Dissertions

Osteopenia of diaphyseal bone

Experimental and clinical studies in osteopenia caused by trauma and stress-shielding

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Studies were carried out on osteopenia of different origin in rabbits, in patients with fractures of the distal radius and in patients operated with total hip arthroplasty (THA) because of coxarthrosis.

Animal studies: Application of an external fixator on the intact rabbit tibia for 6 weeks resulted in a decrease in bone mineral content (BMC) of 7%. The osteopenia was interpreted as a result of stress-shielding, e g a bone segment that is prevented from carrying load because of the external fixator, as another group of animals with the pins but without the external frame did not develop osteopenia. The bone mineral content decreased further when the fixation time was extended to 12 weeks (9%).

Prostaglandins are potent stimuli of bone resorption. Non-steroid anti-inflammatory drugs (NSAIDs) are powerful inhibitors of prostaglandin production. When the externally fixated rabbits also received the NSAID piroxicam during the fixation time, the bone loss was reduced from 9 to 3% after 12 weeks.

Clinical studies: In a study of osteopenia after plaster vs external fixation for Colles' fracture, both groups showed a bone loss of 15%. There was, however, a greater bone loss among the most severe fractures (21%).

A randomized trial of piroxicam in Colles' fracture showed that piroxicam, contrary to the animal experiment above, had no effect on the osteopenia. The drug had no effect on the functional recovery after the fracture but decreased the pain during treatment.

In a prospective study in patients operated with THA for coxarthrosis, the bone mass was assessed by quantitative computed tomography (QCT). Preoperatively, a moderate osteopenia was found in the middle femur and a more marked osteopenia of the trabecular bone in the distal femur and proximal tibia. No changes in the bones occurred up to 6 months postoperatively, but the preoperative muscular atrophy disappeared.

An investigation of an additional trauma, e g patients operated on with rearthroplasty, displayed a marked decrease in bone mass of the middle femur, especially of the bone volume, but only a moderate decrease in muscle mass in the reoperated leg.

Conclusions: External fixation of the rabbit tibia resulted in bone loss and this bone loss was reduced by NSAID. External fixation of Colles' fracture did not give a more pronounced bone loss than fixation of the fracture with a dorsal splint and the bone loss after fixation by a dorsal splint was not reduced by NSAID. THA had no effect on bone mass in spite of a 20% gain in muscle mass after 6 months. After rearthroplasty there was a marked decrease in bone mass.

ISBN 91-628-0456-1

Anterior decompression in the treatment of the traumatic injuries of the cervical spine

Technique and results

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The author presents 60 patients with traumatic injuries that were submitted to anterior decompression of the cervical spine from 1979 to 1989 in the Department of Orthopaedics and Traumatology of the School of Medicine of the University of Sao Paulo, Brazil. The indications for surgical treatment were: vertebral fracture in 34 patients and disc herniation in 26 cases, all with neurologic deficit, being 52 Frankel A, 3 Frankel B, 2 Frankel C and 3 Frankel D. According to the motor index preconized by the American Spinal Injury Association the patients had 17.03 points in the initial examination.

In the cases of vertebral fracture a corpectomy and replacement with iliac bone graft and stabilization with a metallic plate were performed. In the cases of disc herniation a discectomy was done, 17 with the Smith-Robinson technique and 9 with the Cloward technique. In the postoperative period a plastic collar was employed.

There were 11 deaths, all in the completely tetraplegic group. The remaining patients were analysed clinically and radiographically, being observed that in the vertebral fractures group an improvement in the radicular function occurred and in the disc herniation group improvement of the radicular and medullar functions occurred. According to the motor index the patients had an average of 32.44 points in the final follow-up.

Anterior decompression is indicated in cases of vertebral fractures with fragments inside the canal and in cases of traumatic disc herniations with associated neurologic deficit.

Ultraviolet light in operating rooms

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The present study was conducted to evaluate the efficiency and practicability of ultraviolet light (UVC) compared with a Charnley-Howorth enclosure (CH) for the production of ultraclean air (< 10 Colony-Forming Units [CFU]/m^3) in operating rooms. The wound reaction to UVC was studied in rats, as well as the reaction of volatile anesthetics to UVC exposure. An economic comparison was also made.

One OR was equipped with 8 UVC lamps (TUV 40, Philips, Holland) and 8 blue sham light (SHAM) lamps in 8 double ceiling-mounted armatures. UVC and SHAM were monitored independently of one another. The UVC intensity was measured by a UVX radiometer (UVP Inc, California, USA). Air bacteria counts were obtained continuously at the wound (centrally) by an Andersen-sampler and intermittently in the periphery by a Casella slit-sampler. Measurements were made during a gymnastic programme performed in the UVC and SHAM respectively, with an interval of 1 week, by 5 orthopaedic surgeons dressed as they would be for operating. Air-sampling was also performed during 20 pertrochanteric hip fractures randomized for UVC or SHAM and operated on with a Richards sliding screw and plate, at 3 defined times during the procedure. Afterwards, the installation was changed to 10 armatures containing 20 UVC lamps to obtain a higher UVC intensity. Occlusive clothing (CLOTH) on all persons in the OR was also evaluated and 113 cemented Charnley hip replacements for osteoarthritis were performed in CH or CH+CLOTH and in UVC, UVC+CLOTH or CLOTH. The penetration of different materials by UVC was measured by the UVX radiometer. The surgeon's feeling of comfort in the UVC and CH was measured by a VAS test. The fixed costs and running expenses for 1 year, assuming 100 operations/year, were calculated for UVC and CH respectively. The wound tensile strength after exposure to UVC or ordinary lamp light 7 days after surgery was measured in rats. The degradation of 2 volatile anesthetics (Isoflurane and Enflurane) under exposure to UVC or no UVC was measured in a flow reactor connected to a gas chromatograph. Halothane was used as a reference compound as it is known to photodecompose when exposed to UVC.

