Dissertation abstracts

Trauma-induced heterotopic bone formation

Leif Ahrengart
Department of Orthopedics, Karolinska Institute, Huddinge University Hospital, S-141 86 Huddinge, Sweden

Heterotopic bone formation (soft-tissue ossification, frequently occurs around the hip joint after arthroplasty. The process and its results were studied in patients that had undergone total hip replacement, and in rabbits with the aid of an experimental model of traumatically induced heterotopic ossification.

Among patients operated on by the same surgical technique, periarticular bone developed after arthroplasty in 76 percent, and in 22 percent the amounts were significant. The bone was usually located lateral to the hip joint, and in most cases it could be detected on radiographs 2 months after the operation. Factors found to be associated with heterotopic bone formation were male sex, advanced age or the presence of hypertrophic arthrosis in women, and a long operating time in male patients.

By analyzing metabolites in biopsy specimens taken from the gluteus medius muscle at the beginning and at the end of the surgical operation, it was concluded that the postoperative occurrence of heterotopic bone was not associated with muscle ischemia during surgery.

Significant amounts of bone was associated with restriction of hip-joint mobility. The condition was not accompanied by pain, Trendelenburg's sign, or muscle weakness. On the contrary, male patients who developed ossification were stronger in flexion than men without heterotopic bone. The same difference was found around the healthy hip joint among men with unilateral hip disease.

Immobilization of the knee joint in extension in the rabbit led to rapid selective necrotic changes in the vastus intermedius muscle. This process was clearly revealed by MRI examination. Small amounts of heterotopic bone formed distally in the vastus intermedius compartment. When the knee joint was subjected to repeated, passive remobilization during the period of immobilization, considerable amounts of bone formed, usually in contact with the periosteum. It is possible that these event are related to muscle-fiber type. The data from this study suggest that the vastus intermedius muscle, unlike the rest of the quadriceps muscles in the rabbit, consists largely of Type 1 fibers.

This experimentally induced production of heterotopic bone could be prevented by peroral administration of indomethacin or prednisolone, by exposure to ionizing radiation, or by surgical implantation of methylmethacrylate bone cement containing ethane-1-hydroxy-1,1-diphosphonate (EHDP). In vitro studies showed a marked and rapid release of this compound from the vehicle, and the major part of the released EHDP was released during the first few days.

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The reliability of physical factors as predictors of the occurrence of back pain reports

A prospective study within industry

Michele Battié
Department of Orthopedics, Gothenburg University, Sahlgren Hospital, S-413 45 Gothenburg, Sweden, and Department of Orthopedics RK-10, University of Washington, Seattle, WA 98195, USA

A prospective study of risk factors for industrial back pain reports was conducted among 3,020 aircraft-manufacturing employees in the United States. These employees comprised 75 percent of the work force at the plant where volunteers were solicited. The subjects ranged in age from 21 to 67 years, and 78 percent were men. Data collection at the time of induction into the study involved a physical examination entailing measures of anthropometric variables, flexibility, isometric lifting strength, and estimated maximal aerobic capacity. A back examination also was conducted, including lower extremity girths, straight leg-raise testing, and reflex testing among other measures. At the time of the physical examination, the subjects were either interviewed in person or given a take-home questionnaire regarding history of back problems, including specifically whether they had sought treatment in the prior 10 years, and whether they had ever undergone back surgery. Of the 2,322 subjects who responded to the questionnaire, 905 reported such a history of receiving back treatment, and 46 had undergone spine surgery.

During approximately 4 years of follow-up from the time of the examination, 279 subjects reported back problems either through the company medical department or through the filing of an incident report or industrial insurance claim. Univariate and multivariate analyses were completed to identify risk factors or predictors of back pain reporting among 27 individual physical factors, including those listed above, in addition to age, gender, smoking, and history of back problems.

Remarkably few individual physical factors were significantly associated with increased risk of future back-pain reports. None of the strength, flexibility, or aerobic capacity variables were significantly associated with increased incidence of back-pain reports, whether examined independently or multivariately. None of the clinical examination measures were significantly associated with subsequent back-pain reporting in subjects who did not report a history of back problems. Among subjects with a history of back problems, the relatively rare finding of back pain on SLR (85 subjects), was statistically a significant risk factor ($P \leq 0.0001$). Subjects with scoliosis or asymmetrical extensor digitorum brevis muscle bulk who had reported a history of back problems requiring treatment also displayed a tendency towards a higher risk of back pain reports. There was also a tendency in slightly taller men and heavier women to report back problems.

