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Osseointegration in porous coated knee arthroplasty—the sheep stifle joint as in vivo evaluation model

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Although cementless knee arthroplasty is a commonly performed procedure, very little is known about the process of osseointegration of uncemented knee arthroplasty components. The purpose of this work was to study in an in vivo situation the osseointegration of knee arthroplasty components covered with a newly developed mesh coating, with and without an additional hydroxyapatite coating, compared to knee arthroplasty components with a conventional multilayer beads coating, and to study the relationship between histomorphometric parameters, clinical and functional performance, mechanical fixation strength and RSA migration over time in uncemented knee arthroplasty.

The sheep stifle joint was developed as an animal model for this purpose. Its anatomy, kinematic and biomechanic behaviour was analysed and a knee prosthesis, surgical technique and perioperative protocol was developed. The developed knee prosthesis was implanted into the stifle joint of 40 adult Suffolk sheep. In group 1, a tibial component with a newly developed cast mesh porous coating was used, in group 2 the same cast mesh coating with an additional hydroxyapatite coating, and in group 3 a multilayer beads porous coating. Evaluation at 3 months, 6 months, 1 year and 2 years included clinical and functional score assessment, routine radiographic analysis and RSA migration analysis, with non-destructive mechanical testing of the implant fixation in the six degrees of freedom, and subsequent histologic, histomorphometric, and contact radiographic analysis after sacrifice.

No significant differences were noted in clinical and functional score or radiographic assessment between the 3 groups at any stage. The average amount

of bone ongrowth and bone ingrowth in group 2 was, however, significantly higher than in group 1 and 3. The average fibrous ongrowth and ingrowth was significantly smaller in group 2 than in group 1 and 3. Post mortem mechanical tests showed significantly more stable implants in group 2 than in group 1 and 3. RSA migration of the components was significantly lower in group 2 at 1 year and between 18 months and 24 months. Regression analysis showed strong positive correlations between bone on / ingrowth and stability on mechanical testing, and strong negative correlation between fibrous on / ingrowth and stability on mechanical testing. Significant negative correlations were also seen between RSA migration and bone on / ingrowth, together with significant positive correlations between RSA migration and fibrous on / ingrowth. Significant positive correlations were also noted between RSA migration and mechanical fixation stiffness. No significant correlations were noted, however, between clinical score and any of the tested histomorphometric parameters, mechanical fixation strength, or RSA migration. Progressive desintegration of the hydroxyapatite layer was seen in group 2, becoming substantial at 6 months, with total disappearance of the hydroxyapatite layer at 2 years.

It is in summary concluded from this work that substantial osseointegration occurs in hydroxyapatite coated cast mesh coated knee arthroplasties, but not in the same mesh without hydroxyapatite, nor in multilayer beads coated components. It is also concluded that osseointegration correlates with a more stable implant on mechanical testing and on RSA migration analysis, but not with clinical and functional performance.

Destruction and reconstruction of peripheral joints in rheumatoid arthritis—a prospective 20-year study

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Radiographically observed destruction and surgical treatment of hand, forefoot and hindfoot joints were evaluated in 103 patients with recent (≤ 6 months) seropositive rheumatoid arthritis (RA) in prospective follow-up studies at onset and at 1, 3, 8, 15 and 20 years from entry. A total of 83 patients attended the 15-year follow-up, and 68 the 20-year follow-up. Destruction of the joints was assigned by the Larsen method, and the modified Larsen grades were applied for the CMC I joint. In end-point analysis the last or preoperative radiograph was used. Data on treatments were obtained from radiographs and patient documents.

The wrist joint was most severely affected of the hand joints at the end point (mean Larsen grade 2.7), and had a high operation rate (38 total wrist fusions during the follow-up), demonstrating the key importance of the wrist for the whole-hand function. MCP II showed the highest grade of destruction of finger joints (mean Larsen grade 2.2) and MCP I and IV lowest. The mean Larsen grades for PIP joints (0.7–1.0) were lower than those of MCP joints. Reconstructive surgery of hand joints was performed on 40% of patients during the follow-up.

Destruction of CMC I joint did not proceed uniformly with destruction of the entire carpus. The difference was highly significant after 3 years, and later during the follow-up, when comparing the wrist with the ipsilateral CMC I joint. The radiographically manifest destruction of CMC I was significantly higher in hands with wrist fusion compared with unoperated control hands after a follow-up period of 2–6 (mean 4.4) years. Only one arthroplasty was performed for the CMC I joint during the follow-up, although significant deterioration and deformities were present in nearly 30% of the hands. The progression

of the angle between the first metacarpal and proximal phalanx (MCP-I angle) was used in the evaluation of thumb deformities, and a new grading was developed based on the MCP-I angle measurement. The normal value for the MCP-I angle was estimated to be 10–20°. The MCP-I angle in grade-1 boutonnière varied from 20–40° and in grade-2 $> 40^\circ$, while in grade-1 swan-neck it varied from 0–10°; in grade-2 the angles were all negative. At the 20-year follow-up, 39% of thumbs were of the boutonnière type and 30% of the swan-neck type.

Of the forefoot joints, erosiveness was present in 6% of the 1,236 joints investigated at onset, while at the end point 62% of the joints were erosive and 24% showed severe destruction. MTP I and IP joints showed the lowest and MTP V the highest grade (mean Larsen 2.8 at end point) of destruction during the follow-up. MTP synovectomies were performed on 24 joints; a total of 75% of these joints were later resected. MTP II–V resections were performed on 21% and the Keller procedure on 12% of MTP I joints.

At the 20-year follow up, destruction of the subtalar joint complex was relatively slight (mean Larsen grade 1.3, median 0). Subtalar fusions were performed in 12 patients only during the follow-up, spontaneous fusions occurred in 5 hindfeet. At the 20-year follow-up 77 subtalar joints were still assigned a Larsen grade of 0.

Seropositive RA is a severe, continuously active disease, in which the need for surgical treatment may accumulate, especially if conservative treatment is not sufficiently immunosuppressive. A total of 311 reconstructions were performed for hand, forefoot and hindfoot joints in this cohort during the follow-up period.

Quantification of skeletal, muscular and kinematics parameters in scoliosis—methodological and clinical studies

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This dissertation presents new methods derived for precise evaluation of a number of anatomical and functional variables of the complex thoracospinal deformity in scoliosis.

By consensus the scoliotic angle at the frontal plane is measured on radiographs using the Cobb method. Another way of measuring this angle, the Ferguson method, although evidently more accurate than the Cobb, is not in use. The Cobb method uses only the declination of the upper and the lower vertebra of the curve to measure the degree of the curve. The Ferguson method uses the centroid of these two vertebrae and of the apical one to define the angle. In a derived new method the geometrical, i.e., the true, centre of the three vertebrae is defined on antero-posterior radiographs of the spine to delineate the scoliotic angle. Comparison of the measurements by the three methods in three groups of radiographs with different degrees of scoliosis shows that the new method gives higher accuracy and better repeatability than the two other methods.

