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A biomechanical model of the upper extremities—inverse and forward simulations, and some clinical applications

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Direct measurement of forces within the human body is in general not feasible. The only possible way of predicting muscular and articular forces is by means of biomechanical models. Subsequently, these forces can be compared with presenting symptoms. A three-dimensional model of the upper extremity has been developed, consisting of the thorax, clavicle, scapula and humerus. Recent additions are the ulna and radius, and the humeroulnar and radioulnar articulations between them.

All muscles and extracapsular ligaments overlying these articulations are represented in the model. In the inverse simulations the model may be used to calculate muscular forces for a given movement and external symptoms. In the forward simulations, the effect of a change of muscle activation on the resulting movement can be studied.

Optimization of these changes makes it possible to analyse the neuromuscular strategy. So far, the inverse model has been used for the prediction of optimal fusion angles in a shoulder arthrodesis, in a sensitivity analysis of relevant parameters of a glenohumeral endoprosthesis, and for the calculation of muscular forces and supplied power in manually driven wheelchairs. For better understanding of the results by inexperienced users, the model has been combined with a visualization program of musculoskeletal systems (SIMM, Musculographics Inc.), with which it is possible among other things to visualize the movements of the bones, the localization and course of muscles and the active muscles.

Collection of morphological data for elbow and shoulder modelling

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Introduction: A valid and reliable biomechanical modelling of the upper extremity can contribute substantially to the diagnosis and treatment of arm/shoulder symptoms and to the study of fundamental aspects of intermuscular coordination. For the expansion of an existing three-dimensional model of the shoulder in the distal direction, supplementary information concerning the moment arms of the muscles overlying the elbow is required.

Method: A total of five upper extremities (4 right, 1 left) were removed at scapular level from four fresh cadavers after collection of anthropometrical data. The arms, still completely intact, were attached by the scapula to a measuring table leaving the arm to hang completely free. After fixation of measuring sensors of a 3-D electromagnetic digitizer (Isotrack, Polhemus) in the scapula, humerus, ulna and radius, the arms were moved passively in a selection of standard directions (flexion/abduction/endorotation, flexion/pronation). During every measurement, the orientation of every sensor was recorded at a frequency of 10 Hz.

Following the above-mentioned measurements, the positions of anatomical landmarks, origins and insertions and shapes of relevant structures were digitalized locally on every bone.

These measurements were carried out in relation to the sensor previously attached to the bone. To conclude, weight, volume, bundle length and pennation were determined of the muscles prepared free.

Results and Discussion: The measurements described constitute a data set including not only the exact positions of origins and insertions, but also the corresponding (passive) movement possibilities. This implies that the data collected can be used not only for calculations of moment arms, but also for the exact determination of the position of articular axes in three dimensions. Application of these data in the modelling renders possible the exact calculation of individual muscle contributions to movements and the corresponding force directions in articulations.

Variation in the scapulo-humeral rhythm due to projection effects

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The movements of the clavicle, the scapula and the humerus are determined by the degrees of freedom of movement in the sternoclavicular, the acromioclavicular and the gleno-humeral joint, the scapula-thoracic sliding surface and the forces exerted on the bones by ligaments and muscles. The scapulo-humeral rhythm is described in the literature for standard movements: bidimensionally measured angle between the scapula and the humerus. Inman et al. (1944) defined the scapulo-humeral rhythm as the quotient of the arm-elevation angle a and the scapular angle th .

They found this ratio to amount to 3.25. After them, several other authors have described the scapulo-humeral rhythm, reporting values ranging from $2.27 < a/th < 3.69$.

The differences may be attributed on the one hand to the fact that different populations of test persons were used. On the other hand, the differences in the scapulo-humeral rhythm may be explained by differences in the observed structures (glenoid, spina, medial edge) and the direction of the fluoroscopy or the projection (A-P, scapular plane) in which the radiographs were made. A simulation of a radiographic experiment brought to light that the complete range of scapulo-humeral rhythms can be explained on the basis of the above-mentioned choice of structures and projection direction.

A simulation of a radiographic experiment was carried out using the data from a three-dimensional movement registration (by means of palpation, Pronk 1991). The standard distance from the roentgen source to the test subject was 0.80 m, the distance from roentgen source to imaging plate was 1.00 m.

It follows from the simulation of one single scapular abduction movement in an A-P projection that the a/th ratio for the spina equals 2.6, while that for the medial edge equals 3.6.

The spina is a wide edge and as such not clearly to be recognized in the radiographs. The inaccuracy with which this structure can be recognized in a radiograph leads to a peak-peak spread of $2.1 < a/th < 3.3$.

The variation in the projection angle leads to a variation in the scapulo-humeral rhythm. The a/th ratio for the spina in the A-P projection is 2.6. When the projection is rotated to the 'scapular plane', the a/th ratio increases to 3.6. This leads to the conclusion that the scapulo-humeral rhythm is highly sensitive to the angle of fluoroscopy or projection.

It may be deduced from this simulation that the validity of the published data as a control group for examinations of patients has become highly doubtful. Since correction for the projection effects is not possible without additional accessories, it is not advisable to use bidimensional methods to describe the three-dimensional shoulder movement. In a rigidly standardized protocol, on the other hand, an intra-individual comparison of scapulo-humeral rhythms is admissible.

Contraction patterns of shoulder muscles at different external loads

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Investigations of muscular function by means of EMG studies, cadaver models and computer models are done as a rule with a fixed load, often of the magnitude of the weight of the arm. The following experiment was carried out in order to determine whether the contraction pattern of shoulder muscles depends on the magnitude of the external load.

The EMGs of 12 shoulder muscles including three rotator cuff muscles of five test subjects were recorded during isometric exertion of force. With the upper arm fixed in a cuff, force was delivered in 12 directions in a plane perpendicular to the axis of the humerus (steps of 30°, together making a closed circle around the humerus). The magnitudes of the forces delivered amounted to 2, 4 and 6 kg and maximal force in succession.

Plotting the mean EMG against the direction of the force provided unique patterns for each individual muscle, with a distinct peak activity in a particular direction of the force and a silent part. These patterns were found not to change distinctly with increasing force exerted.

This indicates that the shoulder muscles are only active in their favorable direction, even during maximal exertion of force. No evidence was found of the expected phenomenon of 'bringing in' less favorably situated muscles with increasing force.

Proprioceptive function of the gleno-humeral joint

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Objective: The objective of the investigation was to evaluate the proprioceptive capacity, if any, of the gleno-humeral articulation. This investigation consisted of three studies.

Histological study

Material and methods: The articular capsules and the gleno-humeral ligaments of 12 human shoulders were examined histologically by means of optic microscopy. Serial sections of 15 micrometers were collected. The tissue was stained with hematoxylin-eosin and by the Van Gieson method. Specific identification of the neural elements was done with the aid of a special silver impregnation technique, as described by Novotny, with the staining of axons in peripheral nerves.

Results: The ligaments were found to contain axons of different diameters ranging from 0.2 μm to 70 μm . Close to the humeral surface we found small nerves forming neurovascular bundles. Inside their connective tissue sheaths the axons showed a serpentine configuration, possibly providing extra length and allowing stretching of the nerve during movement. Most of the axons discovered were situated in the subsynovial layer of the ligaments. In general, the diameter of these subsynovial axons does not exceed 10 μm . Apart from these axonal structures we found nerve endings that can be classified as type II mechanoreceptors according to Freeman and Wyke (Vater-Pacini corpuscles). These mechanoreceptors had diameters of approximately 150 μm . They were also situated immediately below the synovial membrane and close to the humeral insertion site of the ligaments.

Clinical study

Material and methods: We evaluated the proprioceptive function of the gleno-humeral joint by means of an angle reproduction test in 27 healthy volunteers (9 females, 18 males). The volunteers were asked to hold the arm in different positions with and without visual control. The test was carried out with the dominant as well as with the non-dominant extremity. The following articular positions were measured: 50°, 100°, 150° abduction; 50°, 100°, 150° flexion; +45°, 0°, -45° rotation at 90° abduction. The articular positions were recorded by means of a movement-analysing system with passive reflecting markers.

Results: The results showed significant differences between measurements with and without visual control. The proprioception appears to be poorer below shoulder level (50° abduction, flexion). Two volunteers with generally good coordination had better results than the group as a whole. We found no demonstrable differences between the dominant and the non-dominant extremity, or between males and females.

