Dissertation abstracts

Acute anterior cruciate ligament injuries

Evaluation of surgical and non-surgical treatment

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This study is concerned with the treatment of patients with acute anterior cruciate ligament (ACL) injury. The aim was to compare primary surgical and non-surgical ACL treatment. Treatment was, therefore, instituted at random in all consecutive patients (n=293) with ACL injury.

Initially all patients were investigated by arthroscopy and examined under anesthesia.

After 4 years patients treated by ACL repair with combined intraarticular and extraarticular augmentation had a better stability, fewer knee symptoms and a higher level of activity than patients treated by nonaugmented ACL repair or by repair of the associated injuries alone. The patients in the latter group commonly developed instability symptoms and ACL reconstruction was required in 20% of them. Also they frequently had subsequent meniscal injuries, and an impaired knee function at one-leg-hop tests for distance. Running tests, however, were not correlated to ACL treatment.

Another group of patients with acute ACL injury did not have any primary ligamentous repair. At one year 20% of the patients needed reconstructive surgery. Moreover, anterior-posterior laxity at one year was increased compared to the initial measurements. The greatest initial laxity was found in patients with an associated tear of the medial collateral ligament (MCL). The patients with combined ACL and MCL injuries had the worst prognosis.

In patients with combined injuries who had primary repair of grade 2–3 MCL tears the outcome was similar as for patients with isolated ACL lesion.

A simple device for static measurements of anterior-posterior knee displacement was valuable for evaluating the results of ACL treatment. It can also be used as an aid in the diagnosis of acute knee injury.

Symptoms from neck, shoulders and arms in an industrial population and some related problems

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Neck, shoulder and arm symptoms have been an increasing cause of reported workers' compensation claims and long-term sick leave in Swedish industry. The purpose of this work was to analyse several associated factors in order better to understand how these problems can be prevented.

This work involves 5 cross-sectional questionnaire studies on the prevalence of pain symptoms from the neck, shoulder and arms and on how they relate to certain personal and occupational factors, sickness absenteeism, attitudes (the hidden social contract), certain diagnoses and behaviour among employees in a Swedish aerospace industry. The industry had between 2,900 and 3,800 employees during the period (1982 to 1989) when these studies were performed. The work also includes an intervention-study of smoking cessation. All the patients with ongoing symptoms were seen by an orthopedic surgeon. Correlations were analysed using a multivariate technique and all the tests were two-sided.

Physical stress by type of job was the factor most strongly related to ongoing cervicobrachial symptoms but there was evidence that sickness absenteeism was more related to psycho-social factors. Work with vibrating hand-tools as well as short stature, overweight, stress and female sex increased the rate of symptoms. The diagnostic difficulties are emphazised. The factor strongest associated with high sickness absenteeism was smoking ($p < 0.001$). In an attempt to increase the frequency of smoking cessation, a one-year long quit-smoking contest was attempted. It attracted 10% of the smokers or 73 employees of whom 33% were still abstinent after one year.

It was concluded that work with vibrating hand-tools of the type used in this industry probably increases the prevalence of white finger symptoms and neck/arm pain and that measures for improving the insulation of these tools, resulting in less vibration transfer, need to be evaluated. Moreover, heavy repetitive or static (type 3) jobs need to be automated in order to prevent pain symptoms, especially in women.

It was also concluded that to use a lottery might be a successful way of getting people to stop smoking.

It is suggested that, in addition to further efforts to optimise the ergonomics at the place of work, something should be done to increase the social support, the potential for influencing the working situation, and job motivation in the engineering industry.

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On treatment of medial gonarthrosis

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This study is concerned with treatment of medial gonarthrosis.

Results after high tibial osteotomy were found to deteriorate 8–9 years after surgery. The best result were seen in knees with preoperative Stage I or II arthrosis and valgus deviation after osteotomy.

The rehabilitation period after high tibial osteotomy is long, recovery of the average thigh muscle torque was first seen after 12 months. Stable internal fixation with early mobilization does not seem to be advantageous in this respect.

Gait analysis showed signs of insufficient rehabilitation persisting 8–12 months after high tibial osteotomy, with unimproved maximum gait velocity and reduced stride length at constant maximum velocity.

Rehabilitation with restitution of muscle torque was faster after unicompartmental arthroplasty and gait parameters did improve.

An "anatomical" type of unicompartmental prosthesis seems to be more susceptible to load, with changed strain elicited in external rotation compared to a meniscus bearing prosthesis.

Knees with medial arthrosis showed less rotation clinically during motion than healthy knees. The rotation was not significantly affected by a unicompartmental arthroplasty.

