioned, bilateral lateral spondylodesis was performed. Postoperatively, the patients wore a total contact brace for 3 months, whereafter unrestricted movements were allowed, and rehabilitation started.

Results: The average follow-up time was 17 months (5–43). Preoperatively, the displacement of L5 on os sacrum averaged 47% (21–100); postoperatively 29% (12–59). There were no wound infections, and the time of hospitalizaiton averaged 20 (8–41) days.

Prior to operation all patients were incapable of work because of low back pain. Postoperatively 12 were back in work after an average of 7.5 months (3–27). Five of these were back in physically demanding jobs. Two patients had transitory paresthesia of the L5 root. Two patients developed paresthesia of the left L5 root 23 and 9 months postoperatively. In both cases the left metal plate was removed with immediate relief of symptoms. There were two cases of material failure. In one patient both plates fractured and in another a pedicle screw loosened. In neither of the cases secondary displacement occurred.

Conclusion: The socioeconomical and surgical results after posterolateral spondylodesis, using the described technique, seem promising. The risk for permanent neurological damages is low compared with other techniques.

7. Sequential MRI-investigations after lumbar discectomy

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Introduction: MRI and CT have to a great extent replaced lumbar myelography for the diagnosing of lumbar disc herniation. In early postoperative course after discectomy, however, CT investigations have been demonstrated to be difficult to interpret. The aim of this investigation was to study the value of MRI during the first four postoperative months after lumbar discectomy.

Patients: In total, 15 patients, 10 women and 5 men, operated on for disc herniation, were included in a prospective study. Mean age was 37 (21–53) years. Five herniations were at the L4–L5 level and 10 at L5–S1 level. Six herniations were right-sided and nine left-sided. Contained disc herniation was seen in nine of the cases while in six cases sequestration was found. The amount of disc tissue removed varied between 1.0 and 1.9 ml.

Methods: In all cases, the diagnosis was established by means of MRI using sagittal and axial T1-weighted sequences. The operation consisted of microscopic surgery in 9 cases and conventional surgery in 6 cases.

After 5 days, 6 weeks and 4 months postoperatively, all patients were examined with MRI using T1 as well as T2-weighted sequences. At the same time intervals, clinical examinations were performed. The patients were asked to grade their degree of remaining leg pain and SLR-test as well as the presence of motor or sensory deficits were registered. The clinical findings were correlated with the MRI results. No per- or postoperative complications were seen.

Results and conclusions:

1. Significant soft tissue masses were seen within the spinal canal in all cases, especially after 5 days and 6 weeks.
2. Deformation of the dural sac was common.
3. No correlation was found between the amount of soft tissue masses within the spinal canal and the clinical findings. (All patients except two had significant or total pain relief after 5 days postoperatively).
4. T1-weighted MR images could not discriminate between the posterior border of the disc and oedema in the peridural tissues.

5. Using a combined evaluation of T1 and T2 images, it was possible to define the posterior disc border in the majority of the examinations.
6. The main problem in interpreting the MR images was the high water content within the spinal canal, i.e. oedema. This was still very evident at 6 weeks but had resolved in the majority of cases after 4 months.

8. How does radial bulge change after percutaneous lumbar nucleotomy? An in vitro study

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Until now basic research concerning the changes of the disc after percutaneous treatment of herniated discs has been very rare. For a biomechanical study 14 specimens of the lumbar spine (L1–S1) were scanned with MRI. After that 40 motion segments with the same signal intensity and height of the disc were prepared. The 40 segments were divided in an APLD-group (20) and a NAPLD-group (20). From each disc in the NAPLD-group 1.0 g, 2.0 g and 3.0 g of nuclear material were consecutively removed under an axial load of the segment of 500 N. In the APLD-group nuclear material was removed during 15, 30 and 45 minutes under an axial load of 500 N. At the beginning of every standardized experiment of a motion segment, as well as after the excision of every gram of nuclear material in the NAPLD-group, and after every 15 minutes in the APLD-group, the intradiscal pressure, the height of the disc and the contour of the disc were determined with an axial load on the motion segment of 1000 N. The change in radial bulging of the disc was measured using the computer-assisted drawings of each disc contour. All the data were statistically analyzed using the Friedman-test. The results of both groups were compared after freeze drying of the nuclear material.

For every 0.1 g freeze dried material removed, the radial bulge increased in the APLD-group 0.15 mm and in the NAPLD-group 0.10 mm. The intradiscal pressure decreased (1.88 bar vs 0.94 bar) and the height also decreased: 0.47 mm vs 0.32 mm.

Based on these data, the origin of radicular pain is discussed. The existence of only mechanical components is doubted. Clinical studies report an improvement of the radicular syndrome in 70–80% of the patients with herniated disc, when treated with percutaneous discectomy. However, this study showed clearly that radial bulging increases when nuclear material is removed!

9. The Cotrel-Dubousset instrumentation in trauma, spondylolysis and degenerative spine disease—personal experience over a 5-year period in 180 cases

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Our first CD instrumentation for a nonscoliotic spinal disease was performed in March 1987. 180 Cotrel-Dubousset instrumentations have been performed since that first case over a 5-year period in 70 fractures, 44 cases of spondylolysis with or without spondylolisthesis and 65 degenerative conditions ranging from simple one level fusions to laminectomies combined with multilevel fusions and correction of degenerative scoliosis.

The CD instrumentation and the recently developed compact CD which we had the opportunity to test from June 1990 proved convenient and effective in the management of these pathological conditions.

In trauma both proximal thoracic and thoracolumbar or lumbar fractures could be managed with the same instrumentation since a large range of implants—hooks and screws—are available to fit any vertebra level. Laminar claws, pedicular screws, short or long instrumentations can be used to match any trauma condition, allowing for rapid ambulation and early return to near normal lifestyle provided the neurological condition is not impaired. Even in neurologically impaired patients, the remarkable stability provided by the instrumentation enhances early rehabilitation and braces can often be avoided, which is valuable in paraplegics.

In spondylolysis immediate stability of the lumbosacral spine is regained, permitting once again early ambulation without postoperative braces; vertebral slipping can be corrected with a posterior approach when desired. The only drawback of the instrumentation is the rigidity when screws are placed at every vertebral level weakening the bone graft. Care should be taken to maintain some elasticity to promote bone healing.

In degenerative conditions, the CD instrumentation is particularly useful in the most difficult cases: multilevel fusions, with or without laminectomies and with or without correction of degenerative spondylolisthesis, rotatory subluxation or scoliosis. The CDI is effective for correcting deformation; a firm fixation is not always easy to obtain in cases of severe osteoporosis. A selection of implants for sacrum and ilium makes it possible to create a solid fixation of the instrumentation at the lower end of the spine where most of the loosenings and delayed or nonunions occur with classical techniques. The effectiveness of the instrumentation makes it possible to consider surgery in elderly patients thanks to the short period of confinement to bed.

The CD and compact CD instrumentations have an important place in the treatment of difficult traumatic and nontraumatic conditions of the spine. Its use requires training and perfect knowledge of the various implants available. CD can be performed by a small team provided

the surgeon is well trained. Aids and scrub nurse accustomed to CD are of great help but do not constitute an indispensable prerequisite.

10. Surgical stabilization in metastatic disease of the spine

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During a 10-year period (1981–1990), 150 patients with pathological vertebral fractures as well as spinal metastases with severe pain and/or neurological symptoms were surgically stabilized.

74 of the patients were men and 76 women. The mean age of the patients was 62 (17–79) years.

31% of the metastases were located in the cervical spine and 69% in the thoracic or lumbar spine. The most common location was the thoracic spine—65 patients (43%).

Primary tumours were breast cancer in 31 cases, renal cancer in 28 and myeloma in 13.