The maximum UVC intensity at the operating table level was about 1.20 W/m2 in the first installation. In the gymnastic programme, the mean air bacteria count was 782 CFU/m3 in SHAM and 16 CFU in UVC. Each of the three in the hip fracture series showed a significant reduction ($p < 0.01$) in air bacteria counts while using UVC (24—>14, 44—>14, 28—>9 CFU/m3). In the second installation, the UVC intensity at the same level was 2.90 W/m2. In the hip replacement series, the central mean bacteria counts were as follows: CH = 7.67, CH+CLOTH = 3.20, UVC = 2.96, UVC+CLOTH = 0.47, CLOTH = 5.91 CFU/m3. Different clothing materials showed a great variation as regards the UVC penetration. No difference in the surgeon's feeling of comfort in the UVC and CH was found. The cost of the CH system was 2084 SEK per operation and 62 SEK for the UVC system. No difference was found in the wound tensile strength in rats after exposure to UVC or ordinary lamp light, respectively. No degradation of Isoflurane and Enflurane was found when irradiated by UVC. Halothane showed a significant degradation under UVC irradiation, but no degradation was found in the control experiments.

UVC showed to provide ultraclean air, to be many times less expensive than a Charnley-Howorth enclosure and to be as comfortable for the surgeon. Care should be taken in the choice of protective clothing as UVC does penetrate some materials. Surgical wounds in rats exposed to UVC showed a normal healing process. No degradation of Isoflurane and Enflurane by UVC was found, but Halothane showed a significant degradation when exposed to UVC.

Magnetic resonance imaging of spinal tumors

A study using a 0.3 tesla vertical magnetic field

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A total of 168 patients with spinal tumors were evaluated with MRI (0.3 T scanner, vertical magnetic field). The study shows that MRI is a sensitive method for demonstration of spinal tumors. MRI also provides a possibility of separating different histological types of tumors based on their morphology and signal characteristics.

Intramedullary tumors (25 cases): Ependymomas (6 cases) and astrocytomas (7 cases) were most common. Ependymomas have a more irregular signal pattern than astrocytomas. Astrocytomas are more common in the upper spine and are more often completely cystic. Contrast enhancement is important for separation of cyst, edema and solid tumor.

Intradural extramedullary tumors (31 cases): Neuromas (14 cases) and meningeomas (11 cases) were most common. Neuromas always had markedly increased signal intensity on T2-weighted images. Meningeomas were only hyperintense occasionally. Neuromas were more inhomogenous than meningeomas on T1-weighted images. Contrast enhancement is valuable for delineation of small tumors.

Extradural tumors (91 cases): 76 patients had metastases, 7 primary spinal tumors and 8 multiple myelomas. T1-weighted images are almost always superior to other sequences because tumor invasion in the fatty bone marrow is seen as a low signal area in contrast to the high signal from the fat.

Spinal lymphomas (14 cases): May be divided into vertebral, paraspinal and epidural tumors. Most cases have all locations. Typically, spinal lymphoma often involves the paravertebral lymph nodes with invasion of adjacent vertebrae and extension through the intervertebral foramen to the intraspinal compartment.

Spinal neurofibromatosis (7 cases): Most patients had multiple, often bilateral neurofibromas. One patient had a meningeoma and one spinal dysplasia with meningoceles. MRI is superior to other modalities for evaluation of the full extent of the disease. The coronal view is often valuable because of the arrangement of the tumors. In addition to providing diagnosis, MRI is of great value in treatment follow-up.

Soft tissue injuries and fractures of the cervical spine

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22 cervical spines from traffic accident victims with skull fractures were frozen in situ and removed with all surrounding soft tissues. The specimens were radiographed in multiple planes and all injuries were studied by cryosectioning. In the upper cervical spine, only 1 or 10 gross disruptions were suspected on the radiographs. In the lower cervical spine, 198 lesions at multiple levels were missed, among them 77 facet joint- and ligamentum flavum injuries, 77 uncovertebral lesions, 22 disc ruptures and 8 avulsions of the cartilaginous endplate of the discs.

