Inter-observer reliability of rheumatologists performing musculoskeletal ultrasonography: results from a EULAR ‘Train the Trainers’ course.


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Inter-observer reliability of rheumatologists performing musculoskeletal ultrasonography: results from a EULAR ‘Train the Trainers’ course.

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Abstract

Objective To evaluate the inter-observer reliability between 14 experts in musculoskeletal ultrasonography (US) and to determine the overall agreement of US results compared to magnetic resonance imaging (MRI) which served as imaging gold standard.

Methods The clinically dominant joint regions (shoulder, knee, ankle/toe, wrist/finger) of 4 patients with inflammatory rheumatic diseases were ultrasonographically examined by the 14 experts. US results were compared to MRI. The overall agreements, sensitivities, specificities and inter-observer reliabilities were assessed.

Results Taking an agreement in US examination of 10 out of 14 experts into account, the overall kappa for all examined joints was 0.76. Calculations with regard to each joint region revealed high kappa values for the knee (1), moderate values for the shoulder (0.76) and hand/finger (0.59), and low agreement for ankle/toe joints (0.28). Kappa values regarding bone lesions, bursitis and tendon tears were high (kappa=1). Compared to MRI, we found a relatively good agreement for most US findings for the shoulder (overall agreement 81%, sensitivity 76%, specificity 89%) and knee joint (overall agreement 88%, sensitivity 91%, specificity 88%). Sensitivities were lower for wrist/finger (overall agreement 73%, sensitivity 66%, specificity 88%) and ankle/toe joints (overall agreement 82%, sensitivity 61%, specificity 92%).

Conclusion This is the first study that investigates inter-observer reliability for a large number of physician sonographers. Inter-observer reliabilities, sensitivities, and specificities in comparison with MRI were moderate to good. Further standardization of US scanning techniques and definitions of different pathologic US lesions are necessary to increase the inter-observer agreement in musculoskeletal US.

Key words: ultrasonography – inter-observer reliability – joint – MRI - musculoskeletal
Introduction
Recent technological advances have made musculoskeletal ultrasonography (US) a promising tool for the assessment of patients with rheumatic diseases. US has strengths in visualizing soft tissue inflammatory processes and bone erosions in different joints (1-8). Synovitis can be detected in joints, bursae and tendon sheaths (9-11). In addition, multiple studies have shown that Doppler US allows the visualization of vessels in arthritic joints (5, 11-15).

Since US is a relatively quick to perform and easily accessible bedside procedure with low running costs (16), it is highly relevant to consider the validity of musculoskeletal US measures. Despite increasing evidence of the potential applications of US in the evaluation of arthritic joints, data on its accuracy and reproducibility remain limited (17). The current validity measures for US in rheumatoid arthritis (RA) have recently been summarized concluding that there is further need to evaluate discriminant validity with regard to a sufficient reproducibility (18). It has been stated, but underinvestigated that musculoskeletal US is highly operator dependent. The inter- and intra-observer variations have been tested in a minority of studies while inter-observer agreement has only been assessed between two observers (6, 17, 19). Most studies investigating inter-observer variation for musculoskeletal US, radiography and magnetic resonance imaging (MRI) have assessed the interpretation of images only and not image acquisition (4, 6).

Since 1998, EULAR - US courses have been organized. The trainers of these courses are rheumatologists from many European countries. They are considered experts in the field yet have varied educational backgrounds. We therefore decided to perform a “Train the Trainer” study which was held before the 8th EULAR US course conducted in association with the 2004 annual EULAR congress in Berlin (Germany) to contribute to validity in musculoskeletal US. All 14 trainer-rheumatologists who made up the faculty of this US course participated in the study to address three main issues: first, to collect data on standardization of musculoskeletal US by evaluation of a detailed questionnaire, second, to evaluate the inter-observer reliability between the sonographers and third, to determine the overall agreement of US results compared to MRI serving as imaging gold standard.

Patients and Methods
The 14 trainers represented 10 different countries (1 Austria, 1 Denmark, 1 Finland, 1 France, 3 Germany, 1 Great-Britain, 2 Italy, 2 The Netherlands, 1 Spain, 1 Switzerland). Their mean age was 44 years (range: 33–56 years). The study was divided into two parts. First, a detailed questionnaire on general information about the examiners, the equipment used and the most commonly examined joints was mailed to all trainers before the meeting and anonymously evaluated. Additionally, questions with regard to standardization (transducer orientation, documentation, positioning, and adherence of standard scans according to EULAR recommendations) were asked. Second, each trainer performed practical US examinations of pre-defined joints of 4 patients who had previously been assessed by MRI.