The primary results of the operations were surprisingly good with relief of pain and regained neurological functions in the majority of the patients.

50% of all the patients were alive after 6 months and 33% after 12 months. Twenty patients were living after 2 years.

Patients with metastases of the cervicle spine had a longer survival than those with metastases located to the thoracic or lumbar spine. The tumor types with the longest survival were breast and renal cancer.

In general, the surgical stabilization of metastatic spines has been a very rewarding treatment with an improved quality of life for many cancer patients as well as for their relatives.

11. Surgical treatment of cervical spine metastases—a retrospective study

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Introduction: Metastatic cervical spine lesions are frequently associated with pain and high risk for neurological symptoms. We report our results in 51 consecutive cases treated surgically.

Material and method: This retrospective study includes 51 patients—19 men and 32 women. The mean age at the time of operation was 58 years. The most common primary tumors were breast cancer (19), myeloma (9), urogenital cancer (8) and carcinoma of the thyroid gland (3). All patients had severe pain. Neurological symptoms were present in 25 patients, six had long tract symptoms and 19 rhizopathy symptoms. Four patients were bed-ridden. Surgical treatment was based on an anlaysis of the pathoanatomical changes. In 31 cases with kyphotic collapse of a vertebral body an anterior vertebral replacement was done. Anterior support was reconstructed with bone cement in 22 cases and bone grafts in 9 cases. In 9 cases of pathological dens fracture, a modified Böhler technique was performed. Both anterior and posterior stabilization was chosen for 4 cases with translatory instabilities or multi-level involvement.

Results: All patients with long tract symptoms improved and could walk postoperatively. Relief of local pain and rhizopathy was universally accomplished. One patient died 2 days postoperatively. Two patients needed temporary respiratory assistance. Other major complications were not seen. At follow-up 7 patients were alive. The average postoperative survival was 12 months for the 44 diseased patients. The one year of survival was 38% for the whole series—78% for cancer of the thyroid gland, 63% for myeloma and 42% for breast cancer.

Conclusions: The majority of cervical spine metastases are located in the vertebral body and require an anterior approach for decompression and stabilization. Good pain relief and improvement of neurological symptoms as well as relatively long survival makes surgical intervention rewarding for these patients.

12. Spinal metastases of prostatic carcinoma—variation in pathoanatomy and treatment

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Introduction: Spinal involvement is very common in carcinoma of the prostatic gland. The osseous lesion can be either osteolytic or osteosclerotic.

Material and methods: 29 consecutive patients, aged 65 (59–80) were evaluated retrospectively. The indication for surgery was paraparesis in 25 patients. 17 were bedridden and 8 were able to walk. Local or radicular pain was present in all but one. The symptomatic lesion was thoracic in 21 patients, lumbar in 5 and cervical in 3. Preoperative investigations included CT scans and myelograms or later MRI in all patients with long tract symptoms. The surgical treatment was varied according to the type of compression and instability. Reduction of a kyphotic deformity and posterior stabilization was preferred to a corpectomy in patients with anterior pressure. Laminectomy was per-

formed in all cases with posterior pressure and routinely followed by stabilization.

Results: Analysis of the pathoanatomy in patients with paraparesis showed that anterior pressure due to kyphosis was present in 13 patients. Spinal canal encroachment due to tumor-induced pedicular and laminar hypertrophy was present in 15 patients and epidural tumor growth in 8. Of 25 patients with paraparesis 15 improved postoperatively, 8 were unchanged and 2 impaired. 15 patients could walk postoperatively. Relief of pain was accomplished for almost all patients. At follow-up 3 patients were still alive. The average survival time was 9 months. The 6 months' chance of survival was 40%.

Conclusion: Surgical treatment in symptomatic spinal metastases from prostatic carcinoma gives effective pain relief and often restitutes the walking ability. The great variability in pathoanatomic changes makes a preoperatively analysis necessary to plan a relevant surgical procedure.

13. Operative treatment of septic spondylitis

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Introduction: We have treated septic spondylitis surgically with decompression and stable fixation. The purpose of this paper is to present our experience with this policy.

Material: Twenty patients, 9 women and 11 men, with a mean age of 55±17 (15–86) years were treated in our department between 1983 and 1991. All but 3 were immunologically compromised. The cervical spine was affected in 2 patients, the thoracic spine in 8 and the lumbar spine in 10. All patients presented with severe back pain, 5 patients also had radiating pain. Four patients were neurologically intact, 5 had rhizopathia, 10 were para- or tetraparetic and 1 had a paraplegia.

Methods: In 7 patients with cervical or thoracic involvement, anterior decompression and fixation were performed. In 11 patients with thoracic or lumbar involvement, posterior direct or indirect decompression, correction of the deformity and posterior fusion were done. One patient was treated with external fixation followed by anterior decompression and one patient who was paraplegic after a previous laminectomy was treated with anterior decompression and posterior plating.

Results: Three complications were encountered, one patient had loosening of posterior plates, one developed a wound infection and one elderly patient with a paraparesis died one month after an anterior decompression.

The infections were all brought under control. The effect on pain was excellent. At follow-up 12 of the 16 patients with initial deficits were neurologically intact and two were improved. The one patient initially plegic after a laminectomy remained plegic. The other patient that did not recover was the one that died one month after the operation.

Conclusions: Decompression and fixation of septic spondylitis is effective in bringing the infection under control and in relieving the pain. The chances of neurological restitution are favourable in patients with a partial deficit. Solid fusion in a good alignment is achieved.

14. Pedicular screws at the thoracolumbar junction—a CT study after their removal

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Introduction: Transpedicular screws are now regularly used in the treatment of thoracolumbar fractures. Misplaced screws may cause obvious complications.

Patients and methods: Twenty-one patients treated for burst fractures in T12 (3), L1 (14) or L2 (4) were CT scanned within days after the removal of the transpedicular fixation device. They had been treated by surgeons well experienced in the technique. Image intensifier with C-arm was used during the screw insertion. 5 mm's (56) or 6 mm's (26) screws were inserted. The devices were removed after 14 (10-40) months. All patients who had their devices removed during the study period except one were examined.

CT scans were performed with 2-mm thick continuous slices and displayed with skeletal window. 82 screw canals were examined. Measurements were done on the mid-pedicular slices using a high resolution digitizing tablet. Screw canal inclination and pedicular width were measured. If a defect in the medial wall of the pedicle was present, the pedicle and spinal canal were reconstructed and the screw intrusion into the canal measured. Screws perforating the vertebral body were registered. The position of the aorta in relation to the anterior border of the vertebral body was noted on those scans that displayed the most anterior part of a screw canal. 58 pedicles were adequately visualized on the preoperative CT examinations. Pedicular width was measured on these and visual comparison made with the follow-up examinations.

Results: No patient showed any symptom attributable to a screw. 66 screw canals were entirely within the pedicle; 10 medial and 6 lateral cortical defects were found. Five medial defects indicated intrusion of the screw. The largest intrusion measured 3.5 mm and the remaining four 1.0–1.6 mm. Medial intrusion occurred at all levels. Mean screw inclination in the different vertebral levels differed little. Screws causing medial and lateral cortical defects did not differ in inclination. Of 58 pedicles available from the preoperative studies for comparison ten had cortical defects.

31 of the remaining had increased width at follow-up. 15 of these were uniformly deformed with a straightening of the lateral contour. All screws engaged the vertebral body, one perforated the body laterally and 24 anteriorly. The posterior contour of the aorta was posterior to the most anterior part of the vertebral body in both cases at T11, in 10 of 14 cases at T12, 2 of 7 cases at L1 and one of 14 cases at L2.

Conclusions: Carefully placed pedicular screws carry a very small risk for damage to the neurological tissues. The deformation and widening of the pedicles observed could indicate that the lateral wall of the pedicle often expands or fractures during the screw insertion. Screw perforation of the anterior cortex of the vertebral body should be avoided especially on the left side and above L1.