An effort was made to create a separate multivariate predictive model for men and women considering all the factors investigated. Among men and women the variable denoting recent or current back problems was the most highly associated with subsequent back-pain reporting. After this variable was entered into the model, only back pain on SLR and age added any statistically significant additive predictive power. In addition, weight also had a minor, but statistically significant additive value to the predictive model for women. However, these factors would be of little practical value as screening tools due to their low specificity and sensitivity.

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Talent, occupation, and locomotor discomfort

Hans Bergenudd

Lund University Department of Orthopedics at Malmö General Hospital, S-214 01 Malmö, Sweden

This study was undertaken on the Malmö Longitudinal Study Population—subjects born in 1928: viz., a total of 1,542 pupils who were third graders in the elementary and private schools in Malmö and who had been subjected to a rating of their talents with an intelligence test and also by a classification done by their teachers in 1938. In a series of follow-up examinations, data have been collected on their social background, education, employment, dependence on social welfare, income, success in life, and job satisfaction. In 1983, 580 subjects still residing in Malmö were summoned to a general health examination, and data were collected on complaints of locomotor discomfort, on body posture and build, physical fitness including alcohol and smoking habits, bone mineral content, social support, occupational work load, and job satisfaction. The relationships between these factors and locomotor complaints (shoulder, back and knee pain) and degenerative changes of the hands and feet were analyzed.

Overweight was related to knee and back complaints in men. Body height, posture, bone mineral content, and physical fitness were not related to locomotor discomfort. Men with shoulder complaints were more often smokers. Men with knee complaints had higher levels of serum glutamyltransferase indicating a higher intake of alcohol. Sleeping disturbances were common in subjects with shoulder, back, and knee complaints. Subjects with a moderate or heavy work load had more often locomotor complaints, particularly in the back, hips, and knees; and women with Heberden's nodes had more often a moderate physical work load. In women, locomotor complaints more often coincided than in men. Job dissatisfaction had the strongest independent relationship with locomotor discomfort, but also the level of education and intelligence evaluated early in life seems to influence the occurrence of locomotor symptoms.

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Fluoroscopic assessment of tibial torsion and rotational deformity in adults

Bengt-Göran Clementz
University Hospital Department of Orthopedics, S-751 85 Uppsala, Sweden

A method for assessing anatomic angles was developed. The method was particularly designed for assessing tibial torsion with a mobile C-arm fluoroscope. The examination is performed with the patient supine and with the leg to be examined fully extended. A repeatable position is achieved when the foot rests firmly against a vertical end support. The tangent to the posterior contours of the femoral condyles in the lateral view is used as the proximal line of reference. The distal line of reference is the tangent to the inner surface of the medial malleolus in a specified measuring position.

The angle of tibial torsion is defined as the angle between the distal reference line and the normal to the proximal reference line. Provided that the protractor mounted on the C-arm is properly adjusted, the value of the torsion angle can be read directly. The method can be used in the surgical theater. A plaster cast is not an obstacle. The standard error of a single measurement was 0.74° when measurements were performed in normal adults.

In a series of 100 normal adults, the tibial torsion values ranged from 11° to 50° (mean 30°; SD 7.8°). The difference in torsion between the right and the left tibia in the same subject ranged from −11° to 15° (mean +2.1°, SD 5.2°; the plus sign indicates right-sided dominance). A significantly lower standard error was found with this method than with two other fluoroscopic techniques.

In a study of 10 skeletal specimens, the medial malleolus and the femoral condyles were found to constitute anatomic landmarks for reliable determination of the reference lines with the presented method. This was also the case when the method was modified for use with computed tomography.

The mean absorbed dose of radiation during fluoroscopic assessment of tibial torsion was found to be low, without any scattered radiation to the examiner or to the symphysis of the patient.

Among 38 patients admitted consecutively for treatment of unilateral tibial fractures, the greatest difference in tibial torsion between the tibias of the same subject after reduction and stabilization of the fracture was 49°. Both detection and evaluation of malrotation are difficult with traditional techniques. Therefore, before the quality of reduction of a displaced tibial fracture is accepted, assessment of the tibial torsion should be performed. The fluoroscopic method presented in this thesis is recommended.

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Extreme spinal loading

Hans Granhed

Department of Orthopedics, Gothenburg University, Sahlgren Hospital, S-413 45 Gothenburg, Sweden

The mechanical properties of a human lumbar vertebra are closely related to its bone mineral content (BMC).

A strong increase in the incidence of fragility fractures due to low BMC have been found during recent years. This trend has been clear in women, but only recent findings have indicated that the risk of fragility fractures in men is increasing as well.