Practical scanning: All US examinations were performed anonymously and separately by all the experts. Each sonographer was given a maximum of 10 minutes for US examination per joint region. To ensure standardized documentation, each participant was given a report sheet that listed possible pathologic findings against which a yes or no tick box was used, indicating presence or absence of each particular finding.

Patients: Four patients were recruited from the outpatient clinics of the Medical Centre for Rheumatology, Berlin-Buch (patients 1 and 2) and the Department of Rheumatology and Clinical Immunology, Charité-University-Hospital, Berlin (patients 3 and 4) one week before the study. Medication was kept constant since day of recruitment. Based on the questionnaire
the most often examined joint regions were selected: shoulder, knee, ankle/toe and wrist/finger. The pre-defined joint region of the following patients was ultrasonographically examined by each expert:

**Patient 1:** Female (38 years) with erosive RA (disease duration 11 years) underwent examination of the right **shoulder**. She received prednisolone 7.5mg/day, methotrexate 15 mg/week and infliximab 300mg every 4 weeks, CRP and ESR were normal.

**Patient 2:** Male (69 years) with RS3PE-syndrome (disease duration 3 months) for examination of the right **wrist and finger joints**. He received rofecoxib (25mg/day), CRP was slightly elevated (7mg/l, normal <5), ESR was normal.

**Patient 3:** Male (59 years) with gout for examination of the right **knee** with swelling and pain for 4 weeks. CRP and ESR were normal, uric acid was elevated (10.1 mg/dl, normal: 3.0-6.9). He received celecoxib 100 mg and colchicine 0.5mg bid, allopurinol 300mg once daily.

**Patient 4:** Male (28 years) with reactive arthritis of the left **ankle and toe joints** with pain and swelling of both knees and the left ankle. The patient was HLA-B27 positive, ESR (61/84 mm) and CRP (60mg/l) were highly elevated. He received rofecoxib (25mg/day) and antibiotic therapy (doxycyclin 200mg once daily).

**Ultrasoundography:** We employed a linear probe for all investigations (LA 523, 13-4 MHz; length of the probe, 45mm; Esaote Technos MPX; Esaote S.p.A., Genova, Italy). Scanner settings were uniform for all measurements: frequency setting, 12.5 MHz for wrist/finger and ankle/toe, 10 MHz for shoulder and knee investigations; B-mode gain, 100%; one focus point position in the region of measurement. An introduction to the US device was given to the observers prior to US examinations. Two application specialists from Esaote were present to help in case of problems with regard to machine adjustments during the investigation.

The four joint regions were examined by each ultrasonographer. For the **shoulder joint**, examination of the biceps tendon, rotator cuff (subscapularis, supraspinatus and infraspinatus tendons), glenohumeral joint cavity, humeral bone surface and subacromial-subdeltoid bursa, was required. For examination of the **wrist/finger joints**, evaluation was performed of the right wrist and MCP II joint as well as tenosynovitis of the extensor carpi ulnaris, flexor and extensor tendons II. For the **knee joint**, the suprapatellar recess, infrapatellar bursae, popliteal cysts and patella ligament were evaluated. For the **ankle joint**, US was performed for the tibio-talar and talo-navicular joints as well as the Achilles tendon, plantar fascia and the extensor, flexor and peroneus tendons.

Two sonographers (MB, WAS) performed the US examination blinded to the other results in the exact way as described above 4 days prior to the “practical examination”, while their findings were included in the final evaluation. One hour prior to the “practical examination” performed by the 12 other experts, patients were re-examined by MB and WAS to ensure that pathologic findings were still present.