50 patients with whiplash-type distorsions sustained in car accidents were studied. All emergency plain radiographs were normal. After 6 weeks, 26 patients had recovered completely and 24 still had neck pain and 19 of these also had radicular pain. In 5 patients with neck pain, flexion-extension radiographs indicated segmental instability. MR showed decreased signal intensity in 49 discs and disc protrusions in 27. 8 patients required disc excision and were fused with the Titanium Locking Screw Plate (TLSP) and bone grafting. 2 patients with ligament ruptures were fused posteriorly. At 4-year follow-up, the surgically treated patients were markedly improved whereas most symptoms persisted in the non-surgically treated patients.

40 patients with 19 fractures and 21 fracture dislocations in the lower cervical spine were treated prospectively with open reduction and fixation with the TLSP system. 8 patients were tetraplegic, 12 tetraparetic and 6 had nerve root injuries. 11 of the fractures and 18 of the fracture dislocations were also plated posteriorly. Complications included 2 transient cardiac arrests, 2 neurologic impairments, 2 severe gastrointestinal bleedings and 1 esophageal fistula. 3 of 10 patients who had complete motor loss initially had regained useful muscle function. Patients with incomplete motor loss usually recovered to normal. All fusions had healed in good or acceptable position. 24 of 60 posterior plates impinged on facet joints and 5 were loose. 6 screws transgressed facet joints below the fusion. 10 posterior fusions extended to adjacent segments by exuberant bony overgrowth. Ancillary posterior plating significantly decreased the range of neck mobility and also caused significantly more pain than anterior plate fixation alone.

The Uppsala Cryoplaning Technique was modified for studies of spine specimens with surgical metallic implants. The specimens were frozen in situ after injection of the arteries of the spine with red contrast medium. After partial thawing of the soft tissues, metallic implants were extracted and the screw tracts and implant cavities were filled with a blue casting medium. High resolution CT scans of the frozen specimens were correlated with closely spaced cryosectional images at the same levels. This technique not only facilitated radiologic-pathoanatomical correlations, but also allowed a detailed assessment of implant placement, reduction, decompression and also analysis of surgical complications.

This technique was applied to study 4 articular pillar screw-plate fixation systems that were surgically implanted in both fresh specimens and intact cadavers. All methods with screws of recommended standard length inserted at osseous landmarks carried risk for neurovascular complications, especially at C6 and C7. Safety was enhanced by directing the screws toward the pedicle projection on the fluoroscope and by separately measuring the length of each drill hole.

Rheumatoid cervical spine

Focusing on changes in the atlanto-axial area

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Publications of the University of Tampere, Acta Universitatis Tamperensis, ser A, vol 339, 1992, Tampere Finland

Clinical and radiological findings concerning 164 patients suffering from chronic destructive rheumatoid arthritis (RA) were studied in order to obtain further information on the rheumatoid cervical spine. The rheumatoid inflammation often affects the cervical joints, but earlier research has provided histopathological evidence for such a process in form of focal mononuclear cell infiltration also in the stabilizing ligamentous apparatus of the area. It is possible that the inflammation injures the ligaments before the joints are destroyed. Atlanto-axial subluxation (AAS) was found in 14 of the present patients without radiological evidence of abnormalities in cartilage or bone tissue.

The atlanto-axial facet joints can be destroyed by chronic bilateral inflammation so that the atlas descends around the axis and vertical dislocation (VD) occurs. The skull follows the atlas and the tip of the dens reaches upwards in relation to the skull. In severe cases the tip can even pass through the foramen magnum into the skull and disturb the vital structures there. The diagnostic methods for VD described by McGregor and McRae measure the relation of the tip of dens to the skull, but they cannot be used if the tip is not visible due to overprojection of the mastoids, and they do not reflect the true extent of VD if the tip is eroded and shortened. The value of the Redlund method depends on the height of the axis, and thus it requires previous radiographs for comparison in order to identify abnormalities. The newly devised Sakaguchi-Kauppi method is based on pathogenetically relevant atlanto-axial facet joint changes. the relation of the superior bony facets of the axis to the level of the atlas are examined from lateral view radiographs and the situation is said to be abnormal if the tips reach the lower level of the atlas. The severity of the abnormality can also be graded. The Sakaguchi-Kauppi method seems to be superior to existing VD diagnosing methods for screening purposes.

Although the effect of position on the atlanto-axial distance in AAS is well recognized, the effect of flexion-extension movement on diagnosing methods of VD has not been analyzed before. Flexion significantly increased the prevalence of VD irrespective of the method used. Interestingly, severe AAS may cause a reversible vertical shift of the atlas, which does not presuppose a collapse of the atlanto-axial facets but depends on the biomechanics of the cervical spine. This small movement may be of clinical relevance in critical cases.

20 RA patients were examined clinically by a neurologist and radiologically by low-field MRI in addition to the routine investigations. 4 patients had cord compression in the MRI examination, 3 of whom had also signs of it in their neurological status. The neurological findings matched the MRI results, and it was evident that even with low-field equipment, MRI yields information not obtainable by conventional radiography.

A multivariate logistic regression analysis of 145 RA patients disclosed a high joint score index and a low blood haemoglobin level as independent risk factors for anterior AAS. Linear multiple regression analysis showed an association between the extent of anterior AAS in millimetres and the extent of erosions of the axis and the absence of severe VD. This suggests that whereas the presence of anterior AAS is connected with the severity of the disease, its actual extent is associated with signs of local involvement if severe VD has not developed.