The object of this study was to determine 1) the normal BMC in the lumbar vertebrae in men at all ages; 2) to what extent physical training could improve the BMC values of the vertebrae; 3) if high BMC values among athletes remain after they retire from sports; 4) the in vitro correlation between BMC and the compressive strength of lumbar vertebrae in different degrees of flexion; and 5) if the risk for future low back pain is different in wrestlers and heavy-weight lifters compared with controls of the same age.

BMC was determined with dual photon absorptiometry (DPA). Totally ,199 men were randomly sampled in the age range 16–79 years. BMC was determined in the third lumbar vertebra (L3). The highest amount of BMC was found around 25 years of age. From this age on, there seemed to be a continuous loss of bone mineral at a rate of 0.46 percent annually.

Thirty-nine retired and 33 active wrestlers and heavy weight lifters were compared with an age-matched control group of men with normal physical activities. A close positive correlation was found between the extent of physical activity and the BMC in the lumbar spine. High BMC values, induced by vigorous physical activities in youth, had no long-lasting or permanent positive effect on the BMC later in life.

The loads on the spine were analyzed with a mathematical model of eight power lifters during competition. The BMC values were measured in L3. Training with extremely heavy weights stimulated to very high BMC values in the human spine.

52 lumbar spinal segments were tested in compression at 0, 5, 10, and 15 degrees of flexion. The relationship between BMC and compressive strength did not vary for different degrees of flexion within physiological limits.

Forty-five retired athletes were analyzed for the occurrence of low back pain and radiographic spinal changes. The results were compared with two Swedish population studies. Heavy weight lifting was not found to be a risk for future low back pain. Wrestling increased the risk of future low back pain and radiographic changes.

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Radiography of the total hip prosthesis

Position, orientation, design, component interaction and dislocation

Kristian Herrlin
Department of Diagnostic Radiology, University Hospital, S-221 85 Lund, Sweden.

A method is presented for radiographic determination of orientation and component interaction in total hip prostheses. When compared with available methods it was found to describe these parameters more precisely. The method was applied in a comparison between patients with dislocating total hip prostheses and a control group without dislocation. Also the position of the rotational center of the prosthetic joint relative to the pelvis and femur was compared between the groups. Several significant differences were found with respect to prosthetic orientation and component interaction. All of these were attributable to a lower range of flexion among the dislocating prostheses. The reason for the diminshed range of flexion was impingement between the rim of the socket and the neck of the femoral component. This was mainly caused by insertion of the femoral component in a reduced anteversion, or by a prosthetic design with a small head/neck ratio or a snap fit configuration of the cup.

The risk for dislocation is reduced by inserting a prosthesis with a design and orientation that will permit a phyisologic range of motion until impingement occurs.

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The femoral neck anteversion

Anatomy, definitions, measuring methods, errors, and related anatomy

Arne Høiseth
Department of Radiology, Ullevål University Hospital, Oslo, Norway

The measurement of the femoral neck anteversion (AV) has been considered a methodologic problem, and a variety of solutions have been proposed.

The intention of this thesis was 1) to make a detailed anatomic study of the different axes and definitions of the AV; 2) to estimate the precision of definitions and measuring methods and to determine any systematic differences (accuracy) by comparing with standardized references consistent with precise definitions; 3) to correlate the AV with other parameters of the hip joint.

It was shown that there are substantial variations between different axes used in the femoral neck, shaft, and condyles, and that these may give substantial variations in the measured values. There are even some inconsistencies between the real and theoretic anatomy. There are two principally different definitions of the anteversion (ANTEV1 or the anatomic anteversion) and Norman's definition (ANTEV2). The precision of both definitions was high. For measuring ANTEV1 a modification of the method described by Dunlap et al. was the most precise. The main problem with the commonly assumed precise CT measurements is the variability of the neck center with slice position. Use of computerized reconstruction of the AV based on arbitrary projections is imprecise because of the substantial variability and asymmetry of the anatomy. For this reason, precise projections are needed for precise axis construction. For measuring ANTEV2 the conventional method is inexact in contrast to the CT method. The present study shows that the poor agreement between ANTEV1 and ANTEV2 found previously is mainly due to the poor precision of measurements. There was no correlation between the AV and angles describing the acetabulum and the femoral head cartilage.

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In vivo strain changes following intramedullary nailing

An experimental study in rat femoral bone

Otto Schnell Husby
Departments of Dental Materials and Surgery, University of Bergen, Bergen, Norway

Mechanical properties of bone following application of fixation devices have usually been evaluated by in vitro techniques, such as bending tests or torsion tests. Introduction of implanted strain gauges into the field of orthopedic research has made it possible to measure surface deformation during normal activity.