**MRI** of the above mentioned joint regions was performed in our 4 patients by a musculoskeletal radiologist (KGH), serving as imaging gold standard. MRI was performed with a 1.5 Tesla whole body magnet (MAGNETOM Sonata Maestro Class, Siemens AG Medical Solutions, Erlangen, Germany) 4 days prior to the course. Standard imaging protocols were applied for all joints: for the shoulder, the protocol comprised T1-weighted fast spin echo (T1/FSE) sequences (slice thickness (SL): 4mm) in axial and oblique coronal views, a short tau inversion recovery (STIR) sequence in oblique coronal view, and T1-weighted fast spin echo sequences with fat saturation after application of gadolinium diethylenetriamine pentaacetic acid (T1/FS-Gd). For the wrist/finger joints, coronal and axial T1/FSE (SL: 3mm), a coronal STIR, and coronal and axial T1/FS-Gd sequences were used. The protocol for the knee comprised of a coronal T1/FSE (SL: 4mm), coronal STIR, sagittal proton density/T2-weighted sequence, and coronal, sagittal and axial T1/FS-Gd sequences.
The ankle joint was examined using sagittal and coronal T1/FSE (SL: 4mm), sagittal STIR, and coronal, sagittal and axial T1/FS-Gd sequences. Evaluation was performed blinded to the diagnoses and clinical data using the same standardized report form as for US examinations.

**Statistical analysis:** Inter-observer agreement was estimated using a modified kappa index for majority agreement (20). The majority was defined as 10 out of 14, which corresponds to 71% agreement among the raters. Overall agreement (defined as the percentage of observed exact agreements) as well as sensitivity and specificity were calculated by means of the statistical software package SAS 8.02 (SAS Institute Inc., Cary, NC, USA).

**Results**

**Results of questionnaire:** The expertise of the sonographers was documented by a total of 89 original articles as first author in the field of musculoskeletal US. All participants frequently perform musculoskeletal US (9/14, >20 examinations per week, range 10 to >40). The most often examined joints are listed in Table 1a. The transducer orientation for longitudinal scans was applied by all sonographers according to the EULAR recommendations (21) (left of screen, proximal or cranial of the patient). On the contrary, for transverse scans 6 of 14 experts assigned their left side to the left of the screen as opposed to the EULAR recommendations (left of screen, medial of patient, 5 of 14). Doppler US is frequently used in musculoskeletal US (13/14). Documentation of normal and pathologic findings is performed by all participants. The transducers mainly used by the experts for musculoskeletal US are listed in Table 1b. The sonographers perform most of the EULAR standard scans (21). However, 29% of the demanded scans were not performed for the shoulder joint (Table 1c). The less frequently performed scans demanded a special position during dynamic examination, e.g. the anterior transverse and longitudinal scans in maximal inner rotation of the shoulder were only performed by 5 of 14 sonographers, each.

**Results of practical examinations:** The normal and pathologic findings of the joint structures detected by MRI and US are displayed in Tables 2a-d.  

**Inter-observer agreement:** Taking an agreement in US examination of 10 out of 14 experts as a point of reference, the overall kappa for all examined joints was 0.76. Calculations regarding each joint region revealed good kappa values for the knee (1) and shoulder (0.76) joints, moderate agreement for the hand/finger joints (0.59) and low agreement in ankle/toe joints (kappa 0.28). Kappa values with regard to bone lesions, bursitis and tendon tears (evaluation includes all joint regions) were excellent (kappa=1, respectively). There was also a moderate kappa for the detection of tenosynovitis (0.49) while there were low kappa values for the detection of synovitis/effusion, mainly because small amounts (e.g. acromio-clavicular joint) were missed. The overall agreements between the 14 experts were: for the shoulder 81%, for the wrist/fingers 73%, for the knee joint 88% and the ankle 82%.

**Overall agreement of US findings compared to MRI:** In US examination, we found a good agreement for most findings regarding the shoulder joint (e.g. humeral head erosions, 100%, Figure 1 a,b) with an overall agreement of 81% when compared to MRI findings (Table 2a). However, the detection of synovitis/effusion in the shoulder was moderate (50%, Figure 1 c,d) and poor for the acromio-clavicular joints (29%). US examinations of the shoulder joint revealed a sensitivity of 76% and specificity of 89%.

For the wrist and finger joints, we found a lower overall agreement of US findings compared to MRI (73%) (Table 2b). Especially tenosynovitis from palmar and synovitis/effusion in MCP II joint showed a low agreement with MRI findings (50% each, Figure 2 a,b). However, agreement for dorsal synovitis findings (e.g. tenosynovitis 79%) was clearly better possibly since evaluation of joints is –in many countries- routinely performed.
only from the dorsal sides and palmar inflammation may be missed. The overall sensitivity for US of the wrist/finger joints was rather low (66%) with a higher specificity (88%).