Although an association between glucocorticoid treatment and rheumatoid cervical changes has been suggested in some earlier articles, neither the duration nor the cumulative dose of low-dose glucocorticoids found here to be associated with pathology of the upper cervical spine.

The series included 34 patients with radiographs obtained because of cervical spine pain before AAS had developed. To better understand the origin of this pain, neuroimmunohistochemical tests were performed on cervical spine ligamentous tissue samples from 5 surgically treated RA patients. Neurofilaments and calcitonin gene-related peptide (CGRP) immunoreactive nerves were demonstrated in the inflamed ligamentous tissue. This finding may suggest that pain early in the course of AAS could be caused by a local ligamentary involvement

leading to irritation of primary afferent nociceptive nerves.

Most rheumatoid cervical spine patients can and should be treated conservatively, but surgical treatment is needed in special cases. Increased understanding of the pathophysiology and natural course of the disease and the availability of new imaging and neurophysiological examinations now allow better timing of properly planned selective surgical procedures. Surgical treatment gave good pain relief in 30/37 cases in our series of 38 patients, and all 6 cases with tetrapareses were improved. One patient died of postoperative sepsis, and a further 18 patients died during the follow-up of at least 10 years, but their mortality was not related to the surgical treatment of the cervical spine pathology. Pre-existing cardiac disease at the time of surgery and severe VD were predictive of increased mortality in survival analysis. 4 patients needed re-operation because of new subluxations below the primarily fused segments.

ISBN: 951-44-3109-X
ISSN: 0496-7909

Internal fixation of femoral neck fractures

A study with special reference to the positioning of the fixation device

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The present study describes the effect of percutaneous bone grafting and the influence of different designs and positioning of the fixation device on the outcome after femoral neck fractures.

The results of percutaneous bone grafting combined with multiple pinning was studied in 28 patients with displaced femoral neck fractures. Cancellous bone graft was obtained from the ipsilateral greater trochanter and introduced into the femoral neck through a drilled channel. 2 years after the operation, only 2 of the surviving 21 patients had needed a second operation, indicating that bone grafting can be of value in the treatment of femoral neck fractures.

To evaluate the influence of different designs of the fixation device, 220 patients with femoral neck fractures were treated with either 2 von Bahr screws, 3 Gouffon screws or 3 non-threaded Hessel pins. 2 years after the operation, the rate of complications including the need for a second operation was higher in the Hessel pin group compared to the von Bahr screw group and the Gouffon screw group.

A new method for determining the position of the fixation pins in femoral neck fractures was devised. The pin positions were determined by geometric calculations from measurements in routine AP and lateral radiographs. A computer program was developed to produce a graphic display of cross-sections of the femoral head and neck with the corrected pin positions indicated. The error of the method was less than 5% of the diameter of the femoral head.

To evaluate the influence of different screw positions on the stability of fixation in femoral neck osteotomies, 30 cadaveric proximal femora were osteotomized and fixed with 2 cannulated screws. The proximal screw was placed with either a posterior cortical support in the femoral neck or centrally, supported only by cancellous bone. The distal screw rested on the medial femoral cortex. The specimens were tested in bending, using an electromechanical test machine. A posterior position with cortical support for the proximal screw increased the stability compared to a central screw position.

In 87 internally fixed femoral neck fractures, the positions of the fixation screws were determined by a new mensuration technique which compensates for the variations in hip rotation in routine radiographs. The rate of union of the fractures was compared with the position of the screws. A posterior placement of the proximal screw and an inferior placement of the distal one in both the femoral head and neck was associated with better results.

On vascular graft thrombosis

A methodological, clinical and experimental study

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Thrombosis of a vascular graft is a multifactorial process, which is reflected in the difficulties to predict early graft occlusion in peripheral arterial surgery and in the still suboptimal methods to prevent graft thrombosis. The principal aim of this thesis is how it would be possible to predict graft occlusion in infrainguinal bypass surgery by evaluating and using a transit time flow meter for volume flow measurements and subsequent calculation of the peripheral resistance and how modifications in blood flow, in the graft surface and in blood characteristics may influence thrombus formation due to graft thrombogenicity.

To fulfil these aims a combination of methodological, clinical and experimental studies has been performed. The evaluation of the transit time flow meter showed an error of measurement was close to 10% and a variability of 2%. The results from flow measurements and the calculation of peripheral resistance in 48 femoropopliteal/distal reconstructions showed that patients with graft occlusions within 90 days had a significantly lower flow before, after reconstruction and a higher peripheral resistance than patients with patents grafts.

Experimentally it was shown that an 85% reduction in blood flow increases the uptake of platelets, fibrinogen and to a certain extent leucocytes in ePTFE grafts. The increase in uptake was particularly evident over the distal anastomosis. The modification of a dacron graft by soaking the graft in a rifampicin solution increased the thrombogenicity of the graft. This could be of importance if the graft is inserted in a low flow high resistance situation. Pharmacological treatment with a thromboxane receptor and a combined thromboxane receptor and synthesis antagonist to prevent thrombus formation in ePTFE grafts had only a limited effect on platelet uptake. The uptake of fibrinogen was lowered indicating that the treatment prevented platelet activation through thromboxane. The platelets seemed however to be activated through other mechanisms.