Changes in dynamic strain in femora of rats during walking were evaluated. Unidirectional strain gauges were implanted. Peak strain at the anterior and medial aspects of the femur was compressive, while peak strain at the posterior aspect was tensile during walking. Median strain values at the anterior mid-diaphyseal aspect varied between 297×10^{-6} and 434×10^{-6}. There were no statistical differences between recordings at different times after implantation as evaluated by daily measurements for 1 week. In vitro measurements on replaced gauges corresponded within 5 percent with results from bones where gauges had been implanted for 1 week. Waterproofing the strain gauge with a resin did not significantly affect the measurements. The method, therefore, enables studies of strain behavior of bone from small species in vivo under physiologic and pathophysiologic conditions.

In vivo changes in dynamic strain following intramedullary reaming and nailing were recorded. Reaming and nailing procedures were performed 2 days after implantation of unidirectional strain gauges at the anterior, mid-diaphyseal level of the femur. Structural stiffness of polyacetal nails was 1/10, and steel nails were three times as stiff as intact bone.

Reaming decreased the median strain value by 26 percent at the measured point. Insertion of polyacetal nails did not reduce the strain value further, whereas steel-nailing reduced strain by 74 percent. Tested by three-point bending, reaming increased stiffness by 5 percent at the anterior aspect compared with intact bone. The presence of nails produced stiffness values that were 9 percent (polyacetal) and 56 percent (steel) higher than the reamed condition.

In vivo strain-shielding in rat femora 12 weeks after intramedullary nailing with either flexible or rigid implants was evaluated. Five days prior to killing, unidirectional strain gauges were implanted on the anterior bone surface on both sides. Median strain values of reamed and polyacetal-nailed femora ranged from 67 to 90 percent of the intact side. Removal of polyacetal nails and sham operations revealed negligible changes in strain. Strain of the steel-nailed femora was 51 percent of the intact side, but removal of these nails increased strain to 91 percent of the intact side. Mechanical testing of femora after removal of implants revealed stiffness of 116 and 103 percent of normal in the reamed and polyacetal-nailed groups, respectively. Stiffness in the steel-nailed group was 85 percent of normal. None of these changes were statistically significant.

Changes in strain throughout the rat femur following intramedullary reaming and nailing were evaluated. In cantilever testing, strain values were recorded from the anterior, medial, and posterior femoral surfaces at three different levels. Reaming reduced strain at the anterior surface, whereas increased strain was found medially throughout the bone. Steel nails reduced strain most pronounced at the posterior surface proximally, and at the anterior and posterior surfaces at a mid-diaphyseal level.

Cortical porosity and thickness 12 weeks after intramedullary reaming and nailing of intact rat femora were evaluated. Neither reaming alone nor in combination with nailing influenced the frequency of porosities with a diameter less than 10 μm. For larger pores, however, polyacetal-nailing implied a doubling of the porosity, whereas steel nails increased porosity by a factor of 4.5. Slightly increased porosity was observed in the reamed group. Reduced cortical thickness was found in both nailed groups, whereas cortical thickness increased in the reamed group as compared with the control side.

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Chronic lateral instability of the ankle joint

Jón Karlsson

Department of Orthopedics, East Hospital, Gothenburg University, S-416 85 Gothenburg, Sweden

Ankle joint instability can be defined as either functional or mechanical instability. Functional instability is the most common residual disability after lateral ligament injuries. A correlation was found between good functional results and mechanical stability in both patients treated with Evans reconstruction and anatomic ligament reconstructions. Long-term results after Evans reconstruction were unsatisfactory in 50 percent. In patients treated for chronic lateral ankle instability with anatomic reconstruction, a satisfactory result was found in almost 90 percent. Two different techniques based on the same surgical principle were used for anatomic reconstructions. Restoration of mechanical stability is a primary factor in the treatment of chronic lateral ankle joint instability. A better result was found if both the anterior talo-fibular and the calcaneo-fibular ligaments were reconstructed. Patients with generalized hypermobility of the joints, long-term ligamentous insufficiency, and those previously operated on with tenodesis should be considered as poor risks when anatomic ligament reconstructions are planned. Complications were few in patients treated with anatomic reconstructions as compared with those treated with Evans reconstruction. The anterior talar translation and talar tilt were significantly higher in functionally unstable ankle joints than in a control group with stable ankle joints. There were also significant differences between functionally stable and unstable ankle joints regarding both anterior talar translation and talar tilt in patients with unilateral functional instability. Evaluation of mechanical instability is therefore of value in the diagnostic and therapeutic evaluation of ankle joint instability. A scoring scale based on the patient's subjective and functional status can be used to evaluate ankle joint function. The scale correlates statistically with both anterior talar translation and talar tilt. The reaction time for both the peroneus longus and the peroneus brevis muscles was significantly longer in unstable than in stable ankle joints. With biomechanical analysis, it was shown that receptor stimulation occurs at a constant fraction of the talar tilt angle.