For the **knee joint** the overall agreement of US findings with MRI was 88% (**Table 2c**). Effusion in the suprapatellar recess was seen by all participants (**Figure 3 a,b**) while almost all (13/14) detected the popliteal cyst (**Figure 3 c,d**). The overall sensitivity for US of the knee joint was 91%, the overall specificity 88%.

Results for US examination of the **ankle joints** were similar to the results of the wrist and finger joints. Although the overall agreement was 82%, we found a rather low overall sensitivity of 61% with a high specificity (92%) (**Table 2d**). There was low concordance in the detection of synovitis/effusion in both, tibio-talar (**Figure 4 a,b**) and talo-navicular joints (57%, each) as well as the extensor tendons (36%), while there was better agreement in the detection of flexor (85.7%) and peroneus (71%) tenosynovitis.

The overall total agreement of US findings as compared to MRI with regard to all examined joints (45 sonographic findings) was 82% (sensitivity=71%, specificity=90%).

**Discussion**

There is increasing evidence for that musculoskeletal US has an important role to play in the management of patients with arthritis (16). However, operator dependence remains one of the perceived major limitations to its widespread use (5, 17, 18, 22, 23). There is currently limited available data, however, regarding reproducibility, in particular for a large number of observers. This study has demonstrated moderate to good correlations between 14 independent observers.

Main result of an open blinded questionnaire sent to all experts was that most standard scans as published by the EULAR working group for musculoskeletal US (21) were performed by the sonographers: however, for the shoulder joint there is standardization to a lesser extent (71%) as compared to the other joints (range from 82% for the knee to 100% for the wrist joints). Possibly, the reason for this is that some additional EULAR scans that demand special positions for dynamic examination are not performed by all. These scans, however, are helpful to detect subtle amounts of effusion that can only be visualized by moving the limbs and/or transducer.

For comparing musculoskeletal US results, inter-observer agreement has so far only been calculated between 2 observers (6, 17, 19). The more observers participate for inter-observer computations, the lower is the probability of simultaneous agreement among all observers resulting in too low kappa values (20). In our majority agreement (20) there is already a contribution to agreement if at least 10 out of 14 judgements of a joint are the same resulting in an overall kappa of 0.76. Our overall kappa is higher as described in the literature when 2 observers were compared (range 0.48–0.68) (6, 17) which gives relatively good results taking into account that we compared 14 observers. This difference may be due to several reasons. First, all participants in our study were experienced sonographers; this means that agreement should be tested in further studies with less experienced sonographers. Second, the sonographers may have paid more attention than usual, so that any possible lesion was reported.

The OMERACT MRI in RA working group studied inter-reader agreement for a simple scoring system in RA wrist and MCP joints among 5 different centres (24, 25). They found unweighted kappas with a mean of 0.62 suggesting that the basic interpretation of MRI changes is relatively consistent among readers from different countries, but that further training and standardization are necessary to achieve better intergroup reproducibility (24) which is currently underway as part of the OMERACT process (26). In a follow-up study, the OMERACT working group gained improvement in inter-reader agreement as reflected by acceptable intra-class correlation coefficients (ICC range 0.6-0.91) (25). This measure,
however, is not applicable for our data due to the limited number of cases. Nevertheless, since MRI allows for detailed documentation of joint examinations, these studies compare the reading of images taken at one MR examination while in US the reliability of producing and reading images is considered. Kappa values were slightly higher between ultrasonographers as opposed to MRI-readers disproving the general position of US being highly observer dependent. Calculations of US examinations with regard to each joint region revealed good kappas for the knee (1) and shoulder (0.76) joints, acceptable agreement for the hand/finger (0.59) and low agreement in ankle/toe joints (0.28). However, kappa values of the ankle/toe joints are not fully applicable since there has been an asymmetric distribution of positive and negative findings and the overall agreement between observers should be taken into account (84%).