Studies on the vertebral growth under normal and pathological conditions are based on measurements of the vertebral height at different points of interest on radiographs, since there is no method for evaluation of the vertebral volume. A new stereological method is presented which allows estimation of the vertebral volume in vivo. The volume of one isolated normal and one scoliotic vertebra was measured in a model study using frontal and lateral radiographs and one CT-scan of each. The height of the vertebrae was measured at five points on the radiographs and was expressed as weighted circumferential height. Then the area of the vertebral body was measured using a grid on the CT-scan of the vertebra and the volume was calculated using the Cavalieri method. The accuracy of the measurements with the new method was high compared with serial CT-scans of the whole vertebra. The applicability of the method was evaluated in a series of scoliotic patients who had undergone posterior spinal instrumentation and fusion. The results showed that the weighted circumferential height

of the three vertebrae had increased significantly at the last follow up on average 3 years after the operation. Also the volume of the apical vertebra was found to have increased, though not significantly. It is concluded that the proposed method provides accurate evaluation of vertebral body volume changes.

The role of the intercostal muscles in the development of the thoracospinal deformity in scoliosis and of the respiratory movements of the thoracic cage is well recognized, but poorly studied because of lack of an accurate method for measurement of the surface area of the muscles and hence, indirectly, their function. In a model study the surface area of the intercostal muscles was evaluated in ultrasonographs and CT-scans by measurement of the area of their image either from the perpendiculars or by tracing. In both cases measurements of the surface area from the perpendiculars gave more accurate results than by tracing. The applicability of the method was tested in one healthy person during maximal inhalation and exhalation and no significant difference was found between the left and the right side during maximal inhalation or at full exhalation nor between full inhalation and exhalation for either side,

To investigate if quantitative whole body movement analysis is a suitable method for motor control research, a model study was developed to evaluate the kinematics of different spinal segments and of shoulder-link and pelvis displacement. Fourteen girls participated in the study; eight with right convex adolescent idiopathic scoliosis and six age-matched normal controls. The subjects were asked to stand on two force plates, and seventeen passive reflective markers were attached to certain anatomical landmarks on the dorsal aspect of their body. Six surface EMG electrodes were attached to the paraspinal and hip abductor muscles. The subjects were instructed to perform standardized voluntary trunk rotation and side bending to the left and right side. Simultaneous recording of the displacement of the markers with signals from plate forms recording the ground reaction force and the muscle activity was

done. The results showed that the scoliotic group had a different way and strategy for orientation of different spinal segments displacement during voluntary trunk movements with a significant difference in the amplitude of the displacement of the centre of mass during side bending and during rotation of the trunk, compared with the control group. The resulting horizontal shear forces showed a significant difference between the two groups during side bending of the trunk, which was not the same during trunk rotation.

The EMG study of the recorded activities from the paraspinal muscles and hip abductor muscles showed a different patterns and large variability between subjects and between the trials of each subject. In conclusion, this type of investigation helps to understand better the co-ordination of different body segments during voluntary movements and provides an adequate tool for investigation of spine movements and other trunk movements in normal as well as in scoliotic subjects.

ISBN 91-628-3103-8

Clinical examination and follow-up after scalenotomy for thoracic outlet syndrome

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The purpose of this study was to evaluate the consequences of thoracic outlet syndrome (TOS). The following questions received special consideration: What are the predictive factors and long-term results of primary scalenotomy? What is the physical performance capacity and handicap after primary scalenotomy? What is the cardiovascular function level among patients with TOS, tension neck, and controls? What is the prevalence of surgery for TOS in Finland?

Results and conclusions. At the follow-up, mean 4.1 (2–11) years) after scalenotomy, about one third of the 107 patient (86 women and 21 men; mean age at surgery 42 years) considered themselves considerably better and one-third better than before surgery. More than one-half of the patients still had pain at rest, numbness, lack of power, and pain in exertion. Only 28% estimated their pain being low or very low (VAS < 20). Pain affected especially working with hands overhead. Retirement increased from 6% at the time of scalenotomy to 33% at the follow-up, being highest among those over 45 years at surgery and among factory workers.

Beside their scalenotomy, 52 patients (49%) had undergone 78 other operations on the shoulder or upper limb. Active cervical flexion-extension among women, as well as active humeral forward flexion and abduction on the operated side among men and women were all below reference values. Most of the functional tests among women correlated highly significantly with perceived disability.

Increased resting heart rate was found in TOS (11 women) and in tension neck (12 women). The TOS patients showed abnormally high sympathetic activity under orthostatic stress. Tachycardia-bradycardia oscillation early during the orthostatic test found in TOS and tension neck may reflect altered cortical response, increased sympathetic tone, diminished parasympathetic inhibition. Blood pressure responses in the hand-grip test were attenuated among the TOS and tension neck patients which may reflect avoidance of muscular work with the upper limbs or

be a sign of a vasoconstrictive disorder. Both the TOS and tension neck patients suffered significantly more distress than did the control group measured with MSPQ (Modified Somatic Perception Questionnaire). Pain measured with VAS correlated with MSPQ. Noninvasive cardiorespiratory studies are recommended for assessing autonomic nervous system balance. Conservative treatment should also be aimed at endurance training and stress management. During the years 1987 to 1993 the total number of surgical procedures for patients with a TOS-diagnosis was 465 for 446 patients, yearly on average 66 operations for 64 persons. First rib resections (53, annually 7.2, 1.06 per 100,000 inhabitants) were done significantly ($p=0.001$) more often than scale-notomies (13, 1.9; 0.26, respectively). The proportion of scalenotomies became less at the end of the study period. The diagnosis before surgery was TOS with lesion of the brachial plexus in 55% of the cases, ITOS with compression of the subclavian artery 17%, TOS with venous compression in 6%, and TOS not more closely defined 22%. During the same years, 36 first-rib resections were done for the patients with a cervical rib diagnosis; 3 also had an arterial TOS diagnosis, and an undefined TOS diagnosis. The high proportion of the diagnosis of "undefined" TOS shows clearly the need to define the TOS diagnosis more accurately. As long as exact diagnostic criteria are lacking, the division of TOS into subgroups will be arbitrary. A diagnostic division into true neurogenic, arterial, and venous TOS, is recommended.

No serious complications were experienced in the present series. Our results of scalenotomy were comparable with those for first-rib resection of Scandinavian series as assessed by an unbiased examiner. The results were not satisfactory for a large proportion of our TOS patients. TOS is a major risk for losing working ability, which makes it important to analyze the disability of the patients carefully and to consider their need for vocational rehabilitation.

The patient with unilateral transtibial amputation for vascular disease—functional assessments, prognostic factors and cost of prostheses

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The aims of the study were to focus on the functional ability of the dysvascular patient with unilateral transtibial amputation and the early rehabilitation period, defined here as the period between the amputation and the prosthetic fitting.