15. Effects of Cotrel-Dubousset instrumentation on the configuration of the spine and the thoracic cage in idiopathic scoliosis

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Cotrel-Dubousset instrumentation (CDI) was developed to provide a three-dimensional (3-D) correction in scoliosis. Several previous studies have shown an immediately improved correction of the Cobb angle as well as vertebral rotation compared to Harrington rod instrumentation. With CDI, Dubousset reported a 40% rotational correction measured by the Perdriolle method. Measured by CT, Ecker (1988) and Cundy (1990) reported 14% and 26% correction, respectively, of the rotational deformity. CDI has been used in scoliosis at Huddinge Hospital since 1986, and the effect of the instrumentation on the spinal configuration in all three dimensions has been prospectively analysed.

Patients and methods: 43 consecutive patients, 33 girls and 10 boys, were operated on with CDI for idiopathic scoliosis. The mean age was 15 (11–25) years. Mean follow-up time (FU) was 2.3 (0.5–4.2) years. All curves were single right thoracic except one which was a left thoracolumbar. A-P and lateral radiographs of the erect spine and CT scans at the apical level were obtained pre- and postoperatively and at FU.

The coronal plane was analysed by the Cobb angle and also by the translation of the apical vertebra. The sagittal plane was analysed by Cobb angle measurements at the levels T5–T12, T7–T10, T12–L2 and L1–L5 and also by the sagittal diameter of the thoracic cage. The transversal plane was analysed by CT of the vertebral rotation according to Aaro et al. as the angle between the axis of the apical vertebra and the vertical line (RAsag) and by the rib hump index (RHi).

Results: The mean preoperative Cobb angle was 43 degrees (36-65), postoperatively it was 10° (0°–28°) and at FU 14° (4°–35°). The immediate correction was 77% and at FU there was only a 12% loss. The translation of the apical vertebra was preoperatively 8.1% (4–14)—significantly reduced postoperatively to 5.6% (2–10) and unchanged at FU 5.6% (0–14). The sagittal diameter of the thoracic cage was unchanged postoperatively and at FU. The sagittal configuration in patients with a preoperative thoracic kyphosis <20° at level T5–T12 was significantly improved postoperatively from 9° to 14° and at FU it was 17°, which is 76% improvement. The mean RAsag preoperatively was 11°, postoperatively 6° and at FU 10°. The mean RHi preoperatively was 0.22 (0–0.43), postoperatively 0.13 (0.03–0.24; $p<0.01$) and at FU 0.17 (0–0.35)—an improvement of 23%.

Conclusion: The present study shows that CDI results in a permanent 3-D improvement of the deformation of the spine as well as the thoracic cage in idiopathic scoliosis.

16. The treatment of idiopathic scoliosis by Harrington rods and spinal fusion

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Fifty-two patients with idiopathic scoliosis were treated by Harrington distraction, with or without compression rods, and spinal fusion using an autogenous iliac bone graft. There were thirty-seven female and fifteen male patients. The majority, thirty-six, had adolescent scoliosis, ten had juvenile scoliosis and the remaining six were classified, two as infantile and four as adult scoliosis.

Classification of the deformity according to curve pattern was as follows: thirty thoracic, ten thoracolumbar, eight lumbar and four double structural curve.

Postoperative treatment consisted of six to nine months in a thoracolumbar cast or Boston brace.

The mean preoperative curve was 60.4° (38°–150°) in the standing position. The immediate postoperative curve correction was 23° (8°–90°).

No neurological complications or deep wound infection were seen in any of the patients. Six required further surgery for complications, all of whom were successfully treated.

The duration of the follow-up ranged from 1 to 12 years. At final follow-up all patients had resumed their normal preoperative activities, without limitations, and all were satisfied with the postoperative cosmetic appearance of their spine.

17. Selection of fusion levels in idiopathic adolescent scoliosis operated a.m. Harrington-Cotrel

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Introduction: Idiopathic scoliosis is characterized by a three-dimensional curvature of the thoracic and lumbar vertebrae. The consensus of several authors is to operate when the curvature is more than 45 degrees. The selection of fusion levels is still a topic of debate. Some authors have suggested that the fusion should include both the thoracic and the lumbar curves, others that it should extend from one vertebra above the curve to two vertebrae below the neutral vertebra. King has advocated that in Type 2 scoliosis, selective fusion of the thoracic curve could be made to the stable vertebra, and Cochran and Nachemson (1983) have shown a high incidence of low back pain in patients fused to L4 or L5. The policy in our department is to fuse one level above and two levels below the thoracic curvature, and to avoid fusions below L3. The purpose of the present study was to evaluate the results of this strategy, especially when the fusion level deviates from King's criteria.

Patients and methods: We reviewed the clinical charts and roentgenograms of 111 patients operated with Harrington-Cotrel instrumentation for idiopathic adolescent thoraco-lumbar scoliosis in Copenhagen University Hospital from 1983 to 1989. Male/female ratio was 1:8. Median age was 14.5 (11–21) years at the time of surgery. Median follow-up time was 4.0 (1.0–7.5) years.

The data were reviewed to analyze how the difference between the lower level of fusion and the stable or the lower neutral vertebra, influenced on the correction of the thoracic and the lumbar curves as well as the truncal and the shoulder decompensation.

Results: Of the 111 patients 15 had complications. Seven were reoperated, 4 due to slipping of the upper hook and 3 due to fatigue fracture of the Harrington rod before union. In one patient the lumbar curve progressed, and she had to be braced for three years. None of the patients required extension of the lower level of fusion. No deep infections or persisting neurological damage were found. None of the patients were fused beyond the third lumbar vertebra.

In Type 2 and Type 3 scoliosis, there was a trend towards better results if the fusion went to the stable vertebra. In 11 patients with Type 4 scoliosis, all were fused 2 or 3 vertebrae short of the stable vertebra, in contrast to the recommendations by King; all had satisfactory results. In Type 5 scoliosis our results were comparable to those of King, despite the fusion went 2 or 3 vertebrae short of the stable vertebra. None of these trends were significant.

Conclusion: The degrees of curvature preoperatively are comparable to earlier studies, and our corrections of the thoracic curves are comparable to the results gained by King et al. (1983). We conclude that the lower level of fusion in Type 2, 3, 4 and 5 should be the stable vertebra, but not exceed L3. This conclusion is based on the roentgenologic results, and is further supported by the lower incidence of low back pain if fusion to L4/L5 is avoided.

18. Audit of spinal injury in the severely injured patient

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Introduction: In the twelve months 1st May 1989 to 30th April 1990, 1,088 patients were entered into the Mersey Region and North Wales Severly Injured Survey. The criteria for inclusion were (1) patients with an injury severity score of greater than 16 and (2) patients who died as a result of an injury.

Results: Of the 1,088 severely injured patients 181 patients (16.5%) had a spinal injury. There were 127 males and 54 females. The mean age was 41 (1–89) years.

The mechanism of injury was as follows: pedestrian 40 (22%), vehicle driver 30 (17%), fall from a height 29 (16%), motorcyclist 29 (16%), vehicle passenger 27 (15%), cyclist 5 (3%), sport 5 (3%) and others 16 (8%).

106 patients (59%) had a cervical spine injury. 72 (68%) had an associated cord lesion; 54 were complete and 18 incomplete. 90 patients (50%) had a dorsal or lumbar injury. 49 (54%) had an associated cord lesion; 39 complete and 10 incomplete. 54 patients (30%) had two or more spinal injuries.

The pattern of injury and management of the 181 patients is discussed.