This thesis indicates that blood flow can be measured accurately and that the results can be used to identify patients with a high risk of graft occlusion. The thesis also indicates the influence of flow on thrombus formation, that a modification of a graft material could alter the graft thrombogenicity and that pharmacological treatment inhibits platelet activation by thromboxane but that platelets are activated through other mechanisms.

Fracture of the distal forearm

Epidemiological and clinical studies

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Acta Universitatis Upsaliensis. Comprehensive Summaries of Uppsala Dissertations from the Faculty of Medicine 367, 49 pp. Uppsala

The investigation was undertaken to delineate biochemical, bone densitometric and epidemiological characteristics of patients who had sustained a fracture of the distal forearm. All patients (n = 621) registered prospectively with a fracture of the distal forearm during a 1-year period within the County of Uppsala were included in the studies. In addition, all patients (n = 1,338) above the age of 40 years who sustained a fracture of the distal forearm during 1968-1972 were followed up regarding later hip fracture.

Women above the age of 40 were predominantly affected and the age-specific incidence of fractures of the distal forearm and the proportion of reduced fractures caused by low-energy trauma increased with age. The age-specific incidence among the men was one-fourth of that among the women and increased only slightly with age and after the age of 70.

Certain risk factors for osteoporosis were evaluated by means of a questionnaire in patients 40-80 years of age (n = 367). Early menopause, nulliparity but not number of child births per se, no breast-feeding, and less hormone replacement therapy were all associated with an increased risk of fracture. Heredity for fractures of the hip and distal forearm contributed to an increased risk of fracture. Moderate physical activity was possibly protective.

Primary hyperparathyroidism (HPT) affects bone metabolism. Serum calcium screening was performed among fracture patients above 30 years of age (n = 486). On the basis of determinations of intact serum parathyroid hormone (PTH) the HPT prevalence among women over 60 was found to be about 5%, which is clearly higher than in the population at large.

Reduced bone mineral density is a major diagnostic criterion of osteoporosis. Bone density was measured at the distal forearm by single-photon absorptiometry and at the spine and hip by dual-energy x-ray absorptiometry. As a group, patients with a fracture of the distal forearm showed reduced BMD at all sites, although the most prominent losses were at the distal radius. However, there was considerable overlapping between patients and controls.

Hip fractures are the greatest cause of disability and increased mortality among patients affected by osteoporosis. With the aim of determining whether patients with fractures of the distal forearm run an increased risk of hip fracture, a cohort of patients and a cohort of controls were followed up regarding a first hip fracture. The follow-up comprised over 40.000 person-years. The overall relative hazard was 1.54 in the women and 2.27 in the men. Patients with a fracture of the distal forearm are thus at increased risk of sustaining a hip fracture and constitute an appropriate group of patients to be considered for screening and prevention.

Treatment with bisphosphonates reduces bone resorption. In a placebo-controlled short-term trial, the effects of 4 weeks of oral treatment with pamidronate (ArediaTM) on serum and urinary biochemical variables were studied in 60 patients for 16 weeks. Bone resorption was reduced in a dose-related manner and returned to its initial values at the end of the investigation period.

ISBN 91-554-2954-8

Controlled mobilization after flexor tendon repair in the hand

Techniques, methods and results

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The aim of this study was to examine how early controlled motion affects results after flexor tendon repair in zone II of the hand, and to improve results by developing new postoperative mobilization techniques and methods.

A new power source for dynamic hand splinting was developed. The device, which utilizes a flat coil spring of the type used in mechanical watches, was tested in an Instron materials testing machine and evaluated clinically in a trial involving 42 consecutive patients, treated with 3 modifications of dynamic flexion traction after flexor tendon repair in zone II. The results and problems associated with a conventional controlled motion program (Kleinert) were prospectively examined in a group of 51 consecutive patients followed for 1 year after flexor tendon repair in zone II. Controlled interphalangeal joint range of motion during the initial splinting period, the subsequent active range of motion, extension deficits, swelling of the injured digit and grip strength were measured regularly during the follow-up period. The Kleinert program was then modified in 2 successive steps. Each modification was followed by a similar 1 year prospective evaluation in 45 and 44 patients, respectively. The combined series of patients was used to examine the rate of postoperative recovery after the controlled motion period, and in a stepwise multiple regression procedure, variables affecting final results were identified and analyzed. The results of this study showed that

