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Ultrasonography of the elbow joint

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Summary. The nonechogenic space between the bone and the joint capsule was measured in ultrasonographic scans at six different sites in 60 elbow joints of 30 healthy adults as well as in 35 joints with clinical arthritis. The space could be demonstrated in all healthy joints on the volar side at the levels of the trochlea and the capitulum of the humerus. The space was more than 2 mm in three out of the 60 healthy joints at these levels, and the space did not increase in 30° flexion of the joint. The means of the measurements were significantly higher at all six sites in the arthritic joints than in the healthy joints and on the volar site the space increased in 30° flexion of the arthritic joint. The space was more than 2 mm in all arthritic joints at the levels of either the trochlea or the capitulum of the humerus. An ultrasonographic distance of more than 2 mm on the volar side of the elbow joint between the joint capsule and the bone is with high probability a sign of intraarticular effusion or synovitis. The effusion in the olecranon fossa can also be demonstrated in all cases.

Key words: Ultrasonography – Elbow joint – Normal – Rheumatoid arthritis

Introduction

Along with other developments in technology, diagnostic ultrasonography is increasingly being applied in rheumatology. The first experience were obtained in Baker's cyst of the knee joint [1], but since 1979 the technique has been used also for detection of intraarticular effusion of the hip joint [2], which cannot be investigated using clinical methods. In principle, ultrasonography can be used for detection of effusion or synovitis in most joints, bursae, or tendon sheets [3–7], for rupture of rotator cuff [8], or diseases of the spinal canal [9].

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The elbow joint consists of the articulations between the trochlea of the humerus and ulna, the capitulum of the humerus and the head of the radius, and the head of the radius and the radial notch of the ulna. All these joints are inside the common joint capsule, which is loose both in front and behind, allowing free movement. However, because of the strong collateral ligaments, tendons, and other structures, a small effusion in the elbow joint is difficult to detect clinically. Sattler and Schmidt have described the ultrasonography anatomy of the elbow joint [10], but they have given no ultrasonographic criteria for the differentiation of the healthy joint from that which is inflamed. The aim of this study was to investigate the nonechogenic width of the joint space in healthy individuals and in patients with clinical signs of arthritis and thus to create ultrasonographic criteria for the intraarticular effusion or synovitis of the elbow joint.

Materials and methods

After several experiments, three measurements were selected for the ultrasonographic investigation of the elbow joint. First, a longitudinal scan of the radiohumeral joint was made (Figs. 1a, 2) allowing identification of the head of the radius, capitulum of the humerus, radial fossa of the humerus, and the joint capsule. The nonechogenic distance between the joint capsule and the head of the radius, the joint capsule and the capitulum of the humerus, as well as between the joint capsule and the bone on the level of the radial fossa were measured from the magnified picture on the monitor, which allows an accuracy of 0.25 mm. The measurements were carried out in full extension and in 30° flexion of the joint.

Secondly, a longitudinal scan of the ulnahumeral joint was made (Figs. 1b, 3) allowing identification of the trochlea and the coronoid fossa of the humerus and the joint capsule. The nonechogenic distance between the trochlea and joint capsule, as well as that of the bone and joint capsule on the level of the coronoid fossa of the humerus were measured in full extension and in 30° flexion of the joint.

Thirdly, a longitudinal scan of the dorsal side of the joint was made allowing identification of the olecranon fossa (Figs. 1c, 4). The nonechogenic distance between the bone and joint capsule on the level of the fossa was measured in full extension and in 30° flexion of the joint.

These measurements were carried out in 60 joints of 30 healty adults (17 women, 13 men) and in 35 joints of 35 adult patients