Neurophysiological study

Material and methods: In eight patients subjected to operation because of subacromial pathology, peroperative stimulation of the anterior gleno-humeral articular capsule was carried out. The stimulation was provided using a bipolar electrode in a non-conductive medium. Simultaneously, we recorded the EMG signals (using needle electrodes) of the deltoid, trapezius and pectoral muscles and the rotator cuff muscles.

Results: Technical problems prevented completion of the measurements in one patient. In all other patients, positive EMG scores of at least three muscles were obtained.

Clinical relevance: The above-mentioned neural structures in the gleno-humeral ligaments and the positive EMG scores after electric stimulation of the capsule of the gleno-humeral joint are of considerable clinical importance in view of the high incidence of recurrent dislocation of the shoulder and accessory Bankart lesions. The mechanoreceptors in the gleno-humeral ligaments possibly control the stabilizing shoulder musculature. We also observed a slight variance of the

proprioceptive function of the gleno-humeral joint in healthy volunteers. It follows from this premise that rupturing or detachment of these ligaments may lead to the loss of a feedback possibility.

The effect of a plaster corset on lumbosacral mobility

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Currently there exists a controversy in orthopedics about whether or not a plaster corset has an immobilizing effect on the lumbosacral (LS) area. This corset, with or without a pipe, is applied preoperatively to simulate the effect of a spondylosis or postoperatively for temporary support of the spondylosis.

Ten successive patients, admitted to our clinic for a trial fixation according to Olerud, were selected for this study. Two transpedicular screws were inserted subcutaneously into the body of L4 or L5 and two other screws into the sacrum. Reflecting markers were attached to the ends of these screws and the movements of these ends in relation to each other, which corresponded directly to the movements of the lumbosacral area, were recorded three-dimensionally (3-D) with the aid of an opto-electronic system named Primas. The patients were asked to bend over maximally, to tilt the pelvis in various directions and to walk, first without wearing a corset. Subsequently, these exercises were repeated in a plaster corset, first with then without a pipe. The 3-D movements were recorded as translations and rotations. The most significant movements proved to be rotations in the sagittal plane. Statistical analysis (3-way ANOVA) showed that neither of the plaster corsets significantly impaired the lumbosacral movements, and it was concluded that if a patient experiences relief of symptoms in a plaster corset, it should not be concluded immediately that immobilization by means of a spondylosis is indicated.

Adhesion of bone to plasma-sprayed apatite coatings—effect of gap width and coating stability in a goat model

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Introduction: Hydroxy-apatite (HA) coatings improve the adhesion to bone of orthopedic implants, particularly under

suboptimal conditions, such as 'non-press fit' implantation (Søballe 1991). We investigated the questions if there is a maximal gap width that still permits adhesion of bone to apatite coatings and whether this is influenced by the solubility of the coating.

Methods: Cylindrical Ti-6Al-4V plugs with spacers 1 or 2 mm high on both endings were coated with 30% or 62% crystalline HA or 95% crystalline fluoro-apatite (FA). Identical uncoated grit-blasted implants served as controls. Four plugs were implanted into precondylar trabecular bone on both femurs of goats (N=16); the follow-up period was 6 weeks. Optic microscopy and histometry (percentages bone contact and bone fusion) were carried out.

Results: There was direct bone contact on the coated implants with 1 mm gap width, as well as ingrowth of bone from surrounding bone tissue and from the coating.

Coated implants with a 2 mm gap, on the other hand, showed hardly any bone contact at all. Bone ingrowth from the surrounding bone approached the coating but remained separated from it by a layer of connective tissue.

Blanc titanium implants had no bone contact either with 1 or with 2 mm gaps, but did show deposition of connective tissue.

The differences between 1 and 2 mm gaps, and those between uncoated plugs and each of the coatings were significant. The differences between the three coatings were not significant.

Discussion: When apatite coatings were used, bone bridged wider gaps than when uncoated implants were used. The above results suggest that this effect is limited to a maximal gap width. The solubility of the coating causes no significant difference in bone contact and bone fusion in the presence of a gap.

Monoclonal antibodies recognizing antigens specific for chondrocytes

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Introduction: Chondrocytes isolated from arthrotic cartilage show a behavior different from that of chondrocytes from normal cartilage. For this reason, in this study we attempted to find specific markers for chondrocytes in arthrotic cartilage.

Material and methods: Cartilage was collected from the operation room at implantation of a total hip prosthesis in case of arthrosis or a medial fracture of the femoral neck. Chondrocytes were isolated from microscopically healthy articular cartilage and from arthrotic cartilage (Mankin score) by means of collagenase digestion. The cells were cultured for 5 days as high-density cultures in minimal essential medium (MEM) and for one day in methionine-free MEM containing 50 μ Ci/mL [³⁵S] methionine. The cells were washed and lysed and two-dimensional polyacryla-

mid gel electrophoresis (2D-PAAGE) was carried out with the total cell lysates. Five proteins were detected that were absent from one of the two samples. One of these proteins, a 35-kDA protein, was isolated from the gel and used to immunize mice. A number of monoclonal antibodies (Mab) were obtained which were tested by immunohistochemistry on ethanol-fixed paraffin-embedded fragments of cartilage. One section contained healthy as well as arthrotic cartilage. Total cell lysates were also used for Western Blotting to determine the size of the antigens. Other tissues that were stained with the antibodies were collected from the department of Pathology, University Hospital of Maastricht.

Results: Comparison of the 2D-PAAGE proteins patterns of lysates of chondrocytes from normal and from arthrotic cartilage proved that the profile of 'arthrotic' chondrocytes contained four proteins that were not encountered in the profile of 'healthy' chondrocytes. One protein appeared to be specific of 'healthy' chondrocytes and was not present in the lysate of 'arthrotic' chondrocytes. The molecular weights were 68, 38, 35, 47 and 24 kDA, respectively. To begin with, a protein of 35 kDA was chosen to produce Mabs against. From the Mabs obtained, two were selected. Mab 3C9 and Mab 4C11 stain the cytoplasm of chondrocytes in the middle layer of articular cartilage. They were selected because they stained the chondrocytes in arthrotic cartilage more intensely than the chondrocytes in normal cartilage. The Mabs were tested on a panel of different tissues. Mab 3C9 was found not to stain any other cell types, while Mab 4C11 showed some reactivity with nervous tissue. Mab 3C9 was found to recognize two protein bands in a Western Blot, of 75 and 35 kDA. Mab 4C11 stained a protein band of 71 kDA. Seventeen samples of cartilage with different degrees of arthrosis were stained with the Mabs. No correlation was found between the degree of arthrosis and the degree to which the various samples were stained by the two antibodies.

Conclusion: Two monoclonal antibodies were prepared, of which Mab 3C9 recognizes an antigen specific of chondrocytes. There was no correlation between the degree of staining and the degree of arthrosis. Major individual differences were found to occur. This may be due to the fact that the antigens are also individual-specific. Another possibility is that the antigens are related to the arthrotic process, but that the strong individual differences in activity of the disease result in different expression of the antigens and the chondrocytes in question.

The effect of stem roughness on the failure behavior of cemented hip prostheses

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Introduction: The lifespan of a cemented hip prosthesis depends on the patient, the surgeon and prosthesis-related factors. Important prosthesis-related factors are the shape of the prosthesis and the materials chosen. Consequently, in recent

years more and more articles have been published concerning the optimal conditions of the prosthesis surface. Should a cemented prosthesis be treated in such a way that it adheres well in the cement casing (for instance a rough surface, or a so-called pre-coating) and what are the consequences of loosening of this type of prosthesis? Or should the surface rather be as smooth as possible, to minimize damage in case of loosening?

Method: In order to gain more insight into these problems, prosthetic cones were implanted in cement casings and exposed dynamically to a maximal load of 7000 N for a period of 1.7 million cycles. The cones varied in roughness from 0.2 (polished) to 11 (very rough prosthesis surface) micrometers, so that the influence of this parameter on the failure process over time could be followed. The experiments were simulated with the aid of a computer model (the so-called finite elements method).

Results: Loosening of the cone/cement segment occurred in all test cases. Although it was found that the smooth cones slipped down farther into the cement casing, damage to the cement casing was substantially less than with rough cones. The pattern of the slipping also differed. The rough cones slipped down gradually into the cement casing, while smooth cones did so stepwise. It appeared from the computer simulations that the stepwise descent could be attributed to stick/slip phenomena between the polished prosthesis surface and the cement casing in combination with creep of the bone cement.