68 patients (38%) were dead on arrival at hospital, 38 patients (21%) died later in hospital. The cause of death was considered to be due to: multiple injury 55 (52%), spinal injury 22 (21%), head injury 18 (17%), chest injury 9 (8%), abdominal injury 1 (1%) and penetrating injury 1 (1%).

19. The rate dependency of vertebral strength

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Introduction: Differences in compressive strength between human lumbar vertebrae are to more than 90% explained by differences in their bone mineral content (Hansen et al. 1980). These findings were made during semi-static loading conditions (deformation rate 0.1 mm/sec). Tests of cortical bone specimens have revealed a positive rate dependency of strength parameters (Carter et al. 1977). It is reasonable to

assume that such a dependency exists not only for cortical bone but also for trabecular bone as well as for the vertebra as a structure. Since the vertebral bone mineral can be used to predict vertebral strength in vivo it is evident that the relationship used for this prediction is based on testing conditions simulating realistic in vivo loading rates. This study was performed in order to determine rate dependent variations in vertebral compressive strength.

Material and methods: 19 fresh lumbar motion segments consisting of two vertebrae and the intervening disc were obtained during routine autopsies from 19 subjects with an age from 23 to 79 years. The bone mineral was determined in each vertebra with dual photon absorptiometry (DPA) and expressed in the units of g/cm, g/cm2 and g/cm3. Bone cement was then used to rigidly fix the upper and the lower ends of the motion segment to specially made cups adapted for the cross heads of an EZU 100 material testing apparatus. The specimens were then tested in compression at a loading rate of 200 mm/sec. The test was interrupted and the specimen deloaded immediately after the first sign of failure (ultimate failure load) was recorded on the load-deformation curve. The relationship between each specimen's bone mineral and the ultimate load was then calculated. This relation was then compared to a similar relation arrived, however, at a deformation rate of 0.1 mm/sec.

Results: A linear relation was found between the bone mineral in the 19 tested motion segments and their ultimate compression strength and stress respectively. The force needed to cause a detectable failure was almost 50% higher for the 200 mm/sec loading rate than for the 0.1 mm/sec loading rate (Fig 1). The type of failure was identical for the two testing conditions.

Discussion: The compressive strength of lumbar motion segments was rate dependent. Although 2000 times higher than the loading rate used for comparisons in this case, the present rate still corresponded only to a relatively slow in vivo motion rate. It was evident, however, that the more realistic loading rate used here, revealed strength capacities

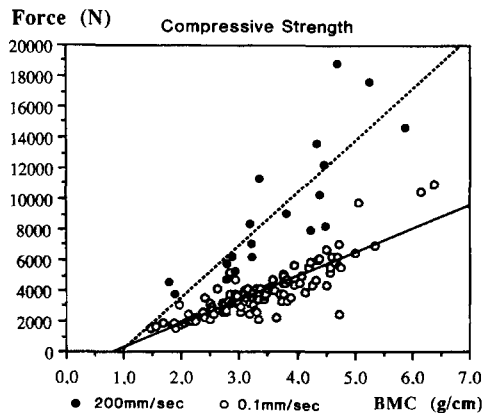

Fig. 1. The relationships between the vertebral bone mineral and ultimate compressive strength at 200 mm/sec and 5 mm/min loading rates.

of the human spine which considerabley exceeded the ones obtained during semi-static loading conditions. The findings indicated that the human spine can resist higher load than what has been assumed so far. This finding might effect among others our predictions of risks for back injuries through the static mathematical loading models used so far.

20. The mechanism of initial flexion-distraction injury in the lumbar spine —influence of vertebral bone mineral content

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Introduction: In order to improve the knowledge of the spinal injury pattern under flexion-distraction loading (from the physiological movements until complete disrupture), the purpose of the present study was to determine the first sign of an injury (the yield point at the load-deformation curve) in the lumbar motion segment during this type of loading.

Material and methods: The BMC (expressed in g/cm) was determined for each vertebra using dual photon absorptiometry (DPA) in ten functional spinal units (FSU). The load was applied statically. The loading in this test situation was supposed to simulate a lap seat-belt injury classified as a flexion-distraction injury (Denis 1983). The load response of the FSU was measured with a force and moment transducer. The displacement was measured from photographs as well as by three mechanical displacement gauges allowing measurement of horizontal and vertical displacements. The FSUs were exposed to increasing loads with increments of 20 N. The first detectable sign of injury was recorded when the force and the moment curve showed a dip greater than 50 N and 15 Nm respectively and when a permanent deformation was noted on the dial gauges. After unloading of the specimens for four minutes flexion-distraction load of 100 N once again was applied.

Results and discussion: In Table 1 it can be seen that the intact specimens did not angulate more than 5-8 degrees when loaded with 100 N in flexion-distracton (1:1). When the injured specimens again were loaded with 100 N, the horizontal and vertical displacements as well as the angulation between the vertebrae increased as seen in Table 1 (1:3). When comparing results in this study with those from the study of ultimate strength (total disruption) of the lumbar functional spinal unit (Neumann et al. 1991), no large difference between the displacements was found. The minor differences in displacement and angulation after loading in flexion-distraction beyond the first sign of an injury (yield point) and the ultimate point (disruption), indicated that the effect on "stability" was almost the same. Consequently this could imply that a radiographically

normal spine potentially could be just as unstable as a radiographically disrupted.

Table 1.

Parameter	Mean (SD) n=10	Range	Corr. to BMC (r)
Horizontal displacement (mm)			
1) Intact (100 N load) (Creep)	1.3 (0.6)	0.5–2.3	0.60
2) First sign of injury (tot)	7.5 (1.4)	5.2–9.8	0.67
3) Injured (100 N load)	7.6 (1.5)	5.5–10.1	
Vertical displacement (mm)			
1) Intact (100 N load) (Creep)	2.3 (0.6)	1.6–3.3	0.66
2) First sign of injury	16.9 (1.4)	14.8–18.3	0.71
3) Injured (100 N load)	17.2 (1.3)	15.1–18.7	
Flexion angulation (°)			
1) Intact (100 N load) (Creep)	6.5 (0.9)	5.1–7.8	0.63
2) First sign of injury	15.8 (0.9)	14.6–17.3	
3) Injured (100 N load)	16.2 (0.9)	14.9–17.8	

Conclusions: 1) The first sign of injury of the lumbar FSU under flexion-distraction loading occurred at about 80% of the ultimate strength. 2) Loading beyond the yield point caused potential instability, reflected by a new neutral zone at loading of the injured segment with 100 N. 3) The BMC determined by DPA predicted both structural and mechanical properties of the entire functional spinal unit under flexion-distraction loading.

21. Stabilization of the upper cervical spine by flexible carbon fibre—10 years of experimental and clinical work

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In stabilization procedures wire breakage is a well known postoperative complication. In the cervical spine it occurs in 7–8% (Brattström and Granholm 1976, Larsson and Toolanen 1981).

Flexible carbon fibre implants have been used as tendon and ligament substitutes in clinical practice since the mid seventies (Jenkins and Mc Kibbin 1980).

In 1982 we reported a new technique using flexible carbon fibre instead of wire for internal fixation in the cervical spine. It has since then been used in clinical practice and published (Clin. Orthop. 1984 and Clin. Biomechanics 1986).

From 1982 to 1991, 38 patients have been treated with this procedure. There have been 36 rheumatoid dislocations and two traumatic subluxations.

The implant was well tolerated by all patients—there were no infections. The fixation has been stable throughout the observation period of 10 years except for in one patient, where the implanted carbon-fibre sling fractured the spinous process.

22. Combined open and percutaneous posterior approach for screw fixation in atlanto-axial instabilities

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Introduction: The most usual surgical treatment in servere atlanto-axial instabilities (RA, odontoid process and hangman's fractures or nonunions) are various posterior wiring techniques. In the last years, screw fixations have become popular both as a primary or as an additional procedure. The posterior screw fixations according to Magerl have been hampered by its extensive surgical exposure. As this method of internal fixation gives a very effective stabilization, the recommended surgical exposure has been modified, to lessen the morbidity in advance of its use.