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Effects of seated whole body vibrations on the spine—an experimental study in man

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Exposure to whole body vibration is potentially harmful to the spine. Physiological effects in human subjects exposed to seated whole body vibration and to static sitting were studied by means of oxygen consumption, electromyography and creep measurement techniques.

A vibration exciter was used for generating sinusoidal input acceleration. The frequency and amplitude chosen for these experiments were 5 Hz and 0.1 g and 0.2 g RMS. Oxygen consumption was measured by means of the "Oxylog", a portable instrument, that is capable of directly measuring the oxygen consumed. Surface electrodes were used to measure muscular activity and muscular fatigue in the erector spinae muscles during sinusoidal whole body vibration and static sitting. Spinal height change was measured means of a linear displacement transducer. Segmental creep was studied invasively of means of a special intervertebral motion device (IMD), that measured relative motion between two adjacent vertebrae.

Vibration exposure caused statistically significant increase in oxygen uptake and a faster development of muscular fatigue than when vibration was not present. Sinusoidal vibration also caused significantly more height loss in the seated subject than did static sitting. Backrest inclination had only a minor influence on the effect of vibration.

It was demonstrated that creep behavior as measured by spine height change was influenced by age. Female subjects of 60–65 years of age lost significantly more height than younger female subjects. The IMD device demonstrated intervertebral creep during exposure to static sitting.

It can be concluded that whole body vibration added load to the seated human spine, as was demonstrated through the development of muscular fatigue and increased rate of height loss. This might be of great practical importance, since professional vehicle operators are exposed to harmful vibrations during extended periods of time, combined with prolonged sitting. These effects might lead to lesser ability to withstand other larger loadings on the spine for instance from lifting and prolonged static strained postures.

Preventional approaches should be aimed at proper ergonomic design of the driving work place, the use of vibration attenuating seats, and time limits for exposure to vibration.

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Femoral neck fracture stability

Evaluation with roentgen stereophotogrammetric analysis, magnetic resonance imaging, scintimetry, radiography and histopathology

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In spite of the multitude of internal devices developed in the past 60 years for treating femoral neck fractures, the knowledge of the fracture stability in vivo is limited.Sixty-one femoral neck fractures treated with internal fixation were studied.

Postoperatively ^{99m}TcMDP scintimetry and repeated radiographic and roentgen stereophotogrammetric analysis (RSA) were performed to study the femoral head vitality and fracture stability during the healing period. The RSA results in 60 of these fractures were compared with corresponding measurements (345 observations) from conventional radiographs (CR). The CR measurements were performed on a digitizing table (DT) and 174 pairs of these radiographs were also measured manually. CR tended to over- or underestimate the displacements up to about 2 mm (SD 3–5 mm). No interobserver difference was found. DT measurements were found to be more accurate than manual measurements.

Twenty-five fractures were studied with RSA immediately after the operation and before mobilization. Before weight-bearing the undisplaced fractures moved 0.5–2.4mm (total translation), which was about one third of the displacement recorded during the first month of weight-bearing. Corresponding values for the displaced fractures were lower when treated with screws (n =7, 0.3–3.5mm) than with hook-pins (n = 10, 0.9–8.7mm).

Ten undisplaced (7 hook-pinned, 3 screw fixated) and 46 displaced (26 hook-pinned, 7 plate and hook-pinned, 13 screw fixated) fractures were studied during the weight-bearing period. All but one of the undisplaced fractures stabilized within 6 months after fracture. The total translations at healing were 2.3 mm (median, hook-pin) and 4.5, 5.4 and 20.3 mm for the screws. The displaced and pinned fractures stabilized between 1–9 months after operation, whereas the screw fixated ones stabilized between 6-12 months. The translations in the displaced fractures were 9.7, 9.3, 13.1 mm (median values) for the three types of osteosynthesis. Fractures resulting in redisplacement or non-union displayed high values (median 23.4 mm). The greatest displacements in all fractures (healed and unhealed) occurred in the distal direction. Most healed fractures displayed forward or backward rotations and varus angulation. Rotations about the longitudinal axis (retroversion) were mainly recorded in displaced fractures. The magnitude of the screw-axis rotations in displaced fractures that subsequently healed did not differ between the three types of ostosynthesis. However, the screw axis was more often positioned inside the femoral head and/or neck when screw fixation had been used suggesting inferior durability of the holding power in the femoral head.

Fifteen fractures operated with screws were examined with serial low field magnetic resonance imaging (MRI). Signs of femoral head necrosis were found two weeks to fourteen months after fracture in six cases. Histological examination revealed correlation between the fracture area bridged by bone trabeculae and the amount of recorded displacements according to the RSA. In three of six fractures a healing complication could be forecasted based on the results of the isotope studies.

The pre- and the postreductional radiographs in 46 displaced fractures were scrutinized for factors considered to be of importance for fracture movements and healing. Adequacy of reduction and fracture comminution was found to negatively influence stability or healing.