- The new power source has significant advantages over other techniques, in terms of dynamic performance, reliability and reproducibility, and in terms of convenience for therapists and patients.
- There is a roughly linear relationship between final active interphalangeal joint range of motion and the controlled range of motion obtained during the first weeks after flexor tendon repair in zone II.
- A combination of dynamic traction and additional passive flexion of all 4 digits, a shorter dorsal splint and immobilization of the interphalangeal joints in extension at night can produce significantly better results (150 to 160 degrees of composite active interphalangeal joint range of motion or 85% to 90% of normal range of motion) and a decrease in the incidence of flexion contractures, compared with conventionally treated motion programs.
- The relative merits of different controlled motion programs can be determined already by the mean active range of motion recorded 4 weeks after the operation.
- The rate of subsequent recovery, from 4 weeks to 1 year after the operation, is the same, irrespective of the type of early controlled motion program used.
- More than a third of the final active distal interphalangeal joint range of motion and nearly 10% of the proximal interphalangeal joint range of motion is recovered more than 3 months after flexor tendon repair in zone II.
- The following variables have a significant effect on the final active interphalangeal joint range of motion: The early controlled range of motion, the age of the patient, the number of tendons and digits injured and the swelling of the injured digit.

ISBN 91-628-0745-5

Quantitative analysis of 99m-Technetium MDP uptake after asymptomatic Charnley arthroplasty

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University of Liverpool, 1992

Mechanical loosening and infection are the main complications after a total hip replacement for which radio nuclide imaging with 99m-Technetium methylene diphosphonate (99m-Tc MDP) remains the commonest investigation. However, increased tracer activity may persist even after uncomplicated hip replacements, simply as a reaction to surgical trauma, for a period that varies in the literature from 2-24 months depending on tracer and method of analysis of uptake.

In order to establish the normal course and pattern of its uptake in quantitative fashion, 99m-Tc MDP scans of 73 primary Charnley hip replacements done for arthrosis in 68 patients were studied at 6, 9, 12, 15, 18, 21, and 24 months after surgery (10-12 patients in each group). All patients were uncomplicated on clinical, radiological, and haematological examination. A Gamma camera (with large field of view, 75 photomultiplier tubes, and high-resolution collimator) was attached to a dot console and microdot imager for analogue images which were stored on computer for data processing. A software programme was designed to obtain uptake from 3 acetabular and 7 femoral peri-prosthetic zones, and an area from the isthmic region of the contralateral femur representing normal bone. Ratios of uptake in each peri-prosthetic zone to normal bone were determined.

Analysis of variance and regression of uptake with time was performed to determine the temporal pattern of uptake in different zones. These tests showed that femoral uptake decreases in linear fashion from 6 to 12 months ($p < 0.05$ in some zones). Uptake then stays at nearly twice normal level in the greater trochanteric region, 1.5 times normal in the lesser trochanteric region, and returns to nearly normal in other femoral zones. Acetabular uptake remains elevated throughout at nearly twice normal levels after a minimal initial decrease.

Establishing a normal pattern may prevent a false-positive diagnosis of loosening or infection and save the patient from undergoing unnecessary studies with other isotopes. Alteration from such a trend would enable exclusion of a 'normal' postoperative course of events.

Kinematics and fixation of total knee arthroplasties

A clinical, radiographic, scintimetric and roentgen stereophotogrammetric evaluation

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Aseptic loosening of the tibial component is an important cause of failure after total knee arthroplasty. Bone destruction often claimed to be caused by the cement makes the revision difficult. In order to treat younger patients, uncemented fixation has been introduced, but the etiology to loosening is multifactorial and only partly known. Early detection of implant migration facilitates research in this field but is difficult using conventional techniques . In this study modified versions of roentgen stereophotogrammetric analysis (RSA) were developed to obtain accurate and standardized evaluations facilitating comparison between prosthetic designs. The method was used to record the efficacy of cemented and uncemented fixation of different designs of the tibial component, to determine the accuracy of scintimetry in the detection of early aseptic loosening, and to analyse the in vivo kinematics of knee arthroplasties with different design and stability between the joint surfaces.

43 arthroplasties with comparatively high inherent stability of the joint surfaces were randomized to cemented or uncemented fixation of the tibial component. In all groups micromovements were rather large, but with no differences between the cemented and uncemented components. The preoperative diagnosis (arthrosis OA, n = 25; rheumatoid arthritis RA, n = 18) did not influence the magnitude of micromotion.

20 arthroplasties with the same design as above but equipped with an intramedullary stem, were randomized to cemented or uncemented fixation in patients with RA. Cement improved the fixation. Uncemented stemmed components displayed micromovements seemingly larger than unstemmed ones.

34 arthroplasties with an unconstrained design of the joint area and fixed to the tibia with 4 pegs were randomized to cemented or uncemented fixation in patients with OA. When used uncemented 4 screws were added. Compared with previously investigated designs small micromotions were recorded, and especially in the cemented cases. Uncemented components with thin polyethylene inserts displayed larger initial micromotions. The preoperative deformity influenced the direction of the micromotion.

33 knees were followed prospectively with RSA and scintimetry to evaluate any correlation between these methods. Low activity under the tibial component at 2 years implied prosthetic stability, whereas high activity indicated instability or high bone remodelling caused by the preoperative malalignment.