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Postural equilibrium function in adolescent idiopathic scoliosis

Jan Lidström

Departments of Orthopedics I, Clinical Data Processing, and Clinical Neurophysiology, Sahlgren Hospital, University of Gothenburg, Gothenburg, Sweden

The possible role of a postural equilibrium dysfunction in adolescent idiopathic scoliosis (AIS) was studied. Postural equilibrium in siblings of scoliosis patients, scoliosis patients, and matched healthy controls was measured by means of stabilometry. Stabilometry measures the body postural sway in the horizontal plane by means of a force platform. Siblings of scoliosis patients were chosen as subjects, because a disturbance in siblings would also point to an etiologic importance in adolescent idiopathic scoliosis, for hereditary reasons.

The method of measuring postural sway by means of stabilometry was refined. The refinement included separation of the sway into acceleration and position sway by means of Fourier transformations and a filter function derived from a model of an inverted pendulum. The model also included the moment of inertia of the separate parts of the body. The new sway analysis was adapted to the sway measurements except in the first study.

A longitudinal study analyzed the possible correlation between the postural equilibrium measured as the initial sway and the progression of the scoliosis curvature during the follow-up period. The diurnal studies of postural equilibrium included measurements of postural sway and curve angle in the morning and in the evening.

Conclusions: Siblings of scoliosis patients showed a postural sway that was less than that among controls and also among scoliosis children. Despite their sway being less, the siblings showed a postural sway that was more asymmetric than in both the other groups. The prospective study showed correlation between the degree of asymmetry and the progress of the scoliosis curve. There was no correlation with the final outcome of the curve. This points to postural dysfunction being a factor that participates in the initiation and early progression of scoliosis. Other factors decide the final curve magnitude. Scoliosis curves on average show no deterioration during the day. However, patients that have a less favorable adaptation of postural sway during the day show a deterioration of their sway. The sway in the control group did not differ between boys and girls. In the sibling group, however, the postural sway of the girls differed significantly from that of the boys. The differences were more pronounced in girls. This speaks in favor of a postural influence on AIS, for AIS is mainly a female disease.

The lesser sway in siblings of scoliosis patients is regarded as an adaptation to a central asymmetric postural control. The deficit in AIS appears to be a deficit adaptation and an asymmetric processing of the peripheral input.

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Acrylic bone cement

A study of mixing techniques

Ulf Lindén
Department of Orthopedics, University Hospital, S-581 85 Linköping, Sweden

Acrylic bone cement is used to anchor implants tot bone. The strength of the bond between bone and implant is influenced by the quality of the cement. Air is entrapped during mixing, leaving voids in the cement, which weakens it. To create a homogeneous cement, it is equally important to obtain an appropriate distribution of the powder in liquid.

The traditional mixing of cement by hand in a bowl was studied and showed a gross variation in porosity. Twenty-three percent of the pores exceeded 0.3 mm in diameter. Manual mixing thus resulted in a cement of unpredictable porosity.

A mechanical mixing technique was developed, and porosity of high- and medium-viscosity cements was reduced by about 50 percent and the variation diminished as compared with manual mixing. Manual mixing of low-viscosity cement resulted in low porosity that was not further reduced by mechanical mixing. Mechanical mixing under a vacuum reduced porosity further by 95 percent. Porosity was not reduced by adding centrifugation to the manual or the mechanical technique. Instead, centrifugation resulted in a gradient of pores within the cement.

Compressive strength of the medium- and low-viscosity cements was increased when mechanically mixed and compared with manual mixing. Shear strength was increased by mechanical mixing of high- and medium-viscosity cements compared with manually mixed ones.

Fatigue properties of medium- and low-viscosity cements were improved by 147 percent and 113 percent, respectively, when mechanically mixed compared with manual mixing. Mechanical mixing under a vacuum improved all the cements, and was superior to other techniques. The low-viscosity cement increased by 148 percent, the medium-viscosity cement by 237 percent, and the high-viscosity cement by 37-fold. The medium-viscosity cement had the best fatigue properties of all the cements.