Force transmission in the tibio-femoral contact complex

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The objective of this study is to increase the insight into the mechanical function of the joint elements in the tibio-femoral contact complex. The relevant joint elements are tibia, femur, cartilage layers, menisci and synovial fluid. The function of the single elements is affected by interaction with other elements. A stepwise modelling approach is adopted in which it is started with simple models. During every step, parameter studies are executed to investigate the function of the relevant components. Numerical analyses, based on the finite element method, are performed and validated by experiments on physical models.

The contact problem is defined by equilibrium conditions for the set of sub-systems and the appropriate contact conditions. Both contact conditions and contact forces are generally dependent on the positions and the deformation field of all the sub-systems in the problem. For the large sliding solid-solid interaction problem a formulation is worked out for which friction is assumed to be zero. The presented algorithm proves to be quite satisfactory for general contact problems.

An axisymmetric model has been utilized for the analysis of the force transmission between the tibia-meniscus-femur connection. The model assumes linear elastic material properties, static loading and frictionless sliding contact between the components. The study explores the effects of the tibial surface geometry, of the presence of soft layers on the bony components and of anisotropic properties of the meniscus. Studies with eight combinations of parameters have been performed starting from a simple reference model. The presence of articular layers and the circumferential stiffness the meniscus appeared to be very important for the load distribution.

The numerical formulation was extended in such a way that model components can be considered as mixtures of a solid and a fluid phase. Interaction between mixtures and interaction between mixtures and fluids can be described. In the model of the tibio-femoral contact complex the cartilage layer and the meniscus are considered as mixtures. These components interact with an ideal fluid, representing the synovia.

Frictionless sliding in the contacts between these sub-systems is allowed. The response of the model for a step change in the load was calculated. Investigations are performed concerning the effects of the permeability of surfaces and of different loading magnitudes. The load distribution in the model appears to change considerably in the course of time.

Spondylolisthesis in children and adolescents

A long-term clinical and radiographic study

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Two hundred and seventy-two children or adolescents with lumbar spondylolisthesis treated at the Orthopedic Hospital of the Invalid Foundation, Helsinki (190 treated operatively and 82 non-operatively) were clinically and radiographically re-examined 15 (5–32) years later on average. There were 134 female and 138 male patients. The fifth lumbar vertebra was affected in 97% of the cases. At admission the slip was on average 37% (5–138%). It was of isthmic type in 97% (95% spondylolyses and 2% elongation of the isthmus) and of dysplastic type in 3% of the cases. The operative treatment consisted of fusion in situ; in 62% using posterior, in 36% posterolateral and in 2% anterior technique, with or without dorsal decompression.

At follow-up, a slip that had progressed more than 10 percentage units was seen in 62 patients (23%), but on average, 90% of the final displacement had occurred already at the first radiographical examination. Spina bifida at the lumbosacral level and female gender were associated with severe slips, but they had no significant prognostic value for further progression. In age groups corresponding to the prepubertal growth spurt (in girls slightly earlier) there was a greater tendency of progression than in the other age groups. The only radiographic variable having predictive value for progression was the primary amount of the slip.

Fusion in situ of severe spondylolisthesis (50% or more) gave excellent or good clinical results in 82% of the 87 cases, and no major complications were seen. The occurrence of preoperative pain associated with the severity of lumbosacral kyphosis, but not with that of the slip. Secondary radiographic changes, such as sacroiliac arthrosis, kissing spinous processes and degeneration of the upper discs was noted at follow-up in the most severe kyphoses.

There was a female dominance in children under 12 years of age. Girls also had an earlier onset and more severe clinical symptoms, earlier worsening and a more severe slip than boys. This seemed to associate with the earlier onset of the prepubertal growth spurt in girls.

Posterior or posterolateral fusion of spondylolisthesis did not prevent the further progression when compared to the non-operatively treated patients. None of the conservatively treated patients were operated on later. Clinical long-term results were slightly better in the patients operatively treated, but not worse in the patients who refused the operation, than in the other patients treated conservatively. Spontaneous segmental stabilization during degeneration of the olisthetic disc also seemed to be part of the natural course of this spinal disorder.

The patients with scoliosis had a higher degree of lumbosacral kyphosis and more severe slip than the non-scoliotic group. Female sex and dysplastic changes (spina bifida) predominated in patients with scoliosis. Lumbar scoliosis, of both sciatic and torsional types, was mild and usually disappeared after lumbosacral fusion. Thoracic or thoracolumbar scolioses were not corrected by lumbosacral fusion. At follow-up, patients with remaining lumbar scoliosis had more back pain than those without any curve, and it seems that lumbosacral fusion must be considered before the lumbar curve becomes a structural scoliosis.