Conclusion: It could be concluded from this study that cemented prostheses with a rough surface constitute a potential danger when the prosthesis comes loose from the cement casing. Under the influence of the cyclic loading, this type of prosthesis may exert a rasp-like action which in its turn can give rise to formation of a soft tissue layer at the cement-bone interface. An additional interesting aspect is that this mechanism may also occur in case of relatively little 'slipping down' of the prosthesis. This is why the functioning of a prosthesis cannot be investigated completely by considering only the pattern of slipping down. The surface of the prosthesis should also be included in the evaluation.

In the last few decades much work has been done toward reinforcing the prosthesis/cement interface. However, as long as this attachment cannot be guaranteed for a sufficiently long period, the question should always be considered what the consequences will be in case of its eventual failure.

Kinetics of the bone-implant interface—differences in early healing between cortical and trabecular bone

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Introduction: Healing and fixation of (uncemented) prosthetic materials in bone have been subjects of extensive research in recent years. It is highly probable that healing in the early postoperative period is important for the long-term success of an implant. However, very little is yet known about this subject. For this reason, a study was made of the development of the bone-implant interface from 3 days to one month after implantation of various materials into cortical and trabecular bone.

Materials and methods: Use was made in this study of four types of implants (cylinder shape, 3.0 x 5.0 mm): Ti6Al4V coated with fluoro-apatite (FA) or hydroxy-apatite (HA), uncoated Ti6Al4V and pure titanium (Ti). These plugs were implanted press-fit into 24 rabbits (NZW), after careful boring out, in the medial and lateral condyles of the left and right femurs, and in the cortical bone of the proximal metaphysis of the left and right tibiae (two implants per tibia). After follow-up periods of 3, 7, 14 and 28 days (six animals per period), the animals were killed and sections for histological examination were prepared of the implants with surrounding bone. The quantity of bone in contact with the implants was quantified with the aid of an IBAS image-processing system. The differences in bone contact between the materials were analysed per follow-up period by means of ANOVA and Scheffe's test ($p \leq 0.05$), and the evolution of the bone contact over time was studied for the individual materials by multiple regression analysis.

Results and Discussion: Cortical bone: In cortical bone, 3 days after implantation, mostly lamellar bone was found in contact with the implants. This was probably due to the press-fit implantation procedure. During subsequent periods, this bone was resorbed from the endosteal side by osteoclasts, followed by migration of mesenchymal cells/osteoblasts along the interface. This led to the formation of new bone, and after 28 days new lamellar bone with a different orientation was found in contact with the implant surfaces. No distinct histological differences between the four materials could be observed during these relatively brief follow-up periods. The bone contact measurements revealed a wide variation, and with ANOVA no statistically significant differences between materials were found. Regression analysis showed that, although the proportion of explained variance (R^2) was relatively small, there was a tendency in press-fit implantation for the quantity of bone contact to decrease in the course of the postoperative period, followed by a period of new increase. A possible explanation of this is remodelling of bone, which in the case of cortical bone has to be preceded by resorption before new bone can be formed along the interface.

Trabecular bone: In trabecular bone, 3 days after implantation, both lamellar bone (trabeculae) and blood clots were observed along the interface. After 7 days, a beginning of remodelling of the bone along the interface was visible, with in the cases of FA and HA implants deposition of osteoid, mostly directly on the surface of the implant. Deposition of osteoid directly on Ti6Al4V and Ti implants was observed only very rarely. All implants after 28 days showed a situation with new lamellar bone or bone marrow in contact with the implant. After 14 days, the amount of bone contact was

significantly larger for FA than for Ti implants, and after 28 days, FA, HA and Ti6Al4V plugs all had a larger percentage of bone contact than the Ti implants. The observation that Ti6Al4V after 28 days showed bone more contact than Ti cannot yet be adequately explained. Regression analysis revealed a different situation in the cortical implants: an initially relatively small amount of bone contact increasing over time. Differences between the materials took some time (14 days) to manifest themselves.

Conclusion: Cortical and trabecular bone differ with regard to the kinetics of the bone-implant interface. Cortical implants after implantation first show a decrease of the amount of bone contact, the trabecular implants an immediate increase. This suggests that for cortical implants there exists a kind of 'critical period' during which the integration in bone, and possibly therefore the fixation as well, are less than during the immediately postoperative situation.

MRI of the shoulder after a first dislocation

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Introduction: A prospective study was made of 35 patients after a first shoulder dislocation. All patients within one week after the injury were subjected to an MRI examination to establish possible intra-articular abnormalities.

Results: Hearnarthrosis was observed in all patients. The rotator cuff showed lesions in 15 patients, consisting of a distinct rupture in five. Hill-Sachs defects (an impression fracture of the head of the humerus) were seen in 29 and complete articular lip lesions in 22 patients. Sixteen of these 22 patients had a Bankart lesion (avulsion of the anterior shoulder capsule). Neither articular lesions nor Hill-Sachs defects were related to age, sex or type of injury. The Kocher repositioning method (repositioning by adduction/endorotation) more frequently resulted in severe damage to the articular lip and humeral head.

Chronic instability developed in 12 patients. Articular lip lesions and Hill-Sachs defects were related to this instability. In nine out of 16 patients with a Bankart lesion, instability persisted. Chronic instability developed in two of the 11 patients with no or minimal articular lip lesions. Chronic instability did not occur in eight patients without a Hill-Sachs defect, but it did occur in eight out of 14 patients with a large defect.

Conclusion: No relation of the abnormalities with age was seen. However, there was a distinct relationship between articular lip lesions and development of a chronically unstable shoulder.

How useful are the sagittal oblique MRI and the supraspinatus outlet view for determining the shape of the acromion?

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Introduction: For the diagnosis of the impingement syndrome (in which the rotator cuff becomes wedged below the acromion) of the shoulder, use is frequently made of the radiographic supraspinatus outlet view because of the postulated relationship between the shape of the acromion and the occurrence of pathology of the rotator cuff.

The shape of the acromion is classified into three types according to Bigliani. Currently, the shape of the acromion is also assessed on the basis of the sagittal oblique MRI image of the shoulder.

The objective of this study was to establish the inter-observer variability in assessing the radiographic supraspinatus outlet view and the sagittal oblique MRI, and the correlation between the assessments of the two imaging techniques.

Method: Of 38 patients, 16 males and 22 females, a sagittal oblique MRI study was made 28 times and a standardized supraspinatus outlet view radiograph was made 51 times (bilaterally in 13 cases).

Of 22 shoulders, both a sagittal oblique MRI and a supraspinatus outlet view radiograph was obtained.

The shape of the acromion was evaluated according to a classification previously described, based on the Bigliani classification, by two orthopedic surgeons and two radiologists.

Results: Three examiners agreed on the classification of 25 of the 51 supraspinatus outlet view radiographs, while 13 times all four scored identically.

Three of the four examiners agreed on ten of the 28 sagittal oblique MRI images, while in eight cases all four agreed.

Regarding the 22 shoulders of which both an MRI and a supraspinatus outlet view radiograph were available, there were only 43 cases (out of 88 assessments) in which the MRI and the conventional radiograph were classified identically.

In this group, the clinically most interesting classification, Bigliani 3, was scored on the MRI in 12 shoulders (14%) and on the conventional radiograph in 26 shoulders (30%).

Conclusion: The reproducibility of the classification of both the sagittal oblique MRI and the supraspinatus outlet view radiograph were found to be low; accordingly, the clinical usefulness is doubtful.

The value of postoperative MRI examination of the shoulder after partial acromion resection according to Neer and repair of the rotator cuff is only limited

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Introduction: Little attention has been paid so far to the changes that occur in the MRI image of the shoulder after surgical treatment.

Method: In a group of 18 patients subjected to a partial acromial resection according to Neer with or without repair of the rotator cuff, an MRI of the operated shoulder was made after an average of 52 months. These MRI images were compared with the preoperative MRI findings, for which use was made of a scoring system developed in Leiden, and with the peroperative findings. The shape of the acromion was also taken into account; Bigliani's classification was used. Subsequently, the changes of the MRI were compared with the postoperative function of the shoulder, assessed according to the UCLA scoring system.