Overall, we found a moderate to good agreement between the expert ultrasonographers and MRI with a high concordance for main findings regarding both bone surface and soft tissue abnormalities. For the shoulder, the overall agreement of US findings compared to MRI was 81%. We found a relatively good agreement with most detected pathologies. More discrete findings as minimal effusion in the acromio-clavicular and gleno-humeral joints were detected to a far lesser extent (29% vs. 50%) which was also reported in a recent study (27). However, inflammation within the joint cavity could only be seen in full inner rotation, again supporting the need for a full dynamic US examination. For the wrist and finger joints, we found a high overall specificity (89%) and a moderate sensitivity (66%) due to low sensitivities in the detection of palmar tenosynovitis and MCP II joint synovitis (50% each). However, since finger joint synovitis was mainly present at the palmar side of the finger in our patients, these findings might have been missed when evaluation was solely performed from dorsal. Similar observations have been reported recently in 42 patients with RA and finger joint inflammation (28). For the knee, US resulted in a high overall sensitivity (91%) and specificity (88%). In particular, US was very sensitive in the detection of suprapatellar effusion (100%) and popliteal cysts (93%). However, there might have been some over-interpretation with US in the detection of bone lesions since there were no bone defects detected by MRI (specificity range 71–79%). The sensitivity for the ankle and toe joints was rather low (61%) with a high specificity (92%) most probably due to a lack in dynamic and both plantar and dorsal examinations to detect even subtle pathologies which can only be seen in special positions and during movement.

Although guidelines have been published, scanning techniques vary to a certain extent in the European countries and between the experts. Ten of the 14 sonographers were not familiar with the equipment and the scanner settings and the level of experience with the US device was different for each sonographer. In addition, the scanner settings were not variable, the sonographers were blinded to the clinical diagnosis, and a symptom driven clinical examination of the affected joint region was not performed. These aspects have a relevant influence on the information that can be obtained in a 10 minutes scanning of complex anatomical areas and reliability might have been better if longer training on US devices had been given.

Concluding, our results show that musculoskeletal US is a reliable technique with moderate to good inter-observer reliability in an expert setting between a large number of observers. Sonographers can differ, for some joints substantially, in their interpretations of the US images. In addition, the study underpins the need for dynamic examination in order to completely detect subtle pathologic findings. Training and standardization of musculoskeletal US are necessary to achieve higher inter-observer reproducibility. In a next step we aim to perform inter-observer testing on semiquantitative and quantitative grading of pathologic structures. As a conclusion of this study, the participants decided to accelerate efforts to standardize the musculoskeletal US investigation techniques in both EULAR and OMERACT settings.
Acknowledgements: The study was supported by a grant from Abbott GmbH + Co. KG Ludwigshafen, Germany, and Abbott Laboratories, Abbott Park, Illinois, USA. The US equipment was generously provided for this study by Esaote Biomedica, (Munich, Germany).

Legends of the Figures

Figure 1: Shoulder joint
1 A and B: Humeral head erosions. A: In MRI, multiple erosions can be seen from the anterior and posterior sides of the humeral head as bone defects with sharp margins (arrows). B: Distinct bone defects below the bone surface (erosions, open arrows) can also be detected by US. This image is taken from the anterior side with maximum inner rotation (transverse scan).
1 C and D: gleno-humeral joint synovitis. C: In MRI, contrast enhancement clearly depicts a subdeltoid/subacromial bursitis (arrows) and synovitis within the joint. D: The US image shows a lateral longitudinal scan of the shoulder joint. Subdeltoid bursitis can be visualized as an anechoic area below the deltoid muscle (open arrows).

Figure 2: Finger joint (MCP II)
A: The MR image shows the metacarpophalangeal (MCP) joints II-V in transverse section. Focusing on MCP joint II shows slight contrast enhancement from dorsal and palmar aspects representing synovitis (arrowheads). Also, tenosynovitis is seen at the flexor tendons (arrow).
B: The US longitudinal image from palmar side displays an anechoic to hypoechoic area at the region of the diaphysis reflecting synovitis (open arrows). Also, there is tenosynovitis along the flexor tendon (upper open arrows).

Figure 3: Knee joint
A: MRI shows some contrast agent enhancement in the suprapatellar recess reflecting inflammatory effusion (2 arrows). B: US also clearly depicts the effusion in the suprapatellar recess (open arrows). C: In MRI, a popliteal cyst is visualized in the sagittal view with a deep part (arrowheads) and a superficial part (arrows). D: Both parts can also clearly be detected by US as anechoic areas (open arrows).