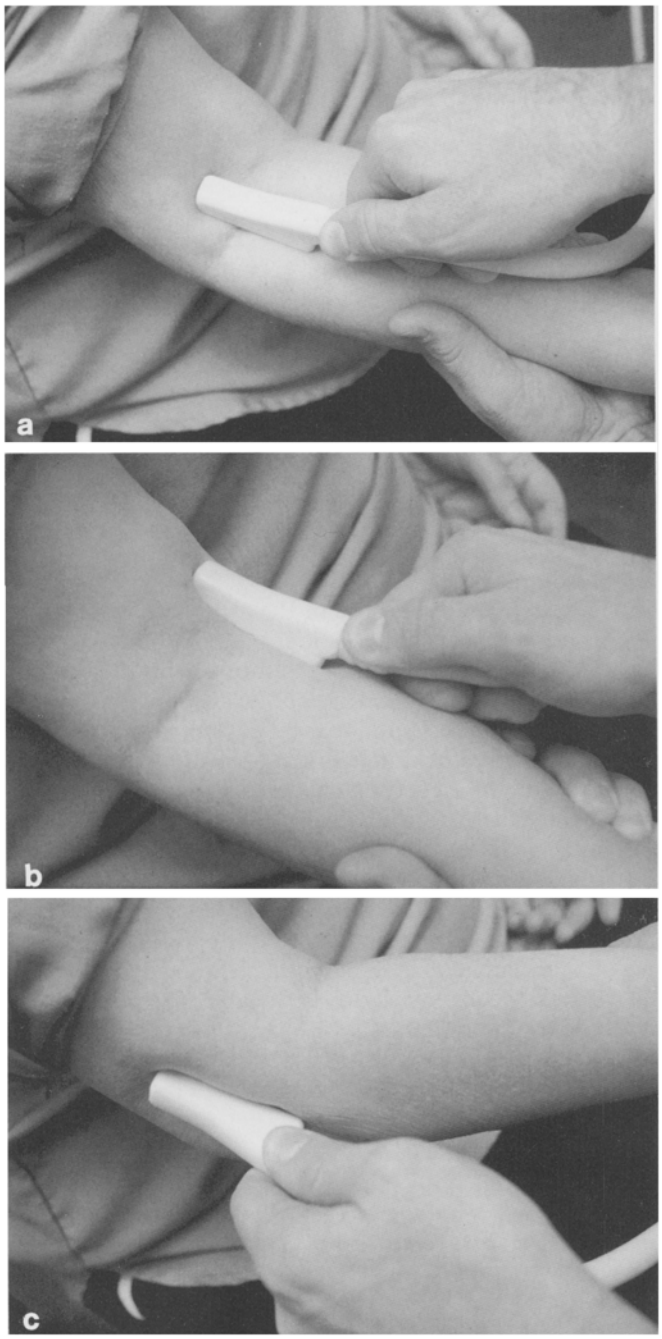

Fig. 1. Longitudinal scans of **a** the radiohumeral joint, **b** the ulnahumeral joint, and **c** the olecranon fossa

(21 women, 14 men) with clinical signs of arthritis in the elbow joint (clinical swelling at the olecranon fossa in extension). The extension deficit in the arthritic joints was 11.1° (SD 9.2, range 0°–25°).

The mean age of the healthy individuals was 45 years (range 20–82 years), the mean height was 170 cm (range 152–190 cm), and the mean weight 72 kg (range 51–100 kg). The mean age of the patients was 46 years (range 18–71 years). The diagnosis was rheumatoid arthritis in 26 patients, juvenile chronic arthritis in five, ankylosing spondylitis in two, psoriatic arthritis in one, and nonspecified oligoarthritis in one.

The measurements were carried out using Aloka SSD 210 Dx 11 with a 7.5 MHz transducer. The accuracy of the measurements was evaluated by measuring the distance between the joint capsule and the trochlea of the humerus as well as that between the joint capsule and the capitulum of the humerus in 32 healthy elbows four times in each and by counting the mean of the differences and standard deviation of the four measurements.

Statistical analysis using Student's *t*-test for paired samples was undertaken for differences of the measurements in full extension or in 30° flexion. The same test for unpaired samples was used in other measurements.

Table 1. The ultrasonographic width (mm) of the joint space in 34 elbow joints in 17 healthy women

Distance between the joint capsule and	Full extension (mean; SD)	30° flexion (mean; SD)	Significance
Capitulum of humerus	1.1; 0.2	1.1; 0.2	NS
Trochlea of humerus	1.1; 0.2	1.1; 0.3	NS
Caput of radius ($n=21$)	0.8; 0.2	0.7; 0.3	NS
Radial fossa of humerus ($n=3$)	2.7; 1.2	3.2; 1.4	
Coronoid fossa of humerus ($n=18$)	5.5; 1.6	5.1; 1.4	NS
Olecranon fossa of humerus ($n=4$)	8.5; 3.7	7.2; 3.2	