Results: The preoperative MRI images showed eight flat acromions (Bigliani type 1), eight curved acromions (Bigliani type 2) and two hooked acromions (Bigliani type 3). Postoperatively, the shapes of 16 acromions were unchanged. Only two acromions were changed from type 2 into type 1.

Of the four patients whose postoperative MRI showed a reduction of the supraspinatus tendinitis image, three had good clinical results. Of the nine patients with unchanged postoperative MRI, seven had good clinical results. The clinical result in the patient whose postoperative MRI image was poorer was also good. The remaining four patients only showed changes in the T1 weighted image or the T2 weighted image. The patient with changes in the T2 weighed image had a poor postoperative UCLA score.

The postoperative MRI of six patients showed a rupture of the cuff, in spite of the fact that in five of them the cuff had been repaired surgically with good clinical results in four cases. In the sixth patient, an intact cuff was seen at operation. This patient, also, had a good postoperative UCLA score.

Conclusion: In this study, no correlations were found between the changes observed in the postoperative MRI images after Neer acromioplasty with or without repair of the cuff, and clinical functional recovery. It was interesting to note that the shape of the acromion in most cases remained unchanged, which fact is possibly connected with the planigraphic image at MRI examination. The value of the postoperative MRI examination is probably restricted by functional scar tissue.

Prospective comparative study of CT arthrography and MRI of the shoulder joint

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Introduction: The MRI technique provides a new possibility of non-invasive diagnostic examination of the glenohumeral joint. The present prospective study was carried out to investigate the diagnostic value of MRI in relation to CT arthrography on the basis of pathology observed at operation.

Patients and method: The tentative diagnosis of injury of the glenoid lip was made on the basis of anamnesis and physical examination in 31 shoulders of 30 patients, mean age 29.4 (10–42) years, who had not previously undergone shoulder operations. After examination by both CT arthrography (CT-A) and MRI of the shoulder joint, arthroscopy or arthrotomy was carried out.

The lesions encountered at operation were used as the criterion of assessment of the radiological interpretations by three radiologists without surgical information. Attention was given to anterior glenoid lip injuries and SLAP injuries.

Results	Anterior		Glenoid lip	
	CT-A	MRI	CT-A	MRI
Sensitivity	96	92	40	80
Specificity	50	83	88	88
Accuracy	87	90	81	74

Conclusion: MRI is a non-invasive diagnostic examination of the shoulder joint with sensitivity and accuracy comparable to those of CT-arthrography in injuries of the glenoid lip. MRI should be the radiological examination of first choice.

Results of surgical treatment of the grating scapula

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Introduction: The grating scapula may cause a symptomatology consisting of pain at the cranio-medial side of the scapula. The condition may be caused by bone tumors over the thoracic surface of the scapula, but frequently, no radiographic abnormalities are visible. The present study was concerned with the results of osteotomy of the superior angle and medial release of the scapula, in 15 patients with a grating scapula without 10-42 abnormalities.

Material and method: Fifteen patients (15 shoulders) between 1991 and 1994 were subjected to osteotomy of the superior angle and medial release of the scapula. The diagnosis

was made on the basis of history and clinical findings. All patients had been given a local injection of lidocaine to confirm the diagnosis. Postoperatively, scores were kept of pain (visual analog score), function (0–10) and personal well-being, as well as an overall score.

Results: The results after 3 months were good to excellent in 12 patients. Two patients had the same condition as prior to the operation. The result in one patient was poorer than in the preoperative situation. The postoperative function was good in all patients.

Conclusion: Surgical treatment of the grating scapula gives a good result in approximately 80% of the patients.

Arthrodesis of the shoulder—indication, technique and complications over a period of time

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Introduction: During the period 1955–1990, shoulder arthrodeses were performed 42 times. The indications and technique changed over time.

Method: The anterior approach was used in the period 1955–1974. The cartilage of the head of the humerus and glenoid cavity was removed and fixation effected by means of one or two perarticular compression screws. The shoulder was immobilized exteriorly in a plaster corset for a considerable period of time.

An external fixation system was used in the period 1974–1978.

After 1978, a large fragment of AO tibia plate was positioned via the posterior approach over the scapular spine and proximal humerus, in combination with perarticular compression screws. This was followed by a brief period in a plaster corset.

Indication: The patient population with a shoulder arthrodesis in our clinic changed with time. Patients in the early stage mostly presented with paralysis due to poliomyelitis, later patients with paralysis due to a traumatic plexus injury. The total group consisted of 23 cases of traumatic plexus injury, eight of poliomyelitis, five of obstetric plexus injury, five of arthrosis and one of an unsuccessful arthroplasty.

Results: With the plate fixation technique, the patients could be mobilized after 6 weeks without plaster. Use of only screw fixation necessitated plaster immobilization for 3 to 6 months. The final result depended in part on the position of the arthrodesis, optimal results being obtained with 30° flexion, 30° abduction and 30° internal rotation.

Complications: Complications were seen in nine cases: four in the period before 1978, viz. two infections and two pseudarthroses, and five in the period after 1978, three fracture of the proximal humerus beneath the plate fixation and two malunions of the arthrodesis due to insufficient internal rotation.

Conclusion: After 1980, this operation was performed mostly in patients with brachial plexus injury. The best and most rapid results were achieved with the dorsal plate fixation technique. In general, 30° abduction, 30° flexion and 30° internal rotation were found to be optimal. Patients with a non-functional hand require more internal rotation so that the forearm can be carried along the body with the elbow in flexion.

1–9-year results of the Souter-Strathclyde elbow prosthesis in patients with rheumatoid arthritis

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Introduction: Hinge prostheses for the elbow often undergo mechanical loosening. The components of the Souter-Strathclyde prosthesis are connected in a less rigid way. The objective of our study was to describe the medium-long term results of this type of prosthesis.

Patients and methods: Between August 1985 and September 1993, primary total elbow prostheses were implanted 40 times in 32 patients (9 males and 23 females), all with severe destruction of the elbow joint due to rheumatoid arthritis. The study was prospective and part of the multicenter trial of Souter (the designer of the prosthesis). The elbows were classified roentgenologically according to Larsen et al. For all operations, the postero-lateral approach was used.

Results: There were six postoperative complications: twice, a fracture of the medial humeral condyle, treated by osteosynthesis; once an olecranon fracture, treated conservatively. Ulnar nerve injuries occurred twice, followed once by spontaneous recovery. One patient developed a recurrent dislocation, followed 7 weeks postoperatively by revision with an excellent result after 8 years.

Five patients (7 prostheses) died during the follow-up period of non-related causes. The results of the 33 remaining prostheses, with a mean follow-up of 5 (1–9) years were as follows: considerable reduction of pain in virtually all patients, as well as distinct improvement of function (flexion improved by a mean of 18°, pronation by a mean of 17°, supination by a mean of 27°). Two cases of aseptic loosening of the humeral component were seen, after 3 and 6 years, respectively, in two highly active patients. One patient refused revision; in the other a hydroxy-apatite-coated stem was implanted, which showed good osseous integration. In two other (male) patients, meanwhile deceased, loosening of the humeral component was observed; loosening of the ulnar prosthesis was never seen.

Summary: The results in the medium-long term of the Souter-Strathclyde elbow prosthesis are good to very good, but the warning is necessary that in highly active patients the risk of aseptic loosening of the humeral component is still considerable. Primary implantation of a HA-coated humeral component should be considered in such patients.

Complications in total elbow prostheses

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Introduction: The literature shows that the principal complications after total elbow prostheses are, in the following proportions of the cases: loosening 2–5%, infection 7%, dislocation 8% and ulnar nerve neuropathy 2–26%.

The various complications after a total elbow prosthesis are discussed on the basis of the first 51 total elbow arthroplasties according to Souter-Strathclyde (Howmedica, Haarlem) performed in Leiden, 1982–1990, with a mean follow-up of 4 years and a minimum follow-up of one year.

Loosening: The percentage of loosening in the series of total Souter-Strathclyde elbow prostheses implanted in Leiden amounted to 4% (2 patients). 6% (3 patients) showed radiographic loosening, but with insufficient clinical symptoms to justify a revision operation.

Infection: Infections occurred in 4% (2 patients), one early and one late infection. Both prostheses were removed. Re-implantation was performed in the female patient with the early infection, with good results, although she functioned adequately with the resection arthroplasty.

Dislocation: Postoperative dislocation occurred in 8% (4 patients): three dislocations immediately postoperatively, the fourth 6 weeks postoperatively when the patient, threatening to fall downstairs, seized hold of the bannister.