Patients and methods: Seventeen patients, 11 men and 6 women with a mean age of 50 years (20–85) were treated with screw fixations. Five had rheumatoid arthritis, five odontoid process fractures, three hangman's fractures and four failed primary fusions (anterior and Gallie). After application of a Trippi-Wells skull tongs, the patient was turned into prone position on an adjustable head rest with 3–5 kg traction. The cervical spine was ligned under fluoroscopic control in the lateral view. In 7 patients, the recommended midline surgical exposure from the skull base to T1 was shortened to run only from the skull base to C3. Extra long 3.0 mm k-wires, one on each side, were introduced percutaneously from the posterior shoulder region through the lower neck muscles and down to the point of entrance on each side of C2. The insertion procedure, through the isthmus area, was then completed with the aid of fluoroscopy. The metal pins were aimed at the anterior atlas ring for atlanto-axial transfixations and at the base of the odontoid process for hangman's fractures. After extraction of the k-wires, self-tapping (malleolar) screws were inserted using a cardan screwdriver. Antibiotics were given for one day and a soft collar was used for 6 weeks postoperatively.

Results: The surgical exposure was minimized to only half of what is recommended. The blood loss and operation time were reduced significantly. No infection occurred and all original fixations and refusions healed solidly and without redislocation.

Conclusion: Posterior atlanto-axial screw fixations are technically demanding procedures. However, they give a highly effective stabilization for fusion healing in both acute and chronic situations. A soft collar is the only support needed postoperatively. With a new combined open and percutaneous approach, the surgical morbidity can be significantly minimized.

23. Structural properties of the anterior longitudinal ligament in correlation with lumbar bone mineral content

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Introduction: The bone mineral content (BMC) has proven to be an accurate predictor of properties like ultimate compressive strength and stress (Hansson et al. 1980), as well as fatigue strength of the vertebral bodies (Hansson et al. 1987), in human lumbar spine motion segments. The BMC has also been found to predict properties of the intervertebral disc (Keller et al. 1986). This could imply that, like bone tissue, even soft tissue structures like the ligaments are subjected to remodelling processes according to Wolff's law. The aim of this study was to determine strength properties of the anterior longitudinal ligament (ALL) and to evaluate their relationship to the BMC of the adjacent intact lumbar vertebrae.

Material and methods: Studied were 21 fresh lumbar motion segments from 13 subjects with a mean age of 47.5 (23–83) years. The BMC was determined in both the vertebrae with DPA. The height of each segment, the anterior and posterior height of the disc and its width in the frontal plane were determined with a micrometer. After excision of the posterior elements the disc was carefully dissected away, leaving the ALL intact. The vertebral bodies were then rigidly fixed between the cross-heads of a servo-controlled dynamic material testing machine (MFL, EZU 100). The width and thickness of the ALL were in all segments determined at a constant distraction force of 100 N. Continuous distraction was then applied until failure was observed on the load-deflection curve. The loading speed was 5 mm/min. 28 variables in each segment were determined and related to the BMC and the age respectively. Statistical significance was set for p-values <0.05).

Results: The correlation (r) between biomechanical properties of the ALL and the BMC in g/cm and age in years are presented in the following table.

vs	BMC (r)	AGE (r)
Failure force	0.79	-0.66
Failure displacement	0.67	-0.71
Energy uptake	0.70	-0.58
Yield stiffness	0.58	-0.35
Ultimate stiffness	0.65	-0.36
Yield stress	0.72	-0.63
Ultimate stress	0.69	-0.6

Discussion: Previous studies have found correlations between age and certain biomechanical properties of the lumbar spine ligaments (Nachemson and Evans 1968, Tkazcuk 1968). The results in this study indicated that the BMC was closer correlated, especially to strenght properties of the ALL, than the age of the motion segments. The finding that BMC was a good predictor of several mechanical properties of the ALL demonstrated the close functional interrelationship between different parts of the lumbar motion segment. The results also tend to demonstrate that the remodelling and adaption processes are determined by similar control mechanisms.

24. Idiopathic scoliosis treated with Boston brace

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Introduction: Idiopathic scoliosis is characterized by a three-dimensional deformity of the spine. The scoliosis requires treatment if the lateral curvature is 20°–30° depending on progression and age of the patients. The purpose of the present study was to find initial radiological factors predictive of the final result, and thus enable the surgeon to select the best treatment primarily.

Patients and methods: The clinical charts and radiograms of 136 patients treated with Boston brace for idiopathic adolescent thoracolumbar scoliosis at Copenhagen University Hospital from 1983 to 1990 were reviewed.

Male/female ratio was 1:10. Median age was 13.3 (8–19) years at the time of bracing, and the median bracing-period was 2.5 (1.0–5.5)years. Follow-up time was 5.0 (1.0–8.5) years.

Results: Of the 136 patients 36 progressed and were later fused. The median thoracic and lumbar curves at the time of bracing were 36° (5°–64°) and 28° (10°–60°) and the median thoracic and lumbar curves at the time of follow-up were 33° (7°–71°) and 26° (12°–62°) in the patients who completed bracing. The correction of the curve was significantly better in patients with apex between T11 and L1 and none of these patients required spinal fusion (p<0.0001).

The flexibility, defined as the percentage correction of the major curve on sidebending roentgenograms, influenced the risk of patients needing spinal fusion, but the magnitude of the major curve on sidebending had a better correlation.

There was a correlation between the Harrington factor, defined as Cobb's angle divided by the number of vertebrae in the curve, and the rate of fusion.

We could divide all patients in three groups:

1) 56 patients (42%) with apex between T11 and L1; or major curve on sidebending <8°; or Harrington factor <4° per vertebra, did not require spinal fusion.

2) 8 patients (10%) where apex differs from T11, T12 or L1; and with major curve on sidebending >31°; or Harrington factor >11° per vertebra progressed despite bracing and were later fused.

3) 72 patients (52%) did not fit into these groups. 39% of these patients required later spinal fusion.

Conclusion: Boston bracing is well known to stop progression in many patients with minor curves. Nachemson and other authors have documented that brace treatment has a long-term psychological impact on the patients. This emphasizes the importance of selecting the group of patients which responds to bracing. Using our guidelines many patients can be told that brace treatment will succeed and thus augment the motivation for the patient using the brace. Other patients can be informed that they probably later will be fused, and therefore either could be spared from bracing or should be braced just to gain time waiting for maturity before spinal fusion.

25. Pathoanatomical evaluation of atlanto-axial screw fixation

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Introduction: Transarticular atlanto-axial screw fixation as proposed by Magerl, provides an effective stabilization of these joints in both acute and chronic situations. The procedure requires a posterior open access of the joints for correct drilling into the articular masses of the atlas. To achieve a correct screw trajectroy without exposing the joints and thereby avoiding the risk for injury to the overlying neurovascular structures, we made a pathoanatomical evaluation of screw trajectories following different drill inclination within the atlas, to optimize the aid of fluoroscopy for this procedure.

Material and methods: Two cadavers were prepared by injecting the arterial tree with a red contrast and application of skull tongs, after which they were placed in the prone position on an operating table. The head was in a halter with maximal flexion and 3 kg traction. The posterior axis was exposed through a midline incision to the lateral border of the articular masses. Using a C-arm for a straight lateral view, a 3.0 mm k-wire was inserted in the center of the articular masses straight forward in the sagittal plane and aiming at, above or below the projection of the anterior arc of the atlas. This was accomplished by different insertion levels on the inferior articular process of the axis and by staying within the isthmus. The trajectories were tapped to the anterior cortex and fully-threaded cancellous screws inserted. To preserve the anatomical and neurovascular relationships undistorted, the cervical spines with all soft tissues were frozen in situ before removal. After radiographic examination, the neck muscles were partially thawed to permit removal of the screws. The screw tracts were filled with a special contrast before cryoplaning in the sagittal plane on a heavy duty cryomicrotome. The findings were documented by photographs of the specimen surface.