Results revealed the standing balance and the gait performance of the dysvascular amputees to be significantly inferior to that of the trauma amputees and healthy controls. The mortality rate six months after the amputation was 33% and after eight years 92%. Six months after the amputation half of the patients were fitted and half of these were prosthetic walkers. Within one year 63% of the patients had been fitted with a prosthesis. Half of the dysvascular amputees were 80 years or older and half of these were fitted, compared to three quarters of those younger. Within six months after the amputation 62% of the patients were able to return to their own homes.

Each patient received a median of one prosthesis and one additional socket. The median cost for prostheses, additional sockets and maintenance was USD 1,582 per patient. The costs of prostheses on average corresponded to 6% of the costs of hospitalization and surgery. No significant difference in the costs between patients with poor or good prosthetic function was revealed.

It appeared to be an advantage to be amputated on the left leg if the patient had been able to walk alone outdoors before the amputation and was not using a wheelchair. Three times as many men as women were found in the group that had good function with the prosthesis. The prognostic factor was ability to walk alone outdoors before the amputation.

The majority of the patients were dependent on another person one week after the amputation, at discharge from the hospital and six months after the amputation. The Katz Index of ADL on days 5–7 after the amputation may be useful in identifying those patients who will probably survive the first month post-operatively and who will be discharged to their own homes. The translated and slightly modified version of the FRSA-scale seemed to be an appropriate instrument for assessing functional ability in dysvascular amputees, with or without a prosthesis at discharge from hospital, and throughout their lives.

Training of balance and gait in the dysvascular patient after the amputation seems to be important for prosthetic rehabilitation and choice of future residence for the patient. Further studies will elucidate whether training before the amputation, especially in women, will result in increased independence with or without prosthesis.

ISBN 91-628-3261-1

Fractures of the tibial plateau

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The aims of this study were to evaluate the replacement tendency of tibial plateau fractures during healing period, to evaluate radiological, subjective, clinical and functional long-term results, and to outline a classification and treatment.

131 consecutive tibial plateau fractures were evaluated after a follow-up of 7.6 (3.3–13.4) years. Three different evaluation methods were used. In 34 patients, the Knee Signature System was utilised to determine sagittal laxity of the knee joint. In 37 patients, the Cybex system was used to determine isokinetic thigh muscle performance.

In women, the fracture incidence increased with age. In men the peak occurred at the age of 40 years. In 76 surgically treated fractures, associated meniscus or ligament injury was found in 38 and 8 knees, respectively.

During the healing period, lateral tilting of the plateau increased 3° or more in 7 of 84 (8%) unicondylar and bicondylar fractures with an initially lateral tilt, while the medial tilting increased in 12 of 28 (43%) initially medially tilted uni- or bicondylar fractures. Osteoporosis increased the displacement tendency. Residual lateral tilt of the plateau by 10° was well tolerated both subjectively and functionally, but the results deteriorated rapidly with increasing values of the medial tilt. Medially tilted bicondylar fractures carried the poorest prognosis. Articular step-off of up to 3 mm was well tolerated. Condylar widening had no prognostic value. Acceptable functional results according to Rasmussen were found in over 80%, which

gave a false impression of these fractures. With the method of Hohl and Luck and with our method only 60% of the patients obtained an acceptable function.

Secondary arthrosis was found in 44% of the cases. When a meniscus was removed the percentage was 74%. Meniscectomy in connection with residual malalignment of the plateau increased the percentage up to 90%.

The Knee Signature System revealed a side-to-side difference of 3 mm or more in 13 of 34 cases. Because changes in bony configuration did not affect the result, the laxity was felt to be a consequence of stretching of the ligaments. The Cybex test for quadriceps showed, that the mean strength deficit of the injured knees was 15% correlating well with the radiological and functional results.

The new division of the bicondylar fractures in medially tilted, laterally tilted, and axial fractures, which is an extension of the Schatzker classification, reflects both the mechanism and prognosis of the injuries. Displaced medial condylar and medially tilted bicondylar fractures should always be reduced and fixed with a buttress plate. If the lateral plateau tilts less than 5° or if there is a step-off less than 3mm, conservative treatment may be justified. In osteoporotic fractures, a cortical bone block may give a better support than cancellous grafts. Menisci should not be removed. Postoperatively, early motion of the knee joint and active thigh muscle exercises should be started immediately. Full weight bearing is allowed after fracture healing and bone graft incorporation.

Magnetic resonance and nuclear medicine imaging in bone and soft-tissue infections

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The aim of this study was to investigate the value of MRI and scintigraphy based on labeling techniques in the evaluation of focal infectious diseases. In particular, answers were sought to the following questions: What is the value of ultra low-field (0.02T) MRI in the diagnosis of soft-tissue and bone infections? What is the value of ultra low- and low-field (0.1T) MRI for the assessment of therapeutic response in soft-tissue and bone infections? What is the value of MRI (1.0T) in the differentiation between spinal infection and malignant disease? What is the ability of ^{99m}Tc -hexamethylpropylenamine oxine (HMPAO)-labeled leukocytes and ^{99m}Tc -human polyclonal immunoglobulin G (HIG) to detect focal purulent infection? What is the diagnostic accuracy of low-field MRI and ^{99m}Tc -HMPAO-labeled leukocytes in complicated bone and soft-tissue infections, what is the value of combined imaging; and in which situations each of them should be used?

Results and conclusions. Acute musculoskeletal infections verified otherwise could be, detected by 0.02T MRI. The sensitivity was poor in chronic osteomyelitis.

There was a strong positive correlation between the signal intensity on transversal relaxation time weighted (T_2w) images and both serum C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR). The signal intensity between the follow-up studies decreased significantly in accordance with clinical reconstitution. The MRI finding according to the signal intensity on T_2w images corresponded better to the actual disease activity than did CRP or ESR.

Spinal infections involved 1 to 4 vertebrae, usually 2 (23/28). The intervertebral disc between the infected vertebrae was involved in 26/28 patients and 21/28 had a paravertebral mass. Spinal malignancies affected the vertebrae alone in 19 patients and paravertebral extension was found in 21/40 patients. The interverte-

bral disk was involved only in one patient with malignancy. The differences in the distribution of the MRI findings between spinal infection and malignancy were highly significant ($p < 0.001$). The highest signal intensity of the infectious lesions on T_2w images was equal or higher than that of the cerebrospinal fluid in 26/28 patients. In contrast, the signal intensity of the malignant lesions in 29/40 patients was low as compared with the CSF ($p < 0.001$).