Ulnar nerve neuropathy: 14% (7 patients) postoperatively displayed an objectively demonstrable neuropathy of the ulnar nerve which had not been present before operation. One of these patients initially also showed loss of motor function, with normalization one year postoperatively.

Other complications after total elbow arthroplasties such as wound/skin problems, triceps insufficiency, ectopic bone formation and pre- and postoperative fractures, played no substantial part in our series and were limited to incidental cases.

Conclusion: Complications are much more frequent after total elbow prostheses than after total hip and total knee prostheses. The elbow joint, due to its structure and localization, is more vulnerable, so that complications will occur more readily.

Hemiarthroplasty of the shoulder with the isoelastic Mathys prosthesis

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Introduction: Shoulder arthroplasty has evolved so much in recent decades that good results can be obtained in particular concerning mitigating pain. Restoration of function and mobility, however, depend largely on the quality and the possibility of repair of the rotator cuff.

The objective of the present study was to assess the results of isoelastic hemiprotheses (Mathys, Switzerland). In view of the fact that the shoulder is a non-weight carrying articulation, a hemiprosthesis of the isoelastic type was chosen (Burri et al.).

Patients and methods: Hemiarthroplasty with a prosthesis was performed 34 times since 1980 in 33 patients. Indications were multifragmented fractures of the head of the humerus (15), rheumatoid arthritis (10), tumor (5) and post-traumatic osteoarthropathy (4). Male/female ratio 10:23. Mean age was 66 (43–78) years. All the operations were performed by the anterior approach. When the long biceps tendon could not be utilized for reconstruction of the rotator cuff, use was made of the short biceps tendon. Reconstruction was always followed by after-treatment with an abduction splint for 6 weeks. The results were assessed according to the shoulder score of Constant et al.

Results: No postoperative complications were seen. Follow-up was possible in 26 patients. Seven had died: 3 rheumatoid arthritis, 3 tumor and one posttraumatic osteoarthritis (age 91 years). The most striking aspect was the dramatic mitigation of pain in virtually all cases (Table 1), but strength and mobility also showed improvement (cumulative results in Table 2). Two patients had to undergo revision after 4 and 10 years, respectively, because of progressive glenoid destruction. Sixteen patients were highly satisfied, six were satisfied and four were fairly satisfied with the result obtained.

Discussion: Hemiarthroplasty of the shoulder gives rise to few complications and gives a very good result where mitigation of pain is concerned. It is particularly in rheumatoid arthritis that repair of the degenerated rotator cuff is only partially possible, so that the functional result is also poorest in these cases (Table 2).

Table 1. Pain score (max. 15 = no pain)

	Preop.	Follow-up
Fracture	4	12 (11–15)
Rheumatoid arthritis	3	12 (10–15)
Tumor	2	14 (10–15)
Posttr. osteoarthritis	2	13 (11–14)

Table 2. Cumulative results (max. 100)

	Preop.	Follow-up
Fracture	4	65 (52–93)
Rheumatoid arthritis	20	57 (50–68)
Tumor	20	75 (61–92)
Posttr. osteoarthritis	17	72 (61–95)

Tennis elbow—overestimated or underestimated?

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Introduction: The severity of a condition such as tennis elbow is occasionally an issue of discussion within orthopedics. Does this condition justify absenteeism from work? Is treatment actually necessary, considering the favorable natural evolution? Do psychogenic factors play an important part? In short: are the consequences of tennis elbow being underestimated or overestimated?

Discussion: Tennis elbow occurs frequently among the general population. Personal investigation showed that the prevalence among the population of South Limburg is 2.7 (SD 0.52). This means that the incidence is between 1 and 2%. Similar figures were encountered in Sweden. An enquiry among 19 general practices in South Limburg (47,500 patients) revealed an incidence of tennis elbow of 5.2 per 1000 patients. This figure, also, is in agreement with statistics for other Dutch and English general practices. Patients seen by the general practitioner were referred to the specialist in 17% of the cases.

This means that out of every 100 persons in the general population presenting symptoms, some 40 are seen by the general practitioner. The orthopedist sees fewer than 10 of the original 100 patients with symptoms. Accordingly, a patient selection occurs, by the patients themselves as well as by the general practitioners. For instance, the general practitioner sees as many males as females with a tennis elbow, while in the general population the condition occurs more frequently in females. In our own practice, on the other hand, we saw more males than females with a tennis elbow.

Comparative selection is based on occupation, duration of symptoms, etc.

Conclusion: Tennis elbow, therefore, may be both underestimated and overestimated, depending on the view of the physician in charge. With regard to generalization of personal experiences, caution is indicated.

Denervation according to Wilhelm for the chronic tennis elbow

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Introduction: Treatment of tennis elbow is still a matter of debate: various surgical techniques are being advocated. This retrospective study assessed the predominantly long-term results of the denervation according to Wilhelm.

Patients and method: All patients who had undergone a Wilhelm denervation in the period 1980 through 1992 were invited for outpatient follow-up consisting of:

- completing a questionnaire regarding pain, serviceability of the arm, resumption of occupational activities, etc.
- physical examination
- power grip tests with the hand dynamometer.

Results: During the period of study, 39 Wilhelm denervations were carried out in 35 patients. All patients were followed up 2–24 years after the operation (median 11 years). Thirty-two elbows scored an excellent result (no more pain, no restrictions), five a good result (occasional pain after intensive use of the arm, no restrictions) and two, a poor result (no improvement).

Conclusion: The long-term results of the Wilhelm denervation (95% excellent and good results) argue in favor of performing this operation after failure of conservative treatment.

Treatment of persistent lateral humeral epicondylitis by percutaneous cervical rhizotomy

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Introduction: Forty-one patients, 21 males and 20 females, aged 34 (24–49) years with persistent lateral humeral epicondylitis were treated between 1986 and 1992. They had had symptoms for 11 (8–20) months, which symptoms failed to respond to conservative measures such as rest, physical therapy, analgetics and (repeated) injections of a local anesthetic combined with a corticosteroid.

Patients and method: This group of patients was treated by percutaneous cervical rhizotomy. This means making a thermic lesion in the sensory ganglion of a cervical segmental nerve, under roentgenological control, after verification of the position of the electrode by means of electrostimulation to exclude motor complications. Rhizotomy C6 was carried out 27 times and rhizotomy C5, 26 times. Twelve patients returned within two years for a second treatment. All were followed up at least two years after the last intervention. They were asked how much the pain had been mitigated compared with preoperatively, and to express the mitigation as a percentage. Results were excellent in 17 patients (42%). They were completely free of pain, had normal elbow function and normal strength in the arm. Results were moderate in 13 patients (31%). They had mitigation of pain by more than 50% and limited elbow function. Eleven patients (27%) had not benefited at all by the treatment (poor result).

No complications were encountered, apart from a transient hypesthesia of the treated dermatome.

Conclusion: Before resorting to a surgical procedure in patients with lateral humeral epicondylitis, it should be considered first to attempt treatment by percutaneous cervical rhizotomy.

Aspiration of chronic calcific tendinitis

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Introduction: Deposition of calcium salts in the rotator cuff may cause chronic tendinitis, leading to pain and restriction of movement. Calcium salts may be removed either surgically or by aspiration, after which the pain disappears. The objective of this study was to examine the results of aspiration of calcium deposits.

Material and method: Fifty-two patients with chronic calcific tendinitis of the shoulder were examined clinically and radiographically, after aspiration of the calcium deposits to deal with the symptoms. Under fluoroscopic control and local anesthesia, two needles were introduced into the calcium. Subsequently it was attempted to soften the calcium slightly with physiological saline and to aspirate the calcium via the other needle. If aspiration proved not feasible, the calcium deposit was pulverized by means of the needle.

Results: The patients in the study group were re-examined on average 18 months after the intervention. 75% of the patients reported disappearance of the pain after the intervention. 80% had complete normalization of the range of mobility. At radiographic examination, the calcium was seen to have disappeared completely in 39 patients, while residual calcium was still visible in 13 patients.

Conclusion: Aspiration of the calcium in calcific tendinitis is a simple intervention which gives good to excellent results in 75% of the patients. This simple treatment can obviate removal of the calcium deposit by surgery.

Age is a predictive factor for the results of subacromial decompression according to Neer

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Introduction: Neer's view of the pathophysiology of subacromial impingement has become generally accepted since his publication in 1972. In our study we attempted to find factors correlated with the result of subacromial decompression.