Results: The best screw trajectory within the articular masses of the atlas was achieved when aiming with the k-wire directly at the projection of the anterior arc of atlas with the aid of fluoroscopy. There was no danger of injury to the medulla. On one side the screw injured the vertebral artery which had an abberrant position at the lateral side of the axis and the screw tract was far below the optimal inclination.

Conclusion: With the aid of a straight lateral view by fluoroscopy, the projection of the anterior arc of the atlas is proposed as a correct landmark to aim with the drill for transarticular atlanto-axial screw fixation. The surgical exposure is minimized and opening of the posterior atlanto-axial joint for correct guiding of the drill into the articular mass of the atlas is not needed.

26. Sick leave and occupation after surgical treatment of lumbar disc herniation

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Introduction: Disability due to low back pain is a frequent and costly problem in industrialized countries. Information is scarce about the influence of preoperative working status on social rehabilitation after surgical treatment of specific lumbar disorders. The present study was undertaken to investigate the correlation between preoperative and post-operative working status among patients with a single operation for lumbar disc herniation before the age of 60.

Patients and methods: 98 consecutive patients below the age of 60 years were operated on for disc herniation in the lower lumbar spine in the late 1980's. Information about reoperation, sick leave, retirement and the patients' occupations 2 years before and 2 years after surgery was obtained from the hospital records, the local Social Insurance Office and from questionnaires. The correlation between pre- and postoperative working status of the 85 patients with no further spinal surgery during the investigative period was studied. There were 51 men and 34 women with a mean age at surgery of 42 (20–58) years. The chi-square test was used for statistical calculations in contingency tables.

Results: Preoperatively, 50 patients were on sick leave for less than 3 months, 10 for 3–6 months, 14 for 6–12 months and 8 for 1–2 years, 3 patients were retired. Postoperatively, 33 patients were on sick leave for less than 3 months, 21 for 3–6 months, 11 for 6–12 months, 4 for 1–2 years and 8 were still on sick leave 2 years postoperatively, 8 patients were retired. The risk for long postoperative sick leave increased with the duration of the preoperative sick leave and the heaviness of the occupation ($p<0.01$). The risk for postoperative retirement, however, was not significantly influenced by the duration of the preoperative sick leave or the heaviness of the occupation.

Conclusion: The findings of this study imply that sick leave before surgical treatment of disc herniation in the lower lumbar spine should be relatively short to minimize

the risk of long postoperative sick leave. New patients reaching the follow-up at 2 years postoperatively are consecutively being added to the study.

27. Surgery for degenerative lumbar spine disorders in the elderly

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Introduction: Decompressive surgery for degenerative disorders of the lumbar spine is today a frequent operation. This is an evaluation of the results 2 years after surgery in elderly patients.

Patients and methods: In a prospective and consecutive study of lumbar spine surgery with a 2-year follow-up, 47 patients aged over 70 (71–83) years were operated on over a 3-year period. 21 of the patients were women and 26 men. The preoperative diagnosis was obtained by means of myelography, CT or MRI and confirmed at operation in all cases. 3 patients suffered from disc herniation, 4 from lateral spinal stenosis, and 40 from central spinal stenosis.

Peroperative antibiotic prophylaxis and per- and postoperative thromboprophylaxis (Dextran 70) were given in all cases.

Results: No cases of cardiopulmonary complications and no cases of deep vein thrombosis were seen. One patient with a central spinal stenosis had a dural fistula postoperatively which closed spontaneously within one week, one patient had to be reoperated on the first postoperative day because of a progressive cauda equina syndrome, unexplained but improved after reoperation. One patient developed a spondylitis after decompression.

Within 2 years from surgery, two of the patients operated on had died of unrelated disease and two had developed cerebral vascular lesions. Among the 43 remaining patients a subjective grading at the 2-year follow-up was as follows:

In total, 34 patients experienced improvement by the operation and nine were unimproved. In no case deterioration was seen. Two of the patients with disc herniation were almost painfree and one moderately improved. Of the 4 patients with lateral spinal stenosis, two were almost or totally painfree, one moderately improved and one unchanged. Of 36 patients with central spinal stenosis, three were totally painfree, 17 almost painfree, eight moderately improved and eight unchanged.

Conclusion: Degenerative disorders of the lumbar spine in patients aged over 70 years could be surgically treated without anesthesiological complications. The indication for surgery was central spinal stenosis in the vast majority of patients. Four patients out of 47 died or developed cerebral vascular lesions within 2 years from surgery while of the remaining 43 patients, 34 experienced pain relief after the procedure.

28. Fractures of the low lumbar spine

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Fractures of the low lumbar spine are considered to be relatively infrequent. Among burst fractures, however, one fourth involve L3, L4, or L5. Despite of this fact reports in the literature are scarse.

Treatment of unstable burst fractures in this area presents special difficulties when treated operatively. Because of this conservative treatment with several weeks of bed rest has been recommended.

18 consecutive cases treated operatively with PSF (Peduncular Screw Fixator) during 1985–1989 were reviewed after 2–6 years. There were 14 burst type fractures and 4 fracture dislocations. Concomitant injuries were frequent and a total of 16 other surgical interventions were undertaken.

Among L3 and L4 fractures the anterior vertebral height was corrected from preoperatively 70.7 to postoperatively 90.2 at one year and at the final follow-up 83.0 and 83.4, respectively. Most of the tendency of kyphosis, however, was caused by disc collapse. Results improved with time and experience. There was one early and one late infection.

13 of the 16 patients who were at work before being injured are now back at work, 3 part-time and 10 full-time.

We conclude that operative treatment is possible and has the advantage of early and safe mobilisation.

29. Neuropeptide-converting enzymes—new diagnostic markers for orthopedic pain

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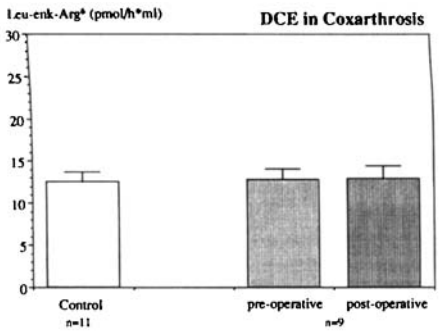
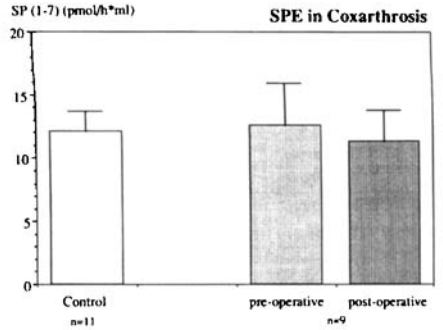
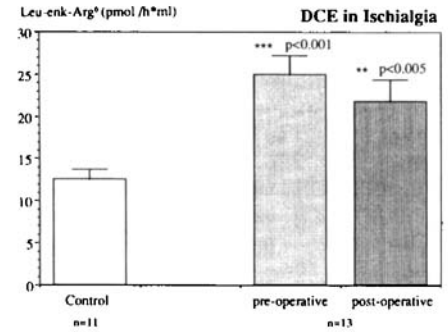
Introduction: Dynorphine Converting Enzyme (DCE) and Substance P Endopeptidase (SPE) are both neuropeptide-degrading enzymes and have been demonstrated in human cerebrospinal fluid. DCE hydrolyzes dynorphine, a pain-repressing peptide. Substance P acting as a transmittor in pain-conducting nerve fibres, is hydrolyzed be SPE. The activity of these enzymes are probably related to the concentrations of the corresponding peptides.