The sensitivity and specificity of imaging with labeled leukocytes were 84% and 100%, respectively, and with labeled HIG 58% and 82%, respectively. The overall accuracy of the leukocyte scan was significantly better than that of the HIG scan (90% vs 67%, $p < 0.001$). There were no cases exhibiting a better imaging result with ^{99m}Tc -HIG scintigraphy than with ^{99m}Tc -labeled leukocytes. The sensitivity of MRI for osteomyelitis was 100% (12/12) and that of scintigraphy 42% (5/12), ($p < 0.01$). The specificity of MRI and scintigraphy for osteomyelitis were 81% (22/27) and 93% (25/27), respectively. The sensitivity of MRI for soft-tissue infection was 96% (26/27) and specificity 75% (9/12). The corresponding figures for scintigraphy were 85% (23/27) and 100% (12/12). MRI and scintigraphy were concordant with respect to the final diagnosis in 28 (72%) sites and discordant in 10 (26%) of 39 sites.

Conclusion. MRI is a useful method in the detection and follow-up of bone and soft-tissue infections. It is a valuable adjunct for differentiating spinal infection from malignancy. Combined imaging with MRI and labeled leukocytes is recommended in diagnostically complicated bone infections of the appendicular skeleton. Concordant positive findings are highly suggestive of infection whereas concordant negative results exclude infection. For the detection of an infectious lesion of the axial skeleton, especially the spine, the preferable method is MRI.

Absorbable self-reinforced poly-L-lactide wires, screws, and rods in the fixation of fractures and arthrodeses, and mini tacks in the fixation of ligament ruptures

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The aims of the present study was to study the use of absorbable poly-l-lactide wires, screws, and rods were used in the fixation of fractures and arthrodeses, and mini tacks in the fixation of ligament ruptures, to analyse the bone mineral density of operatively treated injuries, and to compare the total costs of absorbable and metallic fixation.

401 patients were operated on between 1989 and 1994. 35 patients with olecranon or patella fracture were randomized for operation using either absorbable or metallic implants. The overall results in both fixation groups were good, and the outcome was similar in regard to the fixation method. The bone mineral density after operative ankle fracture treatment in 39 patients was significantly higher ($p < 0.026$) in the distal tibia metaphysis after polyglycolide screw than after metallic fixation.

140 patients with a rupture of the ulnar collateral ligament rupture of the thumb were operated on using a poly-l-lactide mini tack. 118 of them (84%) gained full range of motion of the mp-joint. 5 reoperations were made as follows: scar pain - 1, local infection - 1, instability 1, loosening of the tack - 2. The study showed that the implant is suitable for this indication, and the results were comparable to studies, where other fixation methods were used.

53 arthrodeses were done in 47 patients with rheumatoid arthritis to relieve articular pain and to correct joint malposition using absorbable poly-l-lactide implants. There were 3 superficial infections (1 in the wrist, and 2 in the talocrural joint) and 2 non-unions (both in the talocrural joint). In every group the results were otherwise uneventful. The results were favorable and did not differ from the results obtained in other studies using metallic implants. The study shows that absorbable implants are an alternative for the fixation of arthrodesis in rheumatoid arthritis.

An economical audit was made on ankle fractures treated operatively using 3 different fixation materials - polyglycolide, poly-L-lactide and metal. The average cost of an ankle fracture fixed with polyglycolide was FIM 24 279, in the polylactide group it was FIM 27 072 and in the metallic group FIM 31 217.

According to the present study, absorbable fixation devices are a good option for operative treatment of certain fractures and ligament ruptures, and for arthrodesis in rheumatoid arthritis. Removal of the fixation material is unnecessary, and the patient does not have irritation because of metallic implants. From the economic point of view the use of absorbable fixation devices seems to be profitable.

Quantitative microscopy of proteoglycans and collagen in articular cartilage

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This study was undertaken to investigate the effects of unconfined mechanical loading on articular cartilage plugs *in vitro*. Special attention was paid to the responses of the collagen fibril network and proteoglycans (PGs) of the cartilage extracellular matrix. Collagen and proteoglycans are known to play a major role in determining the biomechanical properties of cartilage ECM. It is also these constituents of cartilage which break down already in early arthrosis. Methods were refined for histological specimen fixation and processing to ensure PG preservation in the tissue sections for microspectrophotometric determination of local PG concentration and to assess by quantitative polarized light microscopy from unstained sections the optical path retardation due to the collagen fibril network.

During histological sample processing, formaldehyde fixation and EDTA decalcification, a loss of about 10% of glycosaminoglycans (GAGs) of cartilage cubes was observed. The loss was reduced to 3.4% when cationic dye Safranin O was included in the fixative. Safranin O proved to be the dye of choice for GAG quantitation with the microspectrophotometer. Thionin was also another excellent GAG stain. Cuprolinic Blue and Cupromeronic Blue, combined with the critical electrolyte concentration-technique, were also useful stains provided that the staining did not show metachromasia. Pretreatment for the processing of unstained cartilage sections for polarized light microscopic analysis was devised. This made it

unnecessary to use Sirius Red staining, which appeared not to bind stoichiometrically to cartilage collagen in sections. A short, 3x5 min xylene treatment proved to be sufficient to completely remove the birefringent paraffin from tissue sections. Since cartilage PGs are orderly arranged and birefringent, they were removed from tissue sections by a 24 h hyaluronidase treatment. The pretreatment also highlights the importance of using a mounting medium with a refractive index as close as possible to that of collagen. The contribution of the PGs to the total birefringence of articular cartilage was shown to be about 6%.

Unconfined 4.1 MPa cyclic (0.5 Hz) *in vitro* loading of articular cartilage plugs caused condensation of the tissue. Sections of the loaded cartilage showed a decrease in thickness of the deep zone at the same time as the superficial and intermediate zones gained in thickness. This was consistent with the polarized light microscopic findings of increased birefringence in the superficial zone and decreased birefringence in the deep zone of cartilage. In the cartilage plugs, PG synthesis and concentration of GAGs increased after cyclic loading at 4 hours, but the stimulatory effect had disappeared at 8 h and, after 20 h, an inhibitory effect in the superficial zone was observed. The microspectrophotometric quantitation of PGs (GAGS) and quantitative polarized light microscopy of collagen network proved to be reliable quantitative tools in detecting subtle structural changes of the articular cartilage in response to mechanical loading.

Absorbable self-reinforced poly-L-lactide plates in the fixation of osteotomies of the distal femur—an experimental study

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The designs and assembling principles of metal implants are not necessary to transfer to absorbable materials. Devices adjusted to specific therapeutic problems and adapted to the characteristic properties of absorbable polymers have to be developed. This can be seen from the good results gained with meniscal arrows, expansion plugs, and tacks. The same concerns the idea of intraosseal plating which arose not until absorbable implants.