Table 2. The ultrasonographic width (mm) of the joint space in 26 elbow joints of 13 healthy men

Distance between the joint capsule and	Full extension (mean; SD)	30° flexion (mean; SD)	Significance
Capitulum of humerus	1.4; 0.4	1.3; 0.3	0.04
Trochlea of humerus	1.4; 0.4	1.4; 0.4	NS
Caput of radius ($n=16$)	0.8; 0.4	0.8; 0.4	NS
Radial fossa of humerus ($n=2$)	3.5; 0.7	3.6; 0.6	
Coronoid fossa of humerus ($n=12$)	6.1; 2.7	5.9; 2.0	NS
Olecranon fossa of humerus ($n=1$)	10	8	

Results

In healthy individuals the nonechogenic space between the capitulum of the humerus and joint capsule as well as that between the trochlea of the humerus and joint capsule could be identified in all cases, but between the caput of the radius and joint capsule only in 61%, between the coronoid fossa and joint capsule in 51%, between the olecranon fossa and joint capsule in 12%, and between the radial fossa and joint capsule in 11% of individuals. The results were similar in full extension and in 30° flexion of the elbow.

Tables 1 and 2 show the measured distances in healthy women an men. In men the distances were significantly longer ($P<0.01$) than in women, both in full extension and in 30° flexion between the capitulum of the humerus and joint capsule as well as between the trochlea of the humerus and joint capsule. The difference between the left and right elbow was 0.12 mm (SD 0.24 mm) in the distance between the capitulum of the humerus and joint capsule and 0.04 mm (SD 0.36 mm) between the trochlea

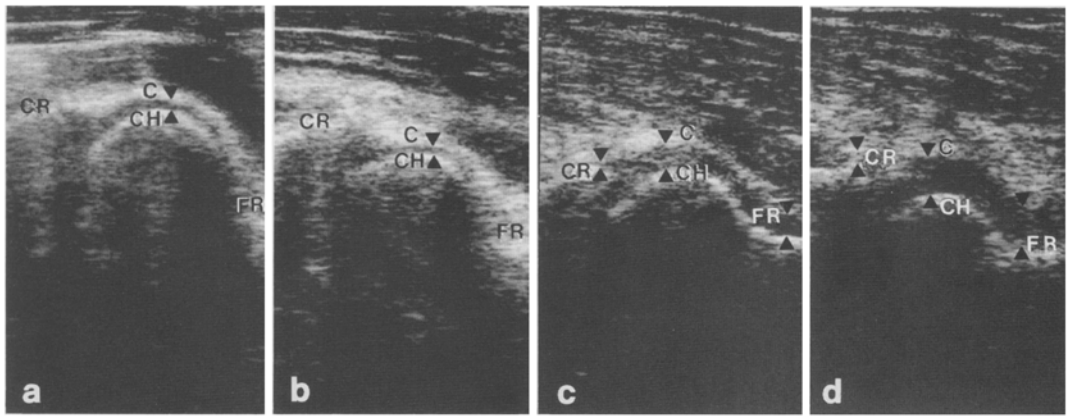

Fig. 2. Ultrasonography of the radiohumeral joint of a healthy individual in **a** full extension and **b** 30° flexion, and of an arthritic joint in **c** full extension and in **d** 30° flexion. C = joint capsule; CR = caput of radius; CH = capitulum of humerus; FR = radial fossa of humerus