Material and method: A retrospective study was made in 1993 of patients who had been subjected to subacromial decompression according to Neer during the period 1981 through 1992. This follow-up study concerned a random sample of 68 patients. Three patients could not be traced. Group characteristics were in accordance with other studies. Mean age was 48 (26–71) years; there were 29 men and 36 women. Twenty parameters were established from the patient records. Follow-up included determination of the

UCLA score. Mean duration of follow-up was 4.5 years.

Results: Multiple linear regression showed that age at operation, and to a lesser degree duration of follow-up predicted the UCLA score according to the equation: $UCLA = 19.4 + 0.194 \text{ times age} - 0.395 \text{ times duration of follow-up}$. Other parameters such as the Neer test and the surgical approach were irrelevant. Correlation between predicted and measured UCLA scores was low ($r = 0.31$).

Conclusion: This study shows that although the correlation is low, the age, in particular, has a predictive value. Older patients and those operated on recently will have higher scores, but among individual patients there are substantial deviations from this pattern.

Treatment of rotator cuff lesions by arthroscopic subacromial decompression

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Introduction: Since Rockwood in 1984 reported good results of subacromial decompression exclusively, without repair of the cuff in patients with a rotator cuff rupture, treatment of these injuries is a matter of some debate.

Method: In our study of the results of subacromial decompression of this nature, 33 patients with a complete cuff lesion (<3 cm) were subjected to débridement of the rupture in the rotator cuff and arthroscopic subacromial decompression. Cuff repair was subsequently performed in three patients because of persistent pain. One patient withdrew from the follow-up study.

The results of 29 patients were assessed after 1 to 3 years using the UCLA score for shoulder pain and function. Mean age was 65 (38–86) years; in 21 patients, the dominant arm was involved. Mean follow-up was 20 months.

Results: The mean preoperative UCLA score was 14 (11–22) points. Results were as follows: excellent 10 patients (34–35 points); good 15 patients (29–33 points); fair four patients (21–27 points). Fifteen patients regained the ability to carry a load on the shoulder.

Conclusion: Treatment of large complete cuff lesions of the shoulder by means of arthroscopical subacromial decompression gives good results in the medium-long term.

Surgical repair in massive ruptures of the rotator cuff

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Introduction: The treatment of major cuff lesions of the

shoulder is controversial. Several authors have demonstrated the positive effect of subacromial decompression without repair of the cuff. Anatomical repair by operation, on the other hand, is regarded by many as technically very difficult or even impossible, or as useless.

Material: 24 patients with a large lesion of the rotator cuff were operated by us between 1984 and 1993. The cuff was repaired and subacromial decompression was carried out. All patients had ruptures of 5 cm or larger. Repair of the cuff proved possible in 22 patients.

Method: These 22 patients were examined postoperatively in a retrospective study by an independent examiner. The preoperative and postoperative UCLA scores were determined by examination and anamnesis, where necessary supplemented by data from the records.

Results: Mean age was 60 (40–70) years, the mean preoperative duration of symptoms was 4 (0.1–19) years and the mean follow-up duration was 2.7 (1.0–9.5) years. An etiological injury was found in the anamnesis of 16 of the 21 patients.

The mean preoperative UCLA shoulder score amounted to 10 (3–18). Mean postoperative score was 25.5 (14–30). The difference is significant ($p < 0.001$). Significant differences ($p < 0.001$) were also found for the separate items of which the UCLA shoulder score consists (viz. pain, function, active forward flexion and strength). None of the patients was dissatisfied with the result.

No significant correlations could be demonstrated between age, sex, size of the cuff lesion, duration of the symptoms, etiology of the symptoms or duration of the postoperative period and the result of the operation, expressed as the total UCLA score or its separate items.

Conclusion: The treatment of large ruptures of the rotator cuff by surgical repair in combination with subacromial decompression is a highly effective method.

Results of the capsular shift according to Neer in multidirectional instability of the shoulder joint

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Introduction: Multidirectional instability (MDI) is a disorder of the shoulder that is difficult to recognize and to treat. The symptomatology is frequently unspecific. The most characteristic finding at physical examination is the sulcus sign, indicating increased downward laxity. Our therapeutic management was as follows: first intensive training of the cuff musculature. If this had insufficient effect, stability determination was carried out under anesthesia plus arthroscopy, to verify the diagnosis and to establish the principal direction of the instability: forward or backward. In the second instance, an anterior or posterior capsule shift according to Neer was carried out. The objective of this study was to as-

sess the results of this surgical treatment.

Material and method: A retrospective analysis was made of the first 14 patients (15 shoulders) treated by this method. There were 4 posterior and 11 anterior capsular shifts. Mean follow-up was 28 (13–71) months. The results were evaluated using the Rowe score (pain, stability, function, mobility and strength).

Results: Excellent (85–100) ten patients, good (70–84) three patients, fair (50–69) one patient and poor (<50) one patient. Complications: no axillary nerve lesions were seen. Two patients had persistent limitation of the function and required further treatment with ultimately one good and one fair result.

Conclusion: A capsular shift according to Neer in our hands is a good method of treatment of MDI of the shoulder that responds insufficiently to conservative treatment. The technique is difficult, however. Thorough planning by means of arthroscopy and stability testing under anesthesia is recommended.

The results of the modified Bankart operation in recurrent gleno-humeral instability

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Objective: To assess the results of the modified Bankart operation in recurrent gleno-humeral instability.

Design: Retrospective with standardized evaluation.

Patients and methods: 33 patients were operated in the period from November 1989 to May 1993 because of recurrent complete or partial gleno-humeral dislocations. The male/female ratio was 27:6 and the mean age at the time of operation was 27.9 (17–39) years. 29 patients had a traumatic primary complete or partial dislocation. All patients were handled by the same surgeon. In 29 patients with avulsion of the glenoid lip, the lip was reattached to the glenoid rim using small metal anchors (Mitek). A capsular plasty via a T-shaped incision was carried out in all patients. The subscapular muscle was reinserted without shortening. The results in all patients were assessed by the first author in the outpatient department after an average follow-up of 29 (12–55, SD 14.2) months. The Rowe score was used as an objective scoring method.

Results: The postoperative morbidity consisted of temporary loss of sensory function of the axillary nerve in one patient. At the most recent follow-up the average losses of axial rotation in the upper arm in adduction and 90° abduction, respectively, were 11.8° and 3.5°. Two of the 33 patients developed redislocation, 35 and 44 months, respectively, after the operation, both due to a substantial accidental injury. The postoperative shoulder function according to the Rowe score was excellent in 25 patients, good in seven and fair in one

patient. The mean Rowe scores were 62 preoperatively and 91 postoperatively. Subjectively, the patients evaluated the results of the operation as excellent in 16 cases, good in 15 and moderate in two cases.

Conclusion: The modified Bankard operation in recurrent partial or total gleno-humeral dislocations gives good to excellent results in over 90% of the patients. Compared with data in the literature, the proportions of loss of exorotation and of recurrence are highly acceptable.

Arthroscopic repair of traumatic recurrent complete or partial anterior dislocation of the shoulder

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Introduction: Between May 1989 and July 1992, 96 patients with a recurrent traumatic partial or complete anterior dislocation of the shoulder were treated with a modified suturing technique developed by Rose (New York). This technique involves suture refixation of the gleno-humeral ligament/lip complex and reefing of the anterior band of the inferogleno-humeral ligament. After-treatment consists of strict immobilization during 4 weeks.

The series included 67 men and 29 women, with an average age of 28 (16–49) years. 68 of them had dislocation as the primary injury, whereas in 28 cases only traumatic partial dislocations were observed. In 26 cases, the injury was due to an athletic exercise. The interval between injury and operation was 3.7 (0.5–19) years. This prospective successive series included all patients with the above-named indication seen in the three hospitals.