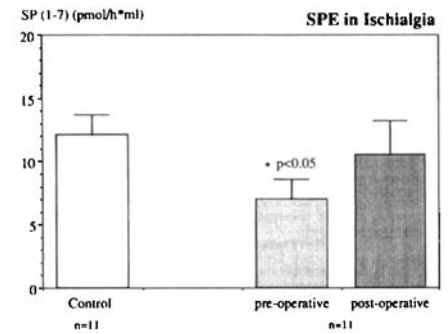
Material: DCE and SPE have been analyzed in cerebrospinal fluid in the following patients:

a) in 11 patients with ischialgia, caused by a herniated lumbar disc, samples were taken before operation and 3-6 months after the operation.
b) in 9 patients with painful coxarthrosis, samples were obtained before total hip arthroplasty and 3-6 months after the operation.
c) 11 nonorthopedic patients without pain problems served as controls.









Results: All patients with herniated lumbar discs had preoperatively higher levels (mean=25 pmol/h.ml) of DCE activity compared with controls (mean=13 pmol/h.ml). Postoperatively the DCE activity had decreased (mean=22 pmol/h.ml) but was still higher than that of the controls.

SPE activity was lower preoperatively (mean=7 pmol/h.ml) compared with controls (mean=12 pmol/h.ml) but had postoperatively increased to almost the same level (mean=10 pmol/h.ml) as registered in the controls.

The DCE and SPE activity in patients with coxarthrosis did not differ from controls.

Conclusion: Our results support that ischialgia is a neurogenic pain and can be registered by changes in DCE and SPE activity, in turn reflecting the dynorphine and substance P concentrations. These measurements may be used in the differentiation between pain caused by pressure on nerve fibres and that caused by other musculoskeletal disorders.

30. The value of CT-discography for indication of automated percutaneous lumbar discectomy (APLD) in patients with herniated discs—a prospective study

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We examined prospectively 97 patients with a disc protrusion who were to be treated with automated percutaneous lumbar discectomy (APLD), a procedure developed by Onik et al. In the evaluation of the herniated disc we used CT-discography. According to the distribution of the dye inside the disc, 5 different disc types can be differentiated. With a follow-up after 3–7 months, the short-term outcomes of the first 40 APLD-treated patients varied, depending on the shape of the protruded nuclear material. After APLD, 11 patients showed no improvement or an aggravation of the radicular syndrome and thus had to undergo open surgery. Nine of the 11 surgical patients had a disc protrusion with a narrow dye-base; two had a disc protrusion with a broad dye-base. The difference between the two operated patient groups was significant (chi square test; $p<0.05$). The preliminary conclusions of this analysis of the first 40 APLD-treated patients was that patients with a broad dye-base disc protrusion on CT-discography had better short-term outcomes than patients with a disc protrusion with a narrow dye-base. Age of the patient, affected segment and amount of nuclear material removed showed no correlation with the outcome. In the next 57 patients whom we treated with APLD these conclusions were confirmed. The success rate of a consecutive group of patients with a disc protrusion with a broad dye-base treated with APLD was 80%.

This study showed that not every patient with a herniated disc is a candidate for APLD. The shape of the disc is of importance. With CT-discography it is possible to differentiate exactly between the different disc herniation stages. That is why the authors recommend CT-discography as a preoperative diagnostic tool for patients with a herniated disc, where APLD-treatment is considered.

31. Bertolotti's syndrome treated by surgery—follow-up of 16 patients

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We treated 16 patients with Bertolotti's syndrome /chronic, persistent low back pain and radiographically diagnosed transitional lumbar vertebra) by surgery; eight had posterolateral fusion and eight resection of the transitional articulation. Thirteen patients had besides the chronic low back pain, suffered from repeated episodes or chronic sciatica. In six cases who had resection treatment, local injections were applied at the transitional articulation before deciding for the resection of the transitional joint and each patient reported transient relief of pain, while this preoperative test did not correlate with successful outcome of treatment.

Six patients had to have second operations. Ten of 16 operatively treated patients had improvement of their low back pain, and this result was similar in the group treated with fusion and in the group treated with resection. Seven had no low back pain at follow-up—the improvement according to the Oswestry pain scale was similar in both groups and significant. Eleven patients had still persisting episodes of sciatica (vs 13 preoperatively). The average disability according to the Oswestry total disability scale was 30%—moderate outcome, and both operatively treated groups did equally well. At the follow-up, the first disc above the fused segments was found to be degenerated in seven out of eight cases and in the resection group the first disc above the transitional vertebra was degenerated in five cases.

As conservatively treated controls we had 16 comparable, but not randomly chosen patients whose age and type and duration of pain prior to the first clinical examination, and the length of follow-up were similar. The operatively treated patients had slightly better Oswestry pain score (mean 1.9 vs 2.5; statistically significant), whereas the total Oswestry disability scale did not differ.

We suggest operative treatment only in very selected patients with Bertolotti's syndrome. Patients with no disc degeneration and whose chronic pain is truly associated with the transitional joint, may be treated with resection of the transverse process. Patients with similar pain, and with degeneration of the disc below but not above the transitional vertebra, may have alleviation of pain and disability after posterolateral fusion.

32. Bone metabolism related factors in 45–55-year old men with and without low back pain

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A comparison was made between men who never, ever had had low back pain (group 1, n=18), men with occasional pain (group 2, n=39) and men with chronic low back pain (group 3, n=21) with regard to factors which are considered to be related to bone metabolism and pain experience. Groups 1 and 2 consisted of a random sample of all men in the age group of 45 to 55 years in an industrial area in Stockholm. Group 3 was an age standardized group of male patients referred to the Department of Orthopaedic Surgery, Karolinska Hospital, because of unspecific, chronic low back pain.

The measured variables were: height, weight, body mass index, fat muscle and skeletal volume, paraspinal muscle area (measured with CT), spinal canal width (measured with CT), bone mineral density (measured with single photon absorptiometry), fibrinogenic activity, neuropeptides—substance P, neuropeptide K and CGRP, serum albumin, calcium, creatinin, GT, TSH, testosterone, alkaline phosphatase, vitamin D3, calcitonin and osteocalcin (bone Gla protein). Statistically significant differences between all three groups were found only in osteocalcin values.

33. Failure to reconstruct anterior support transpedicularly in treatment of thoracolumbar fractures

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Introduction: Thoracolumbar fractures can often be reduced anatomically. A substantial part of the correction is eventually lost. The rationale for transpedicular grafting of fractured veretbral bodies is poor since the late loss of reduction is predominantly due to failure of damaged discs. We have tried to restitute the anterior support and achieve an interbody fusion by performing transpedicular bone grafting of damaged discs. If this succeeds the transpedicular grafting would be worthwhile.

Patients and method: Fifteen patients, eight men and seven women with a mean age of 35 (19–65) years were treated. All but one had suffered a burst fracture. All fractures were localized at the thoracolumbar junction (L1:11, L2:4). After reduction and fixation, a hole was prepared in one pedicle of the injured vertebra. Disc material was evacuated from the upper disc. The lower endplate of the vertebra above was decorticated and bone paste introduced into the disc space through a funnel. In the

beginning of the series the bone grafts were placed centrally in the disc, later in the most anterior part. CT examinations with sagittal and frontal reconstructions were done postoperatively and repeated after one year. Twelve patients had their hardware removed after one year. Follow-up exceeds 18 months in all cases.