The in vivo kinematics in 3 different designs of knee arthroplasties were analyzed during active flexion and extension without weight-bearing. Each type of prosthesis displayed design-specific abnormalities when compared with a normal material. Pronounced posterior tibial translations were recorded during flexion regardless of whether the posterior cruciate ligament had been sacrificed or not. Data from the kinematic and the fixation studies suggest that movements restricted by the design of the joint area are transmitted to the bony interface with design-specific micromotions as the result.

Analysis of knee joint kinematics during extension and weight-bearing revealed small alterations compared with non weight-bearing. Evaluation of the 3-dimensional movements in terms of helical axis rotations and translations confirmed the constrained or unconstrained in vivo behaviour of the designs under study. This analysis also facilitated the interpretation of the kinematic behaviour of the prosthetic knees and may be of value in the evaluation of new designs.

Pelvic fractures

Aspects of epidemiology, acetabular fractures and sacroiliac joint disruptions

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The overall incidence of pelvic fractures in the Swedish county of Skaraborg was 24/100,000. Severe trauma dominated in younger age groups, and moderate in older. 81% were stable fractures of the pubic rami. Associated injuries occurred in 21%. The length of hospitalization was 3 weeks irrespective of the severity of the trauma.

Posttraumatic arthrosis is the major cause of an inferior outcome after acetabular fractures. 60 surgically treated acetabular fractures were followed up for up to 25 years. In 21 of the 24 arthrotic hips the arthrosis developed within 24 months. There was a high correlation between non anatomic reduction and arthrosis. In conclusion, the posttraumatic arthrosis develops early and thus the long-term results can be predicted within 2 years of surgery.

Various approaches have been advocated for surgical treatment of acetabular fractures. In 24 displaced complex acetabular fractures an anterior and/or a posterior incision was used. Posttraumatic arthrosis developed in 7 hips. Full reduction could not be achieved in 13 of the 24 cases, and in 6 of the 7 arthrotic cases. In conclusion, the approaches used in this study might not be appropriate for surgical treatment of complex fractures with displaced dome fragments.

In 23 displaced complex acetabular fractures the triradiate incision was used. All but one fracture were anatomically reduced. At follow-up 7 hips had developed arthrosis, all with comminution in the dome. Heterotopic bone formation occurred in 13 hips, namely in all 9 without indomethacin prophylaxis and in 4 out of 14 with such prophylaxis. In conclusion, the triradiate incision is suitable for surgical treatment of complex acetabular fractures, and heterotopic bone formation can be reduced by indomethacin prophylaxis.

Conservative treatment of unstable sacroiliac joint disruptions leads to long-term problems in more than half of the cases. In 23 unstable sacroiliac joint disruptions (21 patients) open reduction and internal fixation with a specially designed 2-hole square plate were performed through an anterior approach. 18 patients had a satisfactory result. It is concluded that the anterior approach is superior, as the joint can be explored and the reduction confirmed, and the square plate offers a possibility of achieving firm fixation of the disrupted joint to minimize the risk for redislocation.

Distal radius fractures

Classification, function and recommendations to treatment

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The study includes the radiographical and functional evaluation after treatment of distal radius fractures.

The prognostic value of different classification systems was evaluated after treatment with reduction and plaster, and it was concluded that a system including radial shortening, dorsal angulation and comminution was applicable (Older's classification).

Functional evaluation included deformity, pain, range of motion, grip strength and the occurrence of complications. In 2 separate studies the intra- and interobserver variation of measurements of the range of motion of the wrist was studied, and the precision of different dynamometers was investigated. These results were used in a follow-up study of 154 patients with distal radius fractures 3 1/2 years earlier. A logistic regression analysis with the use of graphical models showed that several of the parameters included in the functional score system were interrelated, but that the residual deformity was most important for the final functional result. Furthermore a correlation between the radiographical and functional result was demonstrated, and indirectly the fracture type influenced the end result.

In an attempt to improve the functional result, it was considered rational to try to eliminate the residual deformity. 40 patients were treated by external fixation and the results evaluated after 3, 6, 12 and 29 months, and compared to a previously published series of patients treated by functional bracing in supination or dorsal plaster immobilization. No difference was found when the observation period was short, but after a longer follow-up external fixation showed superior. The statistical analysis showed that the superior results were caused by external fixation preventing secondary displacement with dorsal angulation. Late symptomatical arthrosis in spite of an anatomical radiographical result, however, was not prevented.

The use of external fixation implies higher economical costs (hospitalization etc). An epidemiological study in the County of Frederiksborg demonstrated that the incidence of distal radius fractures implied that between 8000 and 9000 fractures are to be treated in Denmark every year. 30% of the fractures will be severely displaced, and potential candidates for external fixation. The treatment of that number of patients will hardly be realistic, but the present investigation has also showed that the therapeutic advantage was highest in the youngest patients.

On bone cutting

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This study concerns the surgical technique in relation to bone cutting. Out of a number of possible factors influencing the interface between bone and implant, two were investigated, viz the heat generated by power cutting and the quality of the cut surface.