A new technique to study the distribution of powder in liquid was developed. The liquid (monomer) was marked with a dye for methylmethacrylate, which made it possible to distinguish the powder from liquid. Sections of cement were analyzed by image processing. The high-viscosity cement showed smaller areas of inclusions when mechanically mixed compared with manual mixing in a vacuum system. The medium-viscosity cement had smaller areas of inclusions when mechanically mixed compared with centrifugation of manual mixing in a vacuum system. Mechanical mixing and manual mixing of low-viscosity cement in a bowl resulted in smaller inclusions compared with manual mixing in the vacuum system.

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Spinal sagittal configuration and mobility

A kyphometer study

Gunnar Öhlén

Department of Orthopedics, Karolinska Institute, Huddinge University Hospital, S-141 86 Huddinge, Sweden

While the advances in modern medical science have implied a dramatic decrease in specific spinal diseases, the incidence of self-reported back complaints seems to be increasing. This development has created an urgent need for a better understanding of spinal disorders. The present investigation was undertaken with the aim of improving the methods of evaluation in this field.

The specific purpose was to find an objective noninvasive tool for measuring the spinal thoraco-lumbar configuration and mobility in degrees; preferably an easily portable device requiring a minimum of time for a complete investigation, but maintaining the criteria of good reproducibility.

Debrunner's kyphometer, modified to increase its range of measurement of lumbar extension, was studied regarding the reproducibility of its results. It proved satisfactory for measuring sagittal configuration and mobility. The importance of standardization of verbal and visual instructions to patients to minimize inter-examiner variability of measurement is emphasized.

A graphic classification model is presented that facilitates the recognition of variations of the thoraco-lumbar sagittal configuration using the spatial distribution of the relationship between the angle of kyphosis and lordosis. This graphic model may be of clinical significance in evaluating hypocurvatures and hypercurvatures and of solitary changes in either kyphosis or lordosis.

Examination of 127 patients with idiopathic scoliosis revealed no correlation between the degree of kyphosis or lordosis and the Cobb angle, indicating that individuals with straight spines in the sagittal plane are especially prone to develop scoliosis. It is probable that at least in the investigated age groups the limitation in spinal function caused by scoliosis (in the case of curves with Cobb angles below 50°) may not be noticed by most of the patients.

In 96 scoliotic patients who had undergone spinal fusion in combination with a Harrington distraction procedure, the reduced postoperative lordosis emphasized the importance of surgical techniques that preserve the sagittal configuration, such as more caudal application of the distal distraction hook.

By introducing kyphometric measurements as a routine procedure in all spinal patients, we now have an objective noninvasive tool not only for following slowly progressing kyphosis and for epidemiologic studies, but also for preoperative and postoperative assessment of patients with low back pain, scoliosis, and vertebral fractures.

As a result of this study, we feel that at the present time the modified Debrunner kyphometer is the instrument most suitable to fully investigate the sagittal configuration and mobility of the spine in any patient with a spinal problem.

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Subchondral screw fixation in treating cervical hip fractures

Lars Rehnberg

Department of Orthopedics, University Hospital, S-751 85 Uppsala, Sweden

The aims of this study on cervical hip fractures were 1) to establish the incidence and time trend of incidence change of hip fractures in Uppsala County, 2) to measure the stability in the internally fixed fractures and correlate the stability with the clinical course, and 3) to present investigations and results in randomized trials of a new subchondral fixation technique.

The specific annual incidence of hip fractures in patients over 55 years of age in Uppsala County was computed for the years 1980 to 1987. The overall increase in specific incidence was less than 2 percent. The increase is mainly due to a shift in the background population. The number of fractures increases by approximately 4 percent annually.

The stability in cervical hip fractures treated with internal fixation according to the von Bahr technique was measured peroperatively. The fractures showing early complications, redisplacement within 8 weeks (early loosening), or nonunion all had significantly poorer stability than those that healed. In order to reduce the incidence of early instability complications, the so-called Uppsala technique was developed— a technique that utilizes the hard subchondral bone in the femoral head to increase the fracture stability. In a pilot study, there were no early complications with the new subchondral fixation technique. In two prospective randomized trials of the new technique against von Bahr screws and hook-pins, respectively, the new technique resulted in significantly fewer early complications.

To determine whether the screw fixation in the subchondral bone could deform the cartilage of the femoral head, combined arthrography and tomography was performed. With the screws in the correct position, no deformity in the cartilage of the femoral head could be detected.