Results: The preoperative Cobb kyphosis angle—average 14.3°—improved postoperatively to 0.5°. 19% (8–25) of the disc cross-section area was grafted. Radiographs during the first year seemed to indicate integration of the grafted bone. CT after 12 months showed resorption of the grafted bone in six cases, sequestration in eight and healed interbody fusion in one patient. One bridging anterior osteophyte was seen. In 12 patients, who had their devices removed, the Cobb angle at follow-up was 10.6° compared with 12.4° initially.

Discussion: The one patient whose interbody fusion healed had an early mechanical failure of the device. This indicates that stress shielding plays a role for the failure in the other. Other factors to consider are negative influence of remaining disc material and poor vascularization. Bone grafts placed anterior to the disc might improve the spontaneous tendency for anterior bridging osteophytes to occur.

Conclusion: With the described technique interbody fusion and anterior support were not achieved.

34. Disc doctor—a graphic interface to low back pain and sciatica

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Pain is by far the most common indication for surgical procedures. But since pain is an inherently subjective phenomenon, it is hard to assess and document.

We demonstrate a working model of a graphic-based computer program for Windows compatible computers for analysis and documentation of low back pain and sciatica. The patient draws her subjective pain on a standardised form; the location and modality of pain is digitised with an easy-to use graphic interface.

This program allows a convenient documentation, analysis and retrieval of complex clinical problems.

35. Intravertebral vacuum phenomenon

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Intradiscal gas is a not uncommon finding in disc degeneration of the lumbar spine. The first report on intravertebral vacuum phenomenon (IVP) came in 1978 and has been followed by reports from North America and South Asia. The IVP appears in transverse fractures of the vertebra and is believed to be due to ischemic necrosis.

Our 19 patients, 17 women and 2 men, were 74 (61-86) years old and had signs of osteoporosis such as concomitant vertebral fractures or other fragility fractures. Six patients had received corticoid medication, three had diabetes and there were also cases with malignant disease such as multiple myeloma or Wegener's granulomatosis. The initial symptoms were usually as that of acuta lumbago.

The IVP was seen only in fractured vertebrae and the lesions appeared in 16 patients at the thoracolumbar junction (Th11–L2) and in the other three at the Th8, Th10 and L4 levels. The vertebral bodies were collapsed with on an average 40% loss in height. Our longest follow-up is 18 years and no healing has appeared. In three patients a scintigraphic examination had been performed and an increased uptake had been recorded.

Intravertebral vacuum phenomenon do appear also in Scandinavia in patients with osteoporosis, especially in those with diseases predisposing to osteonecrosis.

36. Psoas abscess due to spinal tuberculosis

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We present a case of psoas abscess due to tuberculosis of the spine. These cases, although common in the past in Greece, are very rare nowadays, especially in northern Europe.

A 37-year-old male civil engineer was admitted to our Unit for a lump 20 x 15 cm at the site of the inner aspect of his upper thigh. The patient's history referred to back pain after a fall 7 years previously. He had relief of the pain within 3 days, but the pain recurred a year later. X-rays of the lumbar spine were normal. A year later he had a new episode of acute back pain, aggravated by walking, morning stiffness and a lump 2 x 2 cm in the middle of his back (level O2). The patient never mentioned any lower extremity symptoms. The case was considered as mechanical back pain and no further investigation was made. Until 6 months ago the patient had mild back pain. At that time he first noticed a lump at the inner aspect of his thigh, 3 x 3 cm, which gradually increased in size.

The following examinations were performed: a) radiographs and tomograms of the back and chest; b) bone scan; c) FBC-ESR (98mm); d) Mantoux test (negative); e) Widal Wright tests (negative); f) CT scan.

The history, clinical and laboratory investigations were suggestive of a psoas abscess due to spinal TB. The negative

Mantoux test was confusing. We proceeded to respiration of the abscess for both diagnostic and therapeutic reasons. The product of aspiration was a typical TB fluid. Its nature was confirmed by cultures. The patient was started on anti-TB treatment and had a good final result.

Spinal TB complicated by femoral psoas abscess is rare nowadays. The course of the disease may be mild and diagnosis may be missing for a long time. Constitutional symptoms are not always present.

37. Surgical anatomy and pathology of the lumbar spine and sacrum—a videodisc exhibit

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New procedures in spinal surgery (percutaneous, micro, minimum invasion), new spinal fixation devices and the rapid advances in computed and magnetic resonance tomography (CT, MR) call for increasingly detailed knowledge of the complex relationships of the vertebral column to the neurovascular spinal elements for both surgical approaches and procedures, as well as for multiplanar diagnostic imaging reference.

Over a 10-year period, more than 80 cadaveric spines have been studied. Among these, 53 displayed pathological findings such as fractures, cancer metastases, degenerative conditions such as spondylosis and spondylarthrosis and a wide array of disc pathology. Apart from virtually all stages of internal disc disruption, nine subligamentous disc herniations were encountered. Five discs showed evidence of repetitive herniations: vascularized granulation tissue with arterioles sprouting into the clefts of the old ruptures. Several of these showed communication between the ventral internal venous plexus and the degenerative cavities in the discs. Five specimens with severe central and lateral spinal stenosis were studied in great detail and at submillimeter intervals.

Fifteen postsurgical specimens were examined. The surgical procedures had been performed to correct degenerative compressive conditions, segmental spinal instability and spinal metastases. They encompassed decompression, stabilization with segmental pedicle fixators, laminotomies, fat grafting and filling of the resection sites with autografts or bone cement. After extraction of the devices from the frozen specimens, the screw tracts were filled with coloured contrast. All specimens were examined on a CT scanner before cryosectioning, employing optimized high resolution scanning algorithms. More than 15,000 accurately registered overview and high magnification close-up images, patient and specimen CT scans and radiograms were transferred to an optimal laser videodisc.

Interactive electronic programs were designed for instantaneous random access to all cases and individual images, allowing correlation of the in vivo and in vitro MR and CT scans with the anatomical images. Special tutorial lessons on surgical and diagnostic topics were also designed for each day of the meeting, including surgical standard approaches, percutaneous approaches, pedicle and sacrum screw insertion and entailed studies of a variety of lumbar cancer metastases. Specialized interactive lessons were also designed for self-paced viewing and self-assessment.

Hip arthroplasty

38. The effects of polymerization heat and toxicity from PMMA bone cement and the effects of a new MMA/DMA/IBMA bone cement

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In a paired study on canine tibial diaphysis the effects of polymerization heat were investigated by exposing the bone to curing PMMA bone cement within a monomer "tight" membrane compared to filling with "inert" bone wax (6 dogs, 4 week's observation). Toxicity of hot leaking monomer was studied by filling the bone with PMMA bone cement compared to filling with bone cement within a monomer "tight" membrane (9 dogs, 4 weeks observation). The effects of a new MMA/DMA/IBMA bone cement with lowered exotherm and less MMA leakage were tested against PMMA bone cement (6 dogs, 4 weeks observation and 2 dogs, 12 weeks observation) and filling with "inert" bone wax (6 dogs, 4 weeks observation). The parameters recorded were bone blood perfusion estimated by the microsphere technique, and bone remodelling estimated by ^{99m}Tc-MDP uptake.

Results: No effects of polymerization heat alone could be found. Exposure to hot leaking monomer, however, resulted in lower blood perfusion and decreased remodelling activity ($p<0.03$). MMA/DMA/IBMA bone cement decreased blood perfusion less than standard PMMA bone cement ($p=0.03$). ^{99m}Tc-MDP uptake were larger in 5/6 cases with MMA/DMA/IBMA bone cement (NS). Filling with MMA/DMA/IBMA bone cement compared to bone wax did not disclose any statistical differences.

Conclusion: Polymerization heat alone does not seem to have any significant effect on bone remodelling. Hot leaking monomer, however, inhibits bone remodelling severely. A new cement wit lowered polymerization heat and toxicity, does not inhibit bone remodelling as much as standard PMMA bone cement.