Results: The mean follow-up period was 34 (24–60) months. Two complications were observed: once, a break of a K-wire in the articulation which subsequently necessitated an arthrotomy, and once, transient hypesthesia of the musculo-cutaneous nerve. The results were scored according to Rowe: excellent 74 patients, good 7, fair 4, and poor 11. The deficit of exorotation compared with the contralateral side at 0° abduction as well as at 90° abduction was on average 4° (0°–30°). Analysis of the failures: 7 recurrences in the complete dislocation group, 4 recurrences in the partial dislocation group, dislocations 5 times, resubluxation 6 times. Causes of the 5 redislocations were: a technical problem with peroperative mobilization of the inferogleno-humeral ligament once, redislocation after an adequate injury once and redislocation without adequate injury three times. The causes of the 6 resubluxations were: a patient with multidirectional instability (wrong indication) once, restlessness immediately postoperatively with exorotation of the arm once, failure of compliance during the after-treatment twice,

and no adequate injury twice. The mean interval between operation and recurrence was 15 (6–23) months.

Conclusion: In these series, with a minimal follow-up of 2 years, the proportion of failures (11%) compares favorably with the results of other arthroscopic techniques and approaches that of various open techniques.

Arthroscopic treatment of chronic antero-inferior shoulder instability with the aid of a biodegradable staple—a prospective study

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Introduction: 54 patients with chronic antero-inferior instability of the shoulder joint were treated between January 1990 and September 1992, with arthroscopic refixation of the anterior glenoid lip to the anterior glenoid rim with the aid of one or several biodegradable staples (Suretac) (Acufex, Etten Leur, the Netherlands).

Patients and method: 38 patients, 30 men and 8 women, with an average age of 31 (18–56) years had dislocation, 29 times of the dominant and 11 times of the nondominant shoulder, with an average of 8.5 (3–20) recurrences. (There were 26 patients with recurrent partial dislocations. This group is left out of consideration.)

Apart from a slight limitation of exorotation of 20° at most, the preoperative function was normal, with an average extension strength of 95% and an average abduction strength of 96% compared with the contralateral shoulder.

Radiographic examination showed a Hill-Sachs defect 28 times and a Bankart lesion seven times. At operation, all were found to have a Hill-Sachs defect. Peroperative complications were none. Immobilization: 4 weeks in 34, 3 weeks in 3 and 6 weeks in one patient. Outpatient check-ups after 6, 14, 30, 52 weeks and 2 years. Recently, all patients were seen again. Follow-up was on average 3 (2–4.5) years.

Results: Redislocations occurred in 5: one patient failed to comply with the after-treatment schedule, resumed riding his trailbike 4 weeks postoperatively with redislocation 7 weeks postoperatively, treated with an open Bankart repair. One year later, recurrent instability necessitated a derotation osteotomy with ultimately good results.

One patient had a traumatic redislocation 36 weeks postoperatively and recovered completely after 3 weeks' immobilization; 4 years postoperatively negative apprehension.

One patient had a motorcycle accident 4 months postoperatively and sustained a redislocation, which was treated conservatively, following which a further dislocation occurred without injury.

One woman sustained a redislocation after 14 months when he fell off a stool, and was treated arthroscopically once more with the same technique. She was free of symptoms 3 years after the index operation.

One patient redislocated his shoulder while playing hand-

ball after 20 months, was treated conservatively, and has sustained no further dislocations during 3 years in spite of resumed playing.

After one year, 36 of 38 patients had complete restoration of function, strength and stability, with negative apprehension.

At the most recent follow-up, 33 of 38 patients had a Rowe score of 100. Three patients complained of pain after weight-bearing; in two of these there was a positive apprehension phenomenon, while the third showed signs of subacromial impingement. Two patients had no complaints, but at examination showed a positive apprehension phenomenon.

The most interesting finding was that all cases of redislocation involved the nondominant shoulder.

Arthroscopic decompression in the chronic subacromial impingement syndrome

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Introduction: Treatment of the chronic subacromial impingement syndrome of the shoulder with arthroscopic subacromial decompression (ASD) gives good results. One of the advantages of the arthroscopic method is that it will reveal any intra-articular pathology present.

Material and method: An ASD was carried out in 136 patients who clinically displayed an impingement syndrome. Four patients underwent bilateral operations.

The patients were subdivided into two groups on the basis of the preoperative findings: group 1: 105 patients with an intact rotator cuff and group 2: 35 patients with a partial cuff lesion. The results were assessed one year postoperatively using the UCLA score. Mean age was 49 (20–77) years. The dominant arm was involved in 94 patients; 81 patients had an occupation involving shoulder strain. Preoperative arthrograms were made of 65 patients, with a positive outcome in 17. The mean preoperative UCLA score for both groups was 18 (9–24).

Results: One year postoperatively, the result in the group as a whole was excellent in 34%, good in 47%, fair in 14% and poor in 5%. There was no difference between the two groups. In 11 of the 17 cases with a positive arthrogram, arthroscopy revealed a partial cuff lesion.

Conclusion: Arthroscopic decompression gives good results in the chronic impingement syndrome. The result is not affected by a partial cuff lesion. The usefulness of a preoperative arthrogram is doubtful.

Peripheral reconstructions in the arm in brachial plexus injury

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Introduction: Abnormalities in brachial plexus lesions as a rule affect both the motor and the sensory function, and if a muscle transposition is carried out to improve function there will be no compensation for the sensory loss. To this extent, neurosurgical reconstruction in the first instance is always to be preferred, and it is also indicated if there is no recovery of biceps function after the third month. When no neurosurgical possibilities are left, in C5–C6 lesions there will always be greatly reduced or absent shoulder function (abduction and exorotation) and absence of elbow flexion. On the other hand, there still may be good function of the latissimus dorsi muscle (thoracodorsal nerve C6–C7–C8) and/or the teres major muscle (inferior subscapular nerve C5–C6) and/or the levator scapulae muscle (C3–C4). Reversion of these three muscles, the so-called triple transfer (Narakas) can improve the abduction and the exorotation in the shoulder. Sometimes, only improvement of exorotation is indicated (double transfer with latissimus dorsi and teres major) or just stabilization of the partially dislocating shoulder (monotransfer with levator scapulae).

Patients and methods: A triple transfer was carried out in 12 patients (ages 3 to 12 years) with an obstetrical injury of the brachial plexus; five patients (3–14 years) underwent a double transfer and two patients (4 and 14 years) a monotransfer. The surgical technique is as described in the literature: the detached insertions are always lengthened with a Dacron band and reimplanted at the site of the fixation of the supraspinatus to the rotator cuff or head of the humerus. Aftertreatment with a chest-arm plaster (6 weeks) followed by intensive physical therapy.

Results: No complications were observed. The average follow-up was 10 (6–18) months. The results were assessed pre- and postoperatively according to the Mallet scheme.

18 patients showed improvement. The partial dislocation in five of the nine children was abolished. There was a better equilibration of body sensation in the children capable of reporting this, and of the three children with shoulder pain, two were freed of this pain. The preoperative Mallet scores were IInd degree in 17 patients and IIIrd degree in two patients; during follow-up the Mallet scores were IInd degree in three, IIIrd degree in eight and IVth degree in eight children. In several children, improvement was still progressing.

Conclusion: Specific muscle transfer in brachial plexus lesions after obstetrical trauma may result in substantial improvement of the functional condition of the affected arm.

Steindler flexor transposition in brachial plexus lesions—combined experiences of Leiden University Hospital and De Wever Hospital, Heerlen

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Introduction: Flexor transposition according to Steindler is a musculoplasty applied in paralysis of the flexor muscles of the elbow. Part of the forearm flexors, together with the medial epicondyle of the humerus, is transplanted in the proximal direction on to the humeral diaphysis, to function as flexor of the elbow joint.

Material and method: A retrospective analysis was made of the results of this treatment in the above-mentioned hospitals. In Leiden, in the period 1982–1993, a Steindler transposition was carried out in 12 patients with a brachial plexus lesion with an average age at operation of 28 years. Mean follow-up was 3 years and 4 months.

Results: 13 patients were treated in the De Wever Hospital: seven congenital plexus lesions (mean age 3.2 years) and six plexus lesions after high-energy injury (mean age 23.3 years). Mean follow-up was 9 months. In both groups, distinct functional improvement was achieved in virtually all the cases. The mean active flexion of the elbow was 100° in Leiden and 110° in Heerlen. No major complications were encountered.

Conclusion: The Steindler flexor transposition is a relatively minor operation and causes distinct improvement of the flexor function of the elbow.

Frozen shoulder—manipulation after glenohumeral distention under local anesthesia

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Introduction: The frozen shoulder syndrome is a condition that is still difficult to define, to treat or to explain on morbid-anatomical grounds. Manipulation under general anesthesia is the most widely used treatment. A prospective study was made of the short-term results measured after manipulation under local anesthesia after hydraulic distention of the glenohumeral articulation under radiographic control with use of the image intensifier.