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On prevention, diagnosis, and treatment of infection in total hip arthroplasty

Lennart Sanzén

Lund University Department of Orthopedics at Malmö General Hospital, S-214 01 Malmö, Sweden

Totally, 102 hips in 100 patients were revised in one or two stages for deep periprosthetic infection. New prostheses were implanted with the use of gentamicin bone cement. After 2 to 9 years, the infection in 77 hips was considered healed, resulting in an almost painless hip and near-normal walking ability. Previous multiple surgery, defective wound healing after the revision, and infection caused by more than one bacterial species implied a lower healing rate. Revisions for mechanical loosening had been performed in 8/77 healed cases, but radiographs revealed loosening in 61 percent of the cases followed for 5 years or more. Six months after revision, an ESR of 30 mm or less implied a good prognosis with respect to healing of the infection.

In 18/23 patients with periprosthetic hip infections, C-reactive protein (CRP) exceeded 20 mg/L before revision, whereas the ESR exceeded 30 mm in 14 of these 23 patients. In only 1 patient were both CRP and ESR below the levels mentioned. None of the preoperative CRP values in 33 patients revised for mechanical prosthetic loosening, and only 7 of the 233 postoperative values in 50 control patients exceeded 20 mg/L.

From the 1970s to the 1980s, an increasing proportion of the infections studied were caused by coagulase-negative staphylococci (CNS). Most CNS, cultured from the anterior nares of operating room staff and from patients preoperatively, were highly susceptible to antibiotics. Two weeks postoperatively 31 percent methicillin and 20 percent gentamicin resistance was found.

Air contamination in the operating room could be reduced to well below the suggested upper limit for ultraclean air (10 cfu/m^3) by combining the use of ultraviolet radiation and occlusive working clothes. Levels below 1 cfu/m^3 were regularly found in an ultraclean air enclosure when the operating team wore either a total body exhaust suit or occlusive working clothes under a nonwoven gown.

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Some aspects of the radiographic evaluation of total hip replacements

Björn Thorén
Department of Surgery, Mora Hospital, S-792 00 Mora, Sweden

The aim of this retrospective study of 194 Charnley total hip arthroplasties that have undergone a revision operation was to investigate possible radiographic signs of prosthetic loosening and infection found in the literature.

The prostheses were classified according to their state of loosening or infection at the revision. Information on the clinical firmness of the components was searched for in the records from the operation. The diagnosis of infection was based on cultures taken at the revision, the presence of fistulization, and the erythrocyte sedimentation rate (ESR). The radiographic appearance of the prosthetic components was compared with the clinical diagnosis.

The results arrived at in the first series of 102 prostheses revised between 1970 and 1980 were tested in a second series of 92 prostheses revised between 1981 and 1985. The radiologists examining the second series did not have any knowledge of the clinical diagnosis of the prostheses or the results of the first series. It was concluded that subsidence of the stem component by at least 3 mm, varus shift of the stem by at least 2°, and a radiolucent zone between the metal and the cement of the stem by at least 1 mm were associated with femoral component loosening in this material. Migration of the socket by at least 3 mm and tilting by at least 4° were associated with socket loosening. Cortical thickening and advanced ectopic bone formation were not associated with loosening or infection. Scalloping, periosteal reaction, and sclerosis at the stem were associated with infection in the first patient series, but not in the second one.

ESR played an important role in the classification regarding infection. The clinical relevance of this sign was evaluated in those hips that could be classified regarding infection on basis of peroperative cultures and sinus formation. ESR was found to be a reliable indicator of prosthetic infection.

The signs indicating a change in position of a prosthetic component usually require a comparison between the radiographs taken immediately after the primary operation and those taken more recently. The reliability of such a comparison may be questioned if the radiographic projections are not identical. To determine the apparent changes in socket position caused by improper positioning of the pelvis, a full-scale model of a pelvis with attached prosthetic sockets was examined radiographically in different rotational positions. The projected alignment of the socket indicator wire against the intertuberosity line was markedly influenced by the positioning of the pelvis. An alternative way of measuring the alignment is the use of the long axis of the projected ellipse of the outer circumferential groove of the socket polyethylene. The thus defined socket alignment was not influenced by the positioning of the pelvis within the investigated range. No apparent socket migration was recorded within the range of pelvic rotation and inclination studied.

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Long-term results of Charnley total hip replacement

Björn Wejkner

Karolinska Institute, Department of Orthopedics at Södersjukhuset, Stockholm, Sweden

The study comprises 390 Charnley total hip replacements (THR) done between 1968 and 1973. The hips were classified into four series: Consecutive, Bilateral, Younger (aged 60 years and under), and Older (over aged 60 years).