The mean maximum temperature during clinical tibial bone cutting was 68 °C in the saw blade, and 47 and 42°C in the bone 2 mm and 3 mm respectively below the cutting area. External cooling had no effect. The mean maximum temperature at the cement-bone interface during the cement process was 37 °C. Laboratory in vitro cutting tests on oxbone with 8 different saw blades showed temperatures between 34 °C and 450 °C in the saw blades. An alteration of the cutting edge design did not reduce the heat generation. External liquid cooling on the saw blades was effective if supplied in large amounts (> 600 ml/min), although this was deemed impossible in clinical practice. A specially designed saw blade with channels inside was tested. The cooling fluid (80 ml/min) was directed internally to the cutting edge. The heat generated by this blade was 19-34°C. Clinically the mean maximum temperature was 32 °C.

The cut surface of the tibial metaphysis both in vitro and in vivo, was measured using an imprint technique. An apparently flat surface was found to be uneven to a degree which may be an important factor responsible for the lack of bone ingrowth in non-cemented prostheses.

In a randomized study on 33 total knee replacements the effect on tibial component fixation using the internally cooled versus a standard blade was assessed using roentgen stereophotogrammetric analysis. All knees were clinically successful after 1 year. There were no differences between the 2 groups regarding migration at the 1 year follow-up. Inducible displacement was, however, smaller with the cooled saw blade indicating a stiffer interface.

Factors affecting the survival of the total hip endoprosthesis

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The survivorship method has established itself as a reliable tool in the statistical analysis of total hip endoprostheses (THP). Studies where the survival of different THPs are compared have so far not been published from Finland.

The purpose of this study was to: (1) compare the survival of different total hip endoprostheses and (2) investigate factors affecting the survival of the total hip endoprosthesis

The material consisted of all primary THPs and part of the revision THPs which had been inserted at the Orthopaedic Hospital of the Invalid Foundation, Helsinki, Finland from 1967 to 1986 and followed-up to 1988. More than 16 different prostheses were used during the follow-up time. 5 of these were used in at least 100 patients providing a material which could be stratified into different subgroups for comparison. The final series consisted of 2791 patients who had received 3360 THPs. This material was considered to be large enough for the statistical analyses in this study.

Recalling the aims of the study, the methods, results and conclusions can be summarized as follows:

(1) The Kaplan-Meier product-limit survival analysis and Cox's proportional hazards model were used to estimate the survival of different prostheses. Failure of the prosthesis was defined as the replacement or removal of one or more components for any reason other than infection, the death of the patient or the end of the follow-up in 1988. Over 20% of the patients received bilateral implants. In order to obtain a methodologically correct basis for testing the statistical significance when comparing prosthetic survival, only one randomly selected THP of the bilaterally operated cases was used in the analyses. All survivorship analyses were thus performed per patient and not per operated hip.

The overall survival of the pooled 5 THPs during a 15-year follow-up was on average 95% at 5 years, 85% at 10 years and almost 80% at 15 years. The average yearly failure of the prostheses was 1.4%. The survival probability was not strictly linear. The probability of survival of the most commonly used conventional cemented hip prostheses (Brunswik, Lubinus) was virtually the same at 7 years, i e 90.5% and 90.1% respectively. The survival of the Brunswik prosthesis was 85.0% at 10 years. McKee-Farrar's metal-on-metal prosthesis had an inferior survival at 10 years (83.1%). Lagrange-Letorunel's conventional prosthesis had a markedly inferior survival probability compared with the other prostheses (65.8% at 10 years). Lord's cementless prosthesis appeared to have a better 5.8-year survival in secondary arthrosis (90.0%) than conventional THPs (85.0%).

(2) Factors positively affecting the survival of THPs in arthrosis were bilateral prostheses, experienced surgeon, old age (over 70 years), female gender, private patient and routine operation. In secondary arthrosis, cementless fixation of the implant and also to some extent bilateral prostheses had a positive effect on the prosthetic survival. Factors negatively affecting the survival of THPs in arthrosis were unilateral prosthesis, unexperienced surgeon, younger age (less than 55 years), male gender, non-private patient and difficult operation. In secondary arthrosis cemented hip prosthesis and to some extent unilateral prosthesis negatively affected the survival of the prosthesis.

If the probability of survival of a prosthesis in arthrosis is assumed to be 85% at a certain time, bilateral prostheses increased the survivorship of the prosthesis by 9.8 percentage units. Correspondingly, experienced surgeon, advanced age (over 70 years), routine operation and female gender increased the prosthetic survival probability by 3.5-5.4 percentage units.

Aseptic revisions were more difficult than primary total hip arthroplasties. The average duration of a revision was 172 minutes and the mean intra-operative blood loss 2570 ml. The corresponding figures in primary arthroplasties were 118 minutes and 1418 ml. The survival probability of cemented hip prostheses in revision arthroplasty was 10 percentage units inferior at 10 years, when compared with primary cemented total hip implants.

Based upon this study it is concluded that a thorough surgical experience and a correct choice of prosthetic hip implant is the best guarantee for a long survival of primary total hip endoprostheses, especially in secondary arthrosis and younger patients. A conventional cemented total hip prosthesis is still a reliable choice in THA for the elderly with primary osteoarthrosis. It should be used as a gold standard for comparison and evaluation of newer cementless implants.