The purpose of the present study was to experimentally investigate the ability of ultra-thin self-reinforced poly-L-lactide plates in the fixation of osteotomies in weight-bearing cancellous bone in rabbits. Due to former reported tissue responses and to study a totally new fixation method, the effect of the site of implantation had a special reference, as absorbable plates need no removal. The mechanical properties of former compression-moulded poly-L-lactide screws were satisfactory but not optimal. If screws manufactured by the old compression-moulding method had been used, it would have led to a breakdown of the screws. Especially the torsional forces would have been critical when introducing these small screws in the bone, and the ability of the plates to fix the osteotomy could not have been studied. So, to ensure the fixation, the plates in the present study were fixed with metal screws. However, if absorbable plates are used, it is natural to use absorbable screws, too. Therefore also the manufacturing method of the screws needed further investigations. As in different plating methods, the site and depth of implantation as well as the absorbable material itself affect the tissue responses; therefore these were also investigated in the present study. To have a series large enough, to make the operative procedure as simple as possible, and to keep the costs down, self-reinforced poly-L-lactide and polyglycolide pins and rats were used in the tissue response studies.

Osteotomies of the distal femur were fixed by intraosseous ultra-thin self-reinforced poly-L-lactic acid (SR-PLLA) plates in 29 adult rabbits. The follow-up times were three, six, 12, and 24 weeks. The analyses of specimens were done by macroscopic appearance,

radiology, histology, microradiography, and the fluoro-chromo technique. Although no redisplacements were found radiographically, at 12 weeks two fixations were broken and a fibrotic non-union was observed in one case. At 24 weeks full bone consolidation was seen in all except one osteotomy medially. No foreign-body reactions were observed. A totally new fixation method was created, and SR-PLLA plates proved suitable for the fixation of the distal femoral osteotomies in rabbits.

Distal femur cancellous bone osteotomies in 23 adult rabbits were fixed with two self-reinforced poly-L-lactic acid (SR-PLLA) plates on each side of the femur, and metallic screws were placed through the plates. The follow-up times were from three up to 24 weeks. After killing macroscopic appearance, radiological, histological, microradiographical, and fluoro-chromo technique studies were performed. Except for one histologically confirmed fibrotic non-union at 24 weeks, the osteotomies healed, including a rabbit which had an ipsilateral femoral shaft fracture of an unknown cause. The macroscopically detected swelling was a normal postoperative reaction and no malformations were observed. The present study showed the ability of the SR-PLLA plates implanted on both sides of the bone to fix of weight-bearing cancellous bone osteotomies in rabbits.

Osteotomies of the distal femoral cancellous bone in 20 adult rabbits were fixed intraosseally with two self-reinforced poly-L-lactic acid (SR-PLLA) plates and four metallic screws and in 20 adult rabbits with identical plates fixed on both sides of the bone with four metallic screws. The follow-up times were from three up to 24 weeks. Histomorphometry was used to evaluate the amount of trabecular bone at the osteotomy site. In both groups and after each follow-up time greater trabecular bone percentage values were noticed on the operated sides. The amount of bone was greatest near the plates and particularly strong between the plates in intraosseal plating. Intraosseally implanted SR-PLLA plates do not seem to diminish the amount of trabecular bone as compared to similar plates on the bone.

In vitro and *in vivo* studies on 22 rabbits from three up to 26 weeks were done to solve the effect of the manufacturing method on the strength retention of self-reinforced poly-L-lactide (SR-PLLA) screws. The SR-PLLA screws were manufactured from axially oriented SR-PLLA billets with a new machine-cutting technique and by the conventional compression-moulding process. The new machined SR-PLLA screws (thread diameters 4.5 mm and 3.5 mm) were significantly stronger than the older compression-moulded SR-PLLA screws (4.5 mm and 3.5 mm) in the bending and torque strength tests. The values remained acceptable despite the significantly weaker results in the shear strength tests. In the pull-out tests there were no significant strength differences between the screws. The mechanical analysis and molecular weight measurements confirmed earlier observations that SR-PLLA degrades faster *in vivo* than *in vitro*. These results showed that the new screws are suitable for clinical use.

Self-reinforced poly-L-lactide (SR-PLLA) and self-reinforced polyglycolide (SR-PGA) pins were implanted intra-articularly and directly in the bone of the distal femur of 128 rats on three levels: above, on the same level, and under the surface. The controls were not operated at all or only channels were drilled. Altogether 152 rats were examined. The follow-up times were three, six, and 12 weeks for SR-PGA and

for SR-PLLA three, six, 12, and 24 weeks. The macroscopic appearance and histologically the villus reaction, the giant cells, the mononuclear phagocytosis, the neutrophils, the lymphocytes, the plasma cells, the eosinophils, and the mast cells were analyzed. In the histologic analysis the most favourable implantation depth was found under the surface where the contact between the implants and bone was best and the orifice was covered with new trabecular bone at three weeks. The tissue responses were mild in general and can also be explained in the statistical analysis by normal postoperative tissue response and faster biodegradation of polyglycolide.

To conclude, it seems that intraosseal plating and plates on both sides of the bone are suitable for fixation of weight-bearing cancellous bone osteotomies in rabbits. There is a continuous development going on in this research area as seen in the improvement of the strength properties of the SR-PLLA screws. In general, when absorbable SR-PGA and SR-PLLA devices are used, they are recommended to be implanted under the surface, if possible. The tissue response studies were done in rats, but, as in medical research in general, in spite of the low phylogenetic nature of the rat, the results can be extrapolated to humans regarding that there is a need for thorough observation of possible reactions within the degradation processes of absorbable implants.

Management of tibial shaft fractures—factors influencing the results of treatment

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Six patients each with a solitary, closed tibial shaft fracture treated conservatively were studied using MRI. With moderately T2-weighted imaging, there was a decrease in signal intensity in the intramedullary cavity. No return of signal intensity to the high level of the intact tibia emerged during three months following the injury. In the soft tissues around the fracture, the signal intensity was at first evenly high. Later, a granular pattern of low-intensity nodules appeared. On radiographs, mineralization of the callus could not be seen until several weeks later.

Patients (n=135) each with a tibial shaft fracture underwent primary conservative treatment. The following factors, in order of decreasing importance, lengthened the time to clinical union: severe fracture comminution, high number of cigarettes smoked, severe compounding of the fracture, female sex, and high age of the patient. The mean time to union was more than one month longer for smokers than for nonsmokers. An equation for calculating the expected time to clinical union was presented. Giving up smoking during healing of a tibial shaft fracture may enhance fracture union. Smokers appeared to have a 4.1-fold risk of tibial shaft fracture caused by low-energy injury, compared with nonsmokers.

Patients (n=163) with 165 tibial shaft fractures were treated using a strictly conservative approach; only three fractures were treated primarily operatively. At follow-up, angular deformities exceeding 5° were common: varus in 13%, valgus in 12%, antecurvature in 6%, and recurvature in 23% of fractures. 53% of the patients considered the healing of their fracture to be fair or poor. 54% experienced pain in the lower leg, 49% in the ankle region, 34% in the foot, and 31% in the knee, at least in some stress situations. Subjectively, 42% felt their ankle movement and 27% their toe movement to be limited. 23% of the patients reported marked swelling. 60% felt handicapped in walking, and 73% felt handicapped in running.