Material and method: The clinical diagnosis of idiopathic frozen shoulder was confirmed by arthrography in 23 pa-

tients (25 shoulders) with a mean age of 49 years. After adequate intraarticular anesthesia, 40 mg methylprednisolone and an average of 40 mg cooled physiological saline, the glenohumeral adhesions and the capsule were stretched. Subsequently, manipulation of the affected shoulder was carried out. Minimal follow-up was 3 months. All pre- and postoperative ranges of movement of the shoulder were measured using the Cybex Inclinator.

Results: Mean increase of total abduction amounted to 84°, from a mean of 73° to one of 153°. Mean increase of glenohumeral abduction was 38°, from 31° to 68° on average. Mean increase of exorotation was 48°, from a mean of 13° to one of 60°. Mean increase in endorotation was 40°, from a mean of 7° to one of 56°. No complications occurred. The objective and subjective clinical results were good in all patients.

Conclusion: The technique described is simple, safe and highly effective for the treatment of the frozen shoulder syndrome.

Reconstruction of a large focus of Panner's disease in a teenager

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Introduction: The objective of the treatment of a large intra-articular focus of osteochondrosis is to obtain an articulation with optimal congruence, with preservation of the articular cartilage. If this cartilage cannot be saved, osteoarthritis is likely to develop more quickly.

Material: A male aged 16 years complained of pain and locking symptoms of the right elbow, present since one year, without preceding injury. Clinical examination revealed no abnormalities apart from a flexion/extension of 125°/5°. Radiographically, there was a large focus of osteochondrosis in the humeral capitellum. The MRI showed no clear involvement of the articular cartilage.

Method: In view of the symptoms and the size of the focus of osteochondrosis, surgical treatment was decided on. Via a lateral arthrotomy it became clear that the articular cartilage was markedly degenerated and loose.

The underlying necrotic tissue was removed. The defect, with a diameter of 2 cm, was filled with a corticospongiuous chip taken from the anterior crista. The apophysis of the transplant was handled with great care, in order that it might substitute for the cartilage.

Result: Radiographic examination 2 months postoperatively showed complete consolidation. The patient was free of symptoms, with a flexion/extension of 130°/5° and complete rotation.

Conclusion: A corticospongiuous chip with a non-ossified apophysis attached to it may be used as an autograft in a large focus of osteochondrosis which has destroyed the articular cartilage. The short-term result was good.

Four-part fractures of the humerus

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Multifragmentary fractures of the head of the humerus are hard to treat because of the difficult approach and the risk of avascular necrosis after surgical repositioning. For older patients a hemiarthroplasty is frequently decided on.

Material and method: In the past 2 years, three young patients with a four-part fracture of the humerus were treated functionally. Under anesthesia, in day treatment, the fracture was repositioned as much as possible, percutaneously with the aid of K-wires and an elevator; subsequently, it was stabilized percutaneously with multiple K-wires and screws. Functional exercising was started immediately afterwards. The K-wires were removed after 6 weeks. A CT scan was made 3 months postoperatively to assess the gleno-humeral articulation. In two patients, a central depression of the articular surface was found to have caused a functional block through prominence of the lesser tubercle. The articular surface was improved in these patients by arthroscopy, with the aid of a shaver.

Results: Osteonecrosis of the fragments was not seen in any of the patients. Remaining functional limitation was minimal. Anteflexion: 150°, 150° and 160°; exorotation: 10°, 10° and 0° limited; endorotation 3 vertebrae, 4 vertebrae and 2 vertebrae limited. Pain was very slight.

Conclusion: Functional treatment with temporary K-wires is a minimally invasive intervention with a good functional result. The risk of osteonecrosis is very small.

Incidence of nerve injury after shoulder dislocations and subcapital humerus fractures

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Objective: There is no consensus in the literature concerning the incidence of lesions of the axillary nerve and other nerves in shoulder dislocations and subcapital humeral fractures. In only three prospective studies (Blom/Dahlbäck 1970, Pasila 1978, Toolanen 1993) have attempts been made to objectify the incidence by means of an EMG.

Method: All 101 patients (mean age 62 years), seen during a period of one year via the Emergency Room with a shoulder dislocation or subcapital humerus fracture, were subjected to a prospective clinical and electromyographic examination and followed up. All patients had sustained the injury by a fall from their own height.

Results: An accompanying nerve injury was observed in 45% of the patients, viz. in 34% (15/44) of the dislocation

group and in 53% (30/57) of the fracture group.

In agreement with the literature it was found that the incidence in those over 65 is higher than that in those under 65 (54% and 26%, respectively). A persistent neurogenic injury was seen in 22%. None of them required operation, but substantial loss of function and muscle strength persisted. Eight permanently had a strength ≤ 3 (MRC Score).

Discussion: Diagnosing an accompanying nerve lesion on clinical grounds may be difficult. The findings of our study suggest that paresis and hematoma are prognostic indications of an accompanying neurogenic injury. Electromyographic examination may contribute to the diagnosis.

In view of the (transient) paresis and the inability to exercise independently, we consider early active exercise therapy guided by a physiotherapist of essential importance in case of suspicion of nerve damage.

Arthroscopic suturing of the meniscus—a follow-up of five to seven years

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Preservation of a ruptured meniscus may be of great importance for the stability of the knee and consequently also for the prevention of arthrotic lesions in the knee joint.

24 cases of ruptured meniscus were sutured using an arthroscopical technique (inside-out) between 1986 and 1988. After 5 to 7 years, 20 patients had a good or excellent Lysholm score. Only three patients had failed to resume their athletic activities. Ultimately, 20 menisci were preserved. Presence of a lesion of the anterior cruciate ligament (in 15 patients) did not result in a larger proportion of new ruptures in the repaired menisci.

Accordingly, a lesion of an anterior cruciate ligament does not require reconstruction in all cases, but only if the lesion is complete, with substantial instability.

Off with its head is not so bad—satisfactory functional results of resection arthroplasty of the shoulder

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Objective of intervention in a rheumatically destroyed joint is reduction of the pain and recovery of functions in activities of daily life (ADL). For ADL functions restoration of the rotation is of particular importance.

Material and method: 13 shoulders in 11 patients were evaluated from a group of 16 shoulder after resection arthro-

plasty. Average age was 76 years. Mean follow-up was 3.5 years. There were ten women and one man. The indication for operation was painful, rheumatic destruction of the glenohumeral articulation with pronounced loss of function.

Evaluation of pain and function (part of the Neer score) was 5 = none, 4 = slight, 3 = after activity, 2 = moderate, 1 = marked, 0 = complete disability.

Results: Preoperatively, 7 shoulders scored 0 and six patients 1; postoperatively, 7 shoulders scored 4 and six patients 5.

All patients in the group were capable to reach the mouth (eating), the belt, the other axilla and the buttocks (hygiene) with the affected arm. Eleven of the 13 shoulders allow reaching to the head (hair care). All were capable of throwing, pushing and hitting; six were capable of holding the hand above the head.

Force, depending on the other articulations, was fair to good. ROM was in anteflexion mean 99° (70°–180°), abduction mean 57° (30°–180°), endorotation on average to level Th8 (L5–Th7) and exorotation mean 46° (20°–60°).

These results were achieved 6 months on average after the operation. Patient satisfaction (1–10) was in average 8 (7–9).

Conclusion: In rheumatic patients with a painful, non-functional, destroyed shoulder, resection arthroplasty of the shoulder results in satisfactory ADL functioning and almost complete freedom of pain.

Avulsion of the insertion of the infraspinatus tendon—an injury of adolescents?

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Case report: A girl aged 14 years presented with swelling, pain and restricted mobility of the right shoulder, with onset after participation in a school sports day. During a match of 'shaking hands', she experienced a snap in the right shoulder, following which the shoulder became swollen and painful.

Standard radiographs of the right shoulder: no osseous abnormalities. Puncture of the shoulder: hemorrhagic fluid, no bacterial growth. MRI examination: fluid in the course of the infraspinatus muscle, compatible with rupture. Special radiographs: avulsion fragment of the tendon of the infraspinatus.

Treatment and evolution: Arm sling for 3 weeks. Ten weeks after the injury, the function of the shoulder and strength of the shoulder muscle were normal. Follow-up MRI: no abnormalities.