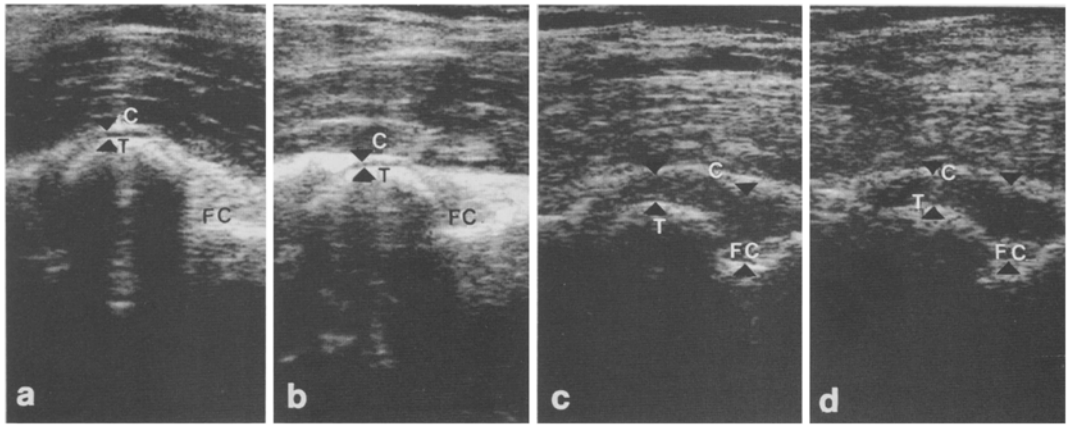

Fig. 3. Ultrasonography of the ulnahumeral joint in a healthy individual in **a** full extension and **b** 30° flexion, and of an arthritic joint in **c** full extension and **d** 30° flexion. C = joint capsule; T = trochlea of humerus; FC = coronoid fossa of humerus

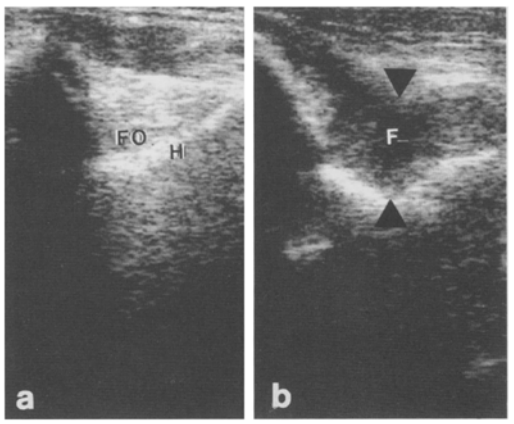

Fig. 4a, b. Dorsal ultrasonography at the level of the olecranon fossa. **a** Healthy joint; **b** arthritic joint. FO = olecranon fossa; H = humerus; F = fluid

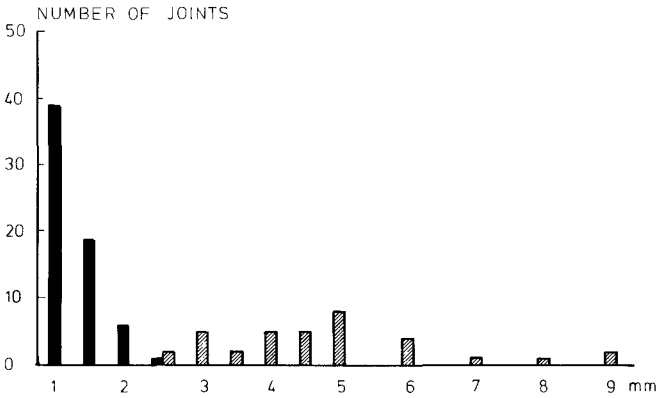

Fig. 5. Distribution of the joints according to the ultrasonographic distance between the joint capsule and the trochlea or the capitulum of the humerus. Distances are the longest observed either in full extension or in 30° flexion. ■ = healthy; ▨ = patients

of the humerus and joint capsule. There was no correlation between the age and the height of the healthy individuals in any of the measurements. The only significant correlation was observed between the weight of the individuals and the distance between the trochlea of the humerus and joint capsule ($r = 0.44$, $P = 0.02$).

The mean of the differences between four separate measurements in 32 elbows was 0.01 mm (SD 0.19 mm) between the capitulum of the humerus and the joint capsule and 0.06 mm (SD 0.19 mm) between the capitulum of the humerus and the joint capsule and 0.06 mm (SD 0.15 mm) between the trochlea of the humerus and the joint capsule.