Patients (n=61) with 64 displaced tibial shaft fractures were treated using intramedullary nailing. More than half the fractures treated by primary nailing were

transverse or oblique and located in the middle third of the tibia. Fractures in which an acceptable position could not be maintained by conservative treatment were treated by delayed nailing. Most of these fractures were spiral in shape and located within or at the proximal border of the distal third of the tibia. Malunion, including angular or rotational deformity exceeding 5° or shortening exceeding 10 mm, occurred in 17 fractures. Closed fractures had a greater probability of rapid bone union after primary nailing than after delayed nailing. The median time from intramedullary nailing to union of closed solitary fractures was about the same after primary nailing as after delayed nailing. It seems that severely displaced, closed fractures within or at the upper border of the distal third of the tibia should be treated primarily by intramedullary nailing. Malunion significantly impaired the functional and subjective outcome. Every patient with a fracture united with a varus or valgus angulation of at least 10° and/or a shortening of at least 15 mm had a poorer subjective outcome than the average for the entire malunion group. Among patients less than 45 years of age, those with malunited fractures had to reduce or abandon physical exercise more often than those with fractures with sound union. Malunion of tibial shaft fracture appears to be particularly detrimental in distal fractures, in fractures with marked initial displacement, in fractures caused by high-energy injury, and among patients less than 45 years of age.

In 440 patients each with a tibial shaft fracture and an accompanying fibular fracture, the tibial fractures of 293 patients were treated conservatively and those of 147 patients using intramedullary nailing. In the latter group, eight accompanying fibular fractures had not united within four months of the injury. These were comminuted and located in the middle or distal third, and all except one were caused by high-energy traffic injury. One patient underwent operative treatment for fibular nonunion. At the follow-up examination, three patients still had radiographic nonunion of the fibular fracture. The subjective symptoms experienced by the patients were mild.

The results of the present study and of the recent literature provide the following indications for primary intramedullary nailing of tibial shaft fractures:

- closed or grade I open fracture displaced more than minimally or angulated at least 10°,
- markedly unstable fracture,
- fracture with a butterfly fragment of at least half the diaphyseal width or with more severe comminution,
- fracture in combination with a femoral fracture in

the same leg, a bilateral fracture, or a fracture in a multiply injured patient,

- fracture complicated by compartment syndrome,
- fracture with a long expected time to clinical union, including grade II, IIIA, or III B open fracture.

In addition, fractures caused by high-energy injury and those located within or at the proximal border of the distal third call for primary intramedullary nailing.

Hip fractures in the elderly—epidemiology, injury mechanisms, and prevention with an external hip protector

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The aim of the study was to determine the time trends of hip fractures and to predict the situation in 2030, to study the injury mechanism and the possibilities for using external protective devices.

The absolute number of hip fractures in Finland increased steadily from 2239 to 6330 during the study period, 1970-1993. The age-specific incidence of hip fractures increased in all age groups in both genders. This increase was most pronounced in the older age groups. Across the study period, the age-adjusted incidence of hip fractures also showed a steady increase. If the current trend continues, the predicted incidences (per 100 000 inhabitants) of hip fractures in Finland in the years 2000, 2010, and 2030 are calculated to be 600, 681, and 1097 in women and 260, 330, and 622 in men.

The purpose of the prospective, case-control hip fracture study was to determine how hip fracture patients fall and to compare the falls with falls not resulting in hip fracture in order to obtain insight into the hip fracture etiology, pathogenesis and prevention. In this study, 206 consecutive patients with fresh hip fracture and 100 controls were interviewed and examined between October 1994 and May 1996. Any eye-witnesses of the event were interviewed. In the majority of the patients, this interview was conducted by educated interviewers within 24 hours of the event. In 98 % of the hip fracture patients, the fracture was a result of a fall. A typical hip fracture was a result of a direct impact on the greater trochanter of the femur. In 56 % of the hip fracture patients, the occurrence of the impact on the greater trochanter was verified by observing a fresh subcutaneous hematoma on that site, while such a hematoma was rare in the controls (6%). Most of the elderly fallers did not manage to break the fall e.g. with an outstretched arm. The clinical implication of this study is that effective prevention of hip fractures among the elderly individuals could be achieved by diminution of the number and severity of the impacts on the greater trochanter and that the severity of impacts could be decreased by an external hip protector.

In the creation of an effective hip protector, a large number of various padding materials were first tested. We found that when using reasonable thicknesses of the currently available hip padding materials femoral impact force could not be lowered below the theoretical fracture threshold, and it was concluded that prevention of hip fractures by external protectors should be based on other ideas than hip padding alone - i.e. increase in the impact surface, shunting the impact energy away from the greater trochanter, or their combination.

After these findings the study group created a hip protector that was designed to cover the greater trochanter and both to shunt the impact energy away from the greater trochanter and partly absorb the impact energy during the fall on the hip. Biomechanical test results showed that this type of hip protector can provide an effective impact force attenuation in typical falling conditions of the elderly. With a typical hip impact force, 6940 N, measured in in-vitro falling tests, trochanteric soft tissue (25 mm polyethylene foam) attenuated the peak femoral impact force to 5590 N, and, the tested protector to 1040 N. Thus, the force received by the proximal femur remained clearly below 4170 N, the average force required to fracture in vitro the proximal femur of the elderly in a fall loading configuration.

These biomechanical test results gave us confidence to test the protector in adult male volunteers under forces that without the protector had the potential to fracture the hip of an elderly individual. In these experiments, the fall-induced peak impact forces did not cause undue pain to the impacted hip region, and, in all probability, the forces delivered to the proximal femur remained below the range of force capable to fracture the proximal femur of the elderly. The protector was also found to be comfortable to wear and it did not slip away during the experiment.

Finally, the protector was introduced to the elderly nursing home residents. We found that 63 % of the elderly to whom the protector was introduced wore the protector on a regular basis without problems.

With relatively low efforts external hip joint protectors could become a feasible strategy to prevent hip fractures among institutionalised elderly persons. The attitude, education and motivation of the staff was believed to be a crucial factor for reaching good acceptance and user compliance. Although the clinical efficacy of one type of hip protectors has been studied in a randomized trial of institutionalised elderly persons, more investigations will be needed to confirm the true population level benefits of hip protectors in prevention of hip fractures.

Overall, we suggest that in addition to the traditional means of prevention of osteoporosis, i.e., maximizing the peak bone mass and prevention of age-related bone loss, the prevention strategies of osteoporotic fractures should include serious efforts for diminution of the number and severity of the falls of the elderly. In prevention of hip fractures, the most serious injury among all osteoporotic fractures, the severity of falls could be decreased with use of a well design and scientifically tested external hip protector.

Reliability of fixation of fractures and osteotomies with absorbable implants

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The purpose of the present investigation was to study the mechanical and clinical reliability of absorbable implants in the treatment of cancellous bone fractures or osteotomies, to sort out problems related to this fixation method, and to find out unsuitable indications for absorbable implants.