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Biocompatibility, biodegradation, fixation properties and strength retention of absorbable implants—an experimental study

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In experimental studies biocompatibility, biodegradation, fixation properties and strength retention of absorbable implants were evaluated. Histological, histomorphometric, microradiographic and oxytetracycline labelling studies revealed that the in situ polymerization of N-butyl-2-cyanoacrylate caused a narrow zone of bone necrosis or connective tissue depending on the interference of blood in the polymerization reaction.

Self-reinforced polyglycolic acid (SR-PGA) rods coated with polydioxanone (PDS), poly-beta-hydroxybutyric acid (PHBA), or poly-L-lactide (PLLA) showed good biocompatibility and sufficient properties in stabilizing cancellous bone osteotomies in rabbits. N-butyl-2-cyanoacrylate showed inferior tissue compatibility compared to the other coatings. The adhesion between the coatings and the SR-PGA core was insufficient for implantation into bone tissue. Coated SR-PGA rods coated were absorbed in 24–36 weeks.

A new method to evaluate the strength retention of absorbable osteosynthesis implants in the bone tissue was compared with in vitro hydrolysis and subcutaneous implantation. SR-PGA rods lost their strength only slightly faster in the medullary cavity than in the subcutis (5–6 weeks), whereas the strength retention time was considerably longer in distilled water at 37 °C (more than eight weeks). Subcutaneous implantation was found a sufficient method to evaluate the strength retention of absorbable implants, as the removal of the implant from the medullary cavity without damaging it became difficult 5–6 weeks after implantation. PDS, PHBA, and PLLA coatings were able to improve the initial shear strength and the in vitro strength retention of self-reinforced PGA rods. SR-PGA rods with a sintered PGA coating showed initial bending and shear strength values 1.1–4.2 times as high as those of cortical bone and 13–28 times as high as the shear strength of cancellous bone. The bending modulus of the SR-PGA rods was very close to that of cortical bone. The rods with diameters of 1.5 and 2.0 mm lost their strength in 4–5 weeks, and the rods with diameters of 3.2 and 4.5 mm lost their strength in 6–8 weeks, which is sufficient for the fixation of cancellous bone fractures that are not exposed to hard mechanical stresses.

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The unsolved fracture

A prospective study of 224 consecutive cases with an intracapsular hip fracture

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Throughout the last decades the intracapsular fracture of the hip has been called "the unsolved fracture" because of the many problems arising in its treatment. When osteosynthesis is carried out as treatment of choice, the high incidence of non-union (NU) and femoral head necrosis (FHN) forms a serious problem. The use of an endoprosthesis is not ideal either as high mortality rates and high reintervention rates are frequently reported.

In a prospective study the method of treatment was chosen according to age, type of fracture and degree of independence. Patients with dislocated fractures aged 71 to 80 years and a very good degree of independence were selected for a randomised trial comparing dynamic hip screw/plate, DHS, with primary hemiaarthoplasty. Early 99mTc-MDP scintimetry was carried out within 72 hours after admission to study the predictive value with regard to FHN, DU and NU.

The results of conservative functional treatment in 43 patients with an impacted intracapsular hip fracture were excellent in patients aged 70 or younger. In elderly patients the incidence of failure was significantly higher, but secondary endoprosthetic replacement led to good results, without additional risk. Patients treated by osteosynthesis with the DHS-device (n=60) with early weight-bearing had excellent results in non- or little displaced fractures in all age-groups. In patients aged 70 or younger with Garden type III or IV fractures results were good. The most serious problem was to achieve optimal reduction and adequate fixation. In elderly patients treated with primary hemiarthroplasty (n=81) clinical morbidity was high with an acceptable early mortality rate. The results were acceptable. The randomised trial DHS (n=21) versus HA (n=22) showed a shorter operation time and less perioperative bloodloss in favour of the DHS-group, but significantly more inadequate reduction and fixation was seen compared to endoprosthetic replacement. With osteosynthesis, less morbidity occurred during the admission period. This did not result in shorter hospitalization or a lower mortality rate. Early and late survival were similar with both methods of treatment. The end-results and rate of reintervention were similar for both methods of treatment.

Scintimetry formed a useful tool in predicting poor outcome due to FHN and/or NU in the treatment of intracapsular hip fractures. Late investigations performed at 2 and 12 weeks were inferior to the results of early scintimetry. Scintimetric follow-up showed that the major injury to the vascularisation of the femoral head is inflicted at the moment of the initial trauma, while no additional damage occurs perioperatively due to closed reduction and DHS osteosynthesis. The possibility to predict a poor outcome due to FHN or NU by scintimetry should lead to a more selective policy in the treatment of intracapsular hip fractures.