In the Consecutive series the clinical results were satisfactory in 92 percent of noninfected hips at 5 years; at 10 years 92 percent of the 5-year successes were again thus graded. The corresponding figures for the Bilateral series were 96 and 93 percent, respectively.

The results indicate the following: 1) the risk of clinical failure is not higher in elderly patients with rheumatoid arthritis than in those with arthrosis; 2) THR for complications of femoral neck fracture carries a high risk of failure in older patients; 3) men run a greater risk of failure than women; 4) the results of bilateral THR are as good as those of unilateral THR; 5) failure is more common after secondary than after primary THR; and 6) the slightly less satisfactory results of the Younger series can in part be explained by the larger proportion of men in this group.

Radiographic stem loosening was common (Consecutive 47 percent, Younger 50 percent, Older 46 percent), largely owing to imperfect cementation technique. At least two thirds of the stems were inadequately cemented.

Unsatisfactory cementation of the stem tip was significantly correlated with radiographic stem loosening. Varus position was associated with posterior orientation of the stem, which in turn was correlated with loosening. The rate of loosening varied from 16 to 77 percent depending on the thoroughness of cementation at the stem tip.

Male sex correlated with stem loosening, but progressive loosening was more greatly influenced by age than sex. In the Younger series the socket migrated more often in patients with rheumatoid arthritis than in those with arthrosis.

In the Consecutive series the clinical failure rates between 5 and 10 years were as follows: hips showing radiographically intact components at 5 years, 1 percent; hips with a loose stem that had migrated 4 mm or less at 5 years, 5 percent; and hips with still more marked stem loosening or a loose socket at 5 years, 28 percent. The corresponding figures for the Younger series were 2, 11, and 40 percent, and for the Older series 0, 0, and 28 percent, respectively.

In the light of today's improved operative technique, the low rate of stem loosening in hips with a well-cemented stem, and the satisfactory clinical results in the present series despite the many hips with poor cementation and component loosening, Charnley's THR may be considered as the management of preference even in patients aged about 50 years. Particular attention should be paid to stem loosening in men and to socket loosening in patients with rheumatoid arthritis.

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Cemented and noncemented total hip arthroplasty

Anders Wykman

Department of Orthopedics, Karolinska Hospital, S-104 01 Stockholm, Sweden

A study has been carried out to compare cemented with noncemented total hip replacement. As the cemented variety, the Charnley prosthesis was chosen; and as the noncemented one, the Honnart Patel-Garches prosthesis (HP-Garches) was selected. Totally, 150 patients with arthrosis, rheumatoid arthritis, and miscellaneous conditions were randomized into either of the two groups with 75 each. In all respects the groups turned out to be similar.

The follow-up was conducted over 5 years with postoperative examinations at 6 months, 1 year, and then annually. The results at 3, 4, and 5 years were identical for each patient. Each examination involved clinical assessment, objective gait analysis, and radiographic examination. In some patients roentgen stereophotogrammetric analysis, stabilometry (analysis of postural stability); and an investigation of hemostatic mechanisms (cascade systems) was carried out.

The results indicated that the Charnley group improved faster than the HP-Garches group during the first 2 years. At the last follow-up the results were excellent or good in 79 percent in the Charnley group and 70 percent in the HP-Garches group (NS). The reason for inferior results at 6 months in the HP-Garches group was mid-thigh pain. This occurred in 64 percent.

Standard radiography revealed radiolucent zones in both groups, but this could not be related to the clinical outcome despite radiolucency being present in all the noncemented replacements on the femoral side. In the HP-Garches group the orientation of the stem was neutral in 26 percent and varus in 74 percent. Ten percent were in varus at the initial examination, whereas 64 percent shifted into varus with time.

In 35 hips the noncemented acetabular component appeared incompletely covered by bone, but this had no relation to clinical outcome.

The roentgen stereophotogrammetric analysis revealed that after 2 years, seven out of eight femoral components in the HP-Garches group had subsided 0.6 to 3.9 mm, and this did not influence the clinical outcome.

Objective gait analysis confirmed inferior clinical results at 6 months in the HP-Garches group. There was no significant difference between the groups at the last follow-up.

Postural stability was improved following total hip replacement in both cemented and noncemented groups, and there was no significant difference between the groups.

Despite thromboprophylaxis a marked activation of the coagulation, fibrinolytic, and kallikrein systems occurred in relation to hip replacement irrespective of the use or nonuse of bone cement and irrespective of volume of blood loss during surgery.

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