A total of 266 patients underwent 250 operations at the Department of Orthopaedics and Traumatology at Helsinki University Central Hospital. Most of the patients were followed up at least for one year. This investigation included studies on redisplacements among 1202 operated ankle fractures, the radiographic changes after chevron osteotomy of the first metatarsal bone for hallux valgus, displaced metacarpal and phalangeal fractures, delayed and non-united scaphoid fractures, radial head fractures, and distal humeral fractures. Of the 250 osteosyntheses, 225 were fixed with different absorbable implants (mostly pins), 10 with metallic screw (Herbert screw, control group) and 15 by combining absorbable implants with metallic implants. The radiographic, functional, and subjective outcome of the treatment as well as the postoperative complications were analysed.

The redisplacement after fixation of ankle fractures with absorbable implants was diagnosed in 30 (2.5%) of the 1202 osteosyntheses. The redisplacement occurred in 8 of the 934 (0.9%) simple, displaced fractures of the ankle and in 22 of the 268 (8.2%) severe fractures. The absorbable implants seem to provide a reliable fixation in simple, displaced ankle fractures. These implants were not reliable for fixation of comminuted and severe fractures of the ankle. After chevron osteotomies postoperative osteolytic changes oc-

curred in 21 (22%) of 94 metatarsals. At follow-up most of these changes resolved. No association was observed between osteolytic changes and foreign-body reaction, infection or the clinical outcome. Absorbable implants showed promising results in the intra-articular fractures of the metacarpal and phalangeal bones with the exception of the Bennett's fractures where the outcome was less favorable. The high rate of foreign-body reactions (25%) made self-reinforced polyglycolide pin fixation unreliable in the treatment of delayed or non-united scaphoid fractures. The final radiographic results were good in 30 (79%) and the functional results were excellent or good in 36 (95%) of the 38 patients with radial head fracture. Displaced fractures of the radial head can be fixed reliably with absorbable self-reinforced polyglycolide pins. The final radiographic results were good in 13 (30%) of the 44 patients with fracture of the distal humerus. The elderly patients had more severely unstable fractures and showed more unfavorable results than did the younger patients. Absorbable implants proved to be reliable for fixation of non-comminuted epicondylar and condylar fractures of the distal humerus as well as in the humeral capitulum fractures. These implants were not reliable in the fixation of comminuted distal intra-articular humeral fractures.

Absorbable implants may play an increasing, but a more specific role in orthopaedic and trauma surgery. There will be more clinical studies on absorbable implants, such as polylactide, with less foreign-body reactions in the future.

Knee injury and knee osteoarthritis—development, evaluation and clinical application of patient-relevant questionnaires

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The overall purpose was to evaluate patient-relevant outcomes in patients with knee injury and posttraumatic osteoarthritis of the knee.

A self-administered questionnaire, The Knee injury and Osteoarthritis Outcome Score (KOOS) was developed according to set guidelines. Two validation studies were carried out, 21 patients were studied following reconstruction of the anterior cruciate ligament, and 142 patients were studied following knee arthroscopy. The KOOS proved to be a userfriendly and patient-relevant outcome measure with satisfactory metric properties. The KOOS is available for use in Sweden and the USA.

The Western Ontario and MacMaster Universities Osteoarthritis Index (WOMAC) is included in the KOOS. The WOMAC was translated into Swedish and tested for reliability and responsiveness in 62 subjects with arthroscopic knee OA undergoing arthroscopy. The metric properties were found satis-

factory and comparable to the original version.

The KOOS was more responsive than the WOMAC when evaluating subjects 20 years after meniscectomy. It is recommended that the KOOS subscales; sport and recreation function and knee related quality of life be added to the WOMAC when assessing post-traumatic OA.

Three months after arthroscopic partial meniscectomy significant improvement was seen in patient-relevant outcomes, but substantial disability and handicap was still reported compared to reference groups.

Twenty years after meniscectomy symptoms and functional limitations were reported, both in subjects with and without radiographic OA. The relation between pain and radiographic OA was poor, 40% of subjects with more severe OA did not report more pain than controls did.

ISBN 91-628-3388-X

Clinical and radiographic outcome of total hip arthroplasty—factors related to loosening

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Basic and applied laboratory research constitute the foundation, but only in the clinical arena the actual performance, success or failure of a certain prosthetic device can be evaluated. The longevity of a total hip replacement may be evaluated by survival analyses, by using clinical rating systems, and by radiography.

The aims of the present investigation were to study the clinical results, radiographic behavior, and survival of different total hip arthroplasties. Three populations were involved: patients with cemented Lubinus components, patients with cementless Link RS arthroplasties, and patients with cementless revision procedure. The risk factors for loosening were different for different types of arthroplasty. Implant design and operative technique were found to affect results of both cemented and cementless arthroplasty.

Patients with radiographic signs of loosening need careful follow-up in order to prevent complicated revisions. The survival of Link RS components was found to be lower than earlier results with cementless components reported in the literature. Likewise, threaded acetabular components and macrot textured or macroporous femoral components yielded poor results in revision. However, Lubinus components used in primary arthroplasty fared well, and microporous and hydroxylapatite-coated components evidenced good results in revision. It is important to report poor results as early as possible in order to prevent further assembly of the design in question. Continuous registration and follow-up of arthroplasties is necessary in order to identify disastrous designs.

Chondromalacia of the patella—a clinical and biochemical study

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Chondromalacia of the patella is a common disease affecting mostly young persons. The articular cartilage becomes softened, later degeneration leads to fibrillation and eventually, erosion of the cartilage tissue causes pain and disability. The etiology and biochemical pathophysiology of the disease are still unknown. This study evaluates the strength and electromyographic behavior of the thigh muscles and the results of lateral retinaculum release in patients with chondromalacia of the patella. Also, biochemical changes in cartilage and synovial fluid were studied.

In chondromalacia patients, the strength and force output were reduced by 23% and 25%, respectively, during isometric extension of the knee. The integrated electrical activation during isometric knee extension was reduced in vastus medialis part of the quadriceps femoris muscle by 41%, in vastus lateralis by 62%, and in rectus femoris muscle by 53% ($p < 0.001$). The electrical activation did not reveal any imbalance in the muscular function between vastus medialis and vastus lateralis. The division of the lateral patellar retinaculum decreased lateral patellar tilting angle and lateral patellar displacement, but did not impair the electrical activation of thigh muscles after 4.1 years follow-up.

The uronic acid concentration was reduced on average to 15% of normal in cartilage samples from chondromalacia foci. In chondromalacia grades II, III, and IV (according to Outerbridge 1961), uronic acid was reduced to 9%, 3%, and 1% of that in controls. A decreased number of large proteoglycans and respectively increased number of proteoglycans in high mobility segment in grades II and III chondromalacia of the patella.