In joints with clinical synovitis the nonechogenic space between the bone and joint capsule could be identified in all patients in all measurements. However, because of the unclear outlines the nonechogenic distance could be measured in only 28 out of 35 joints on the dorsal side at the level of the olecranon fossa. The ultrasonographic distance between the bone and joint capsule was higher than in healthy individuals at all measured levels both in extension (Table 3) and in flexion (Table 4) of the joint. The distances increased significantly in a 30° flexion of the joint measured at the levels of the capitulum ($P < 0.001$) and the trochlea ($P < 0.01$) of the humerus. The nonechogenic distance between the joint capsule and

Table 3. The ultrasonographic width (mm) of the joint space in 60 elbow joints of 30 healthy adults and in 35 elbow joints of patients with arthritis, with the joints in maximal extension

Distance between the joint capsule and	Healthy adults (mean; SD)	Patients (mean; SD)	Significance
Capitulum of humerus	1.2; 0.3	3.2; 1.9	$P<0.00001$
Trochlea of humerus	1.2; 0.3	2.8; 1.3	$P<0.00001$
Caput of radius	0.8; 0.3 ($n=37$)	2.2; 1.2	$P<0.00001$
Radial fossa of humerus	2.8; 1.0 ($n=5$)	7.3; 2.1	$P=0.05$
Coronoid fossa of humerus	6.2; 1.7 ($n=30$)	9.0; 2.4	$P<0.001$
Olecranon fossa of humerus	9; 4.4 ($n=5$)	17.5; 3.5 ($n=12$)	$P=$NS

Table 4. The ultrasonographic width (mm) of the joint space in 60 elbow joints of 30 healthy adults and in 35 elbow joints of patients with arthritis, with the joints in 30° flexion

Distance between the joint capsule and	Healthy adults (mean; SD)	Patients (mean; SD)	Significance
Capitulum of humerus	1.1; 0.2	4.5; 1.9	$P<0.00001$
Trochlea of humerus	1.2; 0.4	3.4; 1.3	$P<0.00001$
Caput of radius	0.7; 0.3 ($n=37$)	2.2; 1.3	$P<0.00001$
Radial fossa of humerus	3.2; 1.2 ($n=5$)	7.7; 2.7	$P=0.001$
Coronoid fossa of humerus	5.9; 1.3 ($n=30$)	8.9; 1.8	$P<0.00001$
Olecranon fossa of humerus	8.6; 3.5 ($n=5$)	16.6; 4.5 ($n=28$)	$P<0.01$

the bone was more than 2 mm in all joints at the levels of the capitulum and the trochlea of the humerus either in full extension or in a 30° flexion (Fig. 5).

Discussion

As Sattler and Schmidt have demonstrated [10], the structures of the elbow joint can easily be identified using ultrasonography. No quantitative measurements have been carried out earlier, and the aim of this study was to compare the healthy and the inflamed joints in order to create quantitative criteria for synovitis in the elbow joint. The method is based on the nonechogenic space between the bone and the joint capsule. The space was significantly longer in joints with clinical arthritis than in healthy joints. This space reflects the amount of the intraarticular effusion or synovitis. It can be measured in millimeters on the monitor, and it gives a semiquantitative tool for the measurement of the effusion. One of its uses is in the follow-up of the effects of the treatment.

The most suitable method seems to be the longitudinal scan on the volar side of the joint at the levels of the trochlea or the capitulum of the humerus. The space between bone and joint capsule could be identified in all healthy individuals, too, and the overlapping between the healthy and arthritic joints was rare. In general, the joint cavity can be demonstrated easily at all studied sites in arthritic joints, while in healthy joints it was always successful only at the levels of the trochlea and the capitulum of the humerus.

According to this study, the space between the trochlea or the capitulum of the humerus and the joint capsule does not increase in the flexion of the healthy joint. The space is a little longer in men than in women, but the difference has no practical significance. The space does not correlate significantly with the height, weight, or age of the individual. In arthritic joints the space is longer and it increases in the flexion of the joint, especially at the level of the capitulum of the humerus. Still steeper flexion would probably increase the space more, but a flexion of 30° is the highest at which the measurement is technically possible in all cases.

Visualization of the olecranon fossa on the dorsal side is not easy in healthy joints. In arthritic joints it can usually be identified, but it is difficult to measure because of the unclear outlines. The dorsal scan of the elbow joint can be recommended only in cases where the measurements on the volar side have been inside the normal limits. Of course, the olecranon bursitis or rheumatoid nodules can also be identified by means of a dorsal scan.

On the basis of the results it can be concluded that a nonechogenic distance of more than 2 mm between the bone and the joint capsule at the levels of the trochlea or the capitulum of the humerus, as well as a nonechogenic space in the olecranon fossa indicate intraarticular effusions or synovitis of the elbow joint.

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