The full-thickness cartilage samples taken with a surgical knife from chondromalacia lesions did not

show changes in their collagen concentration or in concentrations of collagen crosslinks, hydroxylysylpyridinoline and lysylpyridinoline as compared with the controls. In samples containing more fibrillated cartilage, taken with a motorized shaver, the collagen per dry weight ratio was decreased in grades III and IV (33% and 48%, $p < 0.01$) and a decrease of hydroxylysylpyridinoline/collagen ratio was found in grades II, III, and IV chondromalacia (24%, $p < 0.01$). Lysylpyridinoline crosslinks showed equal concentrations in chondromalacia patients and controls. In polarized light microscopy, decreased birefringence was found in the superficial cartilage of chondromalacia lesions, indicating disorganization or disappearance of collagen fibrils in this zone.

Matrix metalloproteinases MMP-3 and -1 concentrations in the joint lavage fluid were elevated in grade IV chondromalacia of the patella. The MMP-1 concentration in lavage fluid correlated with the severity of disease ($r = 0.38$, $p < 0.01$). MMP-1 and -3 concentrations correlated with each other ($r = 0.45$, $p < 0.001$). The concentration of tissue inhibitor of metalloproteinase 1 (TIMP-1) was higher in grade IV chondromalacia than in grades II and III ($p < 0.02$, $p < 0.01$, respectively). Interleukin-1 α , -1 β , and -6 showed no significant changes. The lavage fluid level of phospholipase A₂ increased with the severity of the disease ($r = 0.40$, $p < 0.001$). Serum keratan sulfate was higher in grade IV than in controls ($p = 0.05$), while the concentration in the joint lavage fluid was elevated in grade I ($p = 0.04$). Aggrecan fragments and hyaluronan did not differ in the lavage fluid between chondromalacia patients and controls. Slight or moderate histological signs of inflammation were found in 9% of chondromalacia patients.

Idiopathic scoliosis—radiological measurements, progression and notes on the results of conservative treatment

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Measurement errors of the scoliotic angle and vertebral rotation were examined on posteroanterior radiographs of 30 patients with the mean Cobb angle of 24.4°. The mean interobserver and intraobserver measurement error was 2.4° and 1.5° in scoliotic angle, and 2.4 and 1.1 percentage units in vertebral rotation, respectively.

The spinal growth of 110 girls with untreated idiopathic scoliosis was examined from two successive radiographs with a mean interval of 1.1 years. At the first visit the mean age of the patients was 14 (11–16) years, the mean magnitude of the major curves 24° and that of the minor curves 14°. To avoid shortening of the spine caused by lateral curves the length of T4–L4 segments was measured with a flexible wire through midpoints intervertebral discs projectionale. The spinal growth was most rapid at the age of 11–12 years. The progression of curves correlated with the spinal growth. The correlation between the spinal growth and the progression of the curves was the greater the more pronounced the initial curves were, and the correlation was more significant in thoracic scoliosis ($r=0.560$) than in thoracolumbar and lumbar scoliosis ($r=0.152$).

Bracing results and biological factors that could have a predictive value in the treatment were studied

in 107 patients (102 girls and 5 boys). The mean age of the patients was 14.5 years, and the mean magnitude of curves 36° at the outset of the treatment. The girls with idiopathic scoliosis had an earlier pubertal growth spurt compared with contemporary Finnish girls. Patients who had a period of rapid growth just before or during the treatment had a better final result than the others. The final result was also better when treatment was started before menarche. The final result for scoliosis when treated with brace correlated with the initial correction of curves in brace. The mean final correction of curves was 0°. The best final correction was achieved in thoracic and lumbar curves, and in curves with the apex at T10–12.

Electrical stimulation was begun for the treatment of idiopathic scoliosis in 20 patients. At the outset of the treatment the mean age of the patients was 10.9 years, and the mean magnitude of curves 26°. Six patients were treated until skeletal maturity, and in 14 patients the treatment failed due to skin irritation, sleeping disturbances or curve progression. The control group of 20 patients treated by brace with a mean age of 11.9 years, and the mean magnitude of curves 34°, achieved a significantly better final result.

Cervical discectomy and fusion with or without plate fixation—a randomized clinical and radiographic study on outcome and cost-utility

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The use of plate fixation in anterior cervical disc surgery has been popularized during the last decade despite incomplete knowledge regarding the efficacy of this treatment. This study was undertaken to evaluate the stabilizing effect of anterior cervical discectomy and fusion with and without plate fixation as well as the clinical outcome and the cost utility of these procedures.

The study comprises 46 consecutive patients with neck pain, arm radiculopathy and with MRI verified herniated disc and/or spondylosis at one (27 patients) or two (19 patients) cervical disc levels. They were all on sick leave (mean 18 months) or had pension before surgery. 24 patients were randomized to plate fixation and 22 to surgery without internal fixation. The patients were followed-up after 2 years by an unbiased observer (neurologist). One patient was reoperated due to pseudarthrosis. At 2 years, 73% of the patients with a plate at one level were graded excellent/good with Odom's criteria compared to 67% of the patients without plate fixation. The corresponding numbers for two-level surgery were 89% with plate fixation and 70% without (n.s.). 41 patients were satisfied with their outcome of surgery and 30 patients returned to work within 2 years.

Preoperatively and after 2 years, the patients filled in three different questionnaires, the modified Million index, the Oswestry index and the Zung depression scale. A test-retest was performed for all three tests. The results of all tests correlated significantly to each other and also to the outcome according to Odom's criteria. Patients with an unsatisfying outcome with the Odom's criteria had a significantly higher Zung

score ($p = 0.02$), Million index ($p < 0.0005$) and Oswestry index ($p < 0.0005$) than those that had a good/excellent result after 2 years.

In all patients but the first in the series, radiostereometric analysis (RSA) was used to evaluate the stability of the fusions. RSA examinations were done immediately postoperatively and after 2, 6 and 12 weeks and after 6, 12 and 24 months. In one level surgery the use of plate prevented deformation into kyphosis, but did not significantly affect the clinical outcome measured on visual analogue pain scale (VAS) for neck/arm pain, or the fusion rate. In two level surgery, the plate significantly prevented axial compression ($p < 0.01$) and also deformation into kyphosis ($p < 0.01$). These differences seemed to be clinically important because the patients with plate fixation had significantly lower arm pain ($p = 0.02$) after 2 years.

The outcome of surgery in the last 24 patients was further studied with another three health questionnaires, Euroqol, Hannover ADL and Von Korff pain scale. These questionnaires were administered preoperatively, and after 1 and 2 years. The costs of treatment were studied and the quality of life adjusted years gained (QUALY) was calculated. A subgroup of patients was identified, that did not improve with surgery. These patients related their symptoms to a whiplash like injury. The remaining group of patients improved significantly in all three scores at 2 years. The QUALY for these latter patients was estimated to 507 US\$ provided that the improvement gained the first postoperative years would last during the patients remaining years