Figure 4: Ankle/toe joints
A: The MRI of the ankle shows contrast enhancement in the tibio-talar joint from anterior and posterior aspects (arrows). B: The longitudinal US image is an example of the anterior side of the tibio-talar joint. The anechoic area displays effusion (anechoic) and synovitis (hypoechoic) (open arrows).
Tables

Table 1a Joints mainly examined by expert ultrasonographers

<table>
<thead>
<tr>
<th>Joint/ Frequency</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder</td>
<td>9</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Elbow</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wrist</td>
<td>0</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Finger joints</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hip</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Knee</td>
<td>2</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Ankle</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Toe joints</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
</tbody>
</table>

1=most; 2=second, 3=third frequently examined joint

Table 1b US examination of individual joints transducers

<table>
<thead>
<tr>
<th>Joint</th>
<th>Array</th>
<th>Frequency*</th>
<th>Range (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder</td>
<td>14 linear</td>
<td>7.5 – 10</td>
<td>[4-10]</td>
</tr>
<tr>
<td>Elbow</td>
<td>14 linear</td>
<td>7.5 – 10</td>
<td>[4-13]-[10-14]</td>
</tr>
<tr>
<td>Wrist</td>
<td>14 linear</td>
<td>10</td>
<td>[4-13]-[8-16]</td>
</tr>
<tr>
<td>Finger joints</td>
<td>14 linear</td>
<td>10</td>
<td>[5-10]-[10-22]</td>
</tr>
<tr>
<td>Hip</td>
<td>10 linear</td>
<td>5 – 10</td>
<td>[5]-[5-12]</td>
</tr>
<tr>
<td></td>
<td>4 curved</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee</td>
<td>14 linear</td>
<td>7.5 – 10</td>
<td>[4-13]-[10-14]</td>
</tr>
<tr>
<td>Ankle</td>
<td>14 linear</td>
<td>7.5 – 10</td>
<td>[4-13]-[8-16]</td>
</tr>
</tbody>
</table>

* All participants use frequencies within this range

Table 1c Scanning of individual joints: Standard scans as demanded by EULAR*

<table>
<thead>
<tr>
<th>Joint</th>
<th>Standard scans*</th>
<th>Mean performed scans</th>
</tr>
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<tbody>
<tr>
<td>Shoulder</td>
<td>9</td>
<td>6.4 (71%)</td>
</tr>
<tr>
<td>Elbow</td>
<td>8</td>
<td>6.6 (83%)</td>
</tr>
<tr>
<td>Wrist</td>
<td>7</td>
<td>7 (100%)</td>
</tr>
<tr>
<td>Finger</td>
<td>6</td>
<td>5.3 (88%)</td>
</tr>
<tr>
<td>Hip</td>
<td>3</td>
<td>2.5 (83%)</td>
</tr>
<tr>
<td>Knee</td>
<td>10</td>
<td>8.2 (82%)</td>
</tr>
<tr>
<td>Ankle</td>
<td>8</td>
<td>7.4 (93%)</td>
</tr>
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</table>
## Practical Part

### Table 2a Shoulder joint (right)

<table>
<thead>
<tr>
<th>Anatomic Structure</th>
<th>Pathology</th>
<th>MRI*</th>
<th>Ultrasound findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Long biceps tendon</td>
<td>tenosynovitis</td>
<td>yes</td>
<td>13/14 93%</td>
</tr>
<tr>
<td></td>
<td>tear</td>
<td>no</td>
<td>13/14 93%</td>
</tr>
<tr>
<td></td>
<td>dislocation</td>
<td>no</td>
<td>14/14 100%</td>
</tr>
<tr>
<td>-Subscapularis tendon</td>
<td>tear</td>
<td>no</td>
<td>12/14 86%</td>
</tr>
<tr>
<td>-Supraspinatus tendon</td>
<td>tear</td>
<td>yes</td>
<td>12/14 86%</td>
</tr>
<tr>
<td>-Infraspinatus tendon</td>
<td>tear</td>
<td>no</td>
<td>11/14 79%</td>
</tr>
<tr>
<td>-Humeral head</td>
<td>erosion</td>
<td>yes</td>
<td>14/14 100%</td>
</tr>
<tr>
<td>-Shoulder</td>
<td>gleno-humeral joint synovitis/effusion</td>
<td>yes</td>
<td>7/14 50%</td>
</tr>
<tr>
<td></td>
<td>subdeltoid bursitis</td>
<td>yes</td>
<td>14/14 100%</td>
</tr>
<tr>
<td>-acromioclavicular joint</td>
<td>synovitis/effusion</td>
<td>yes</td>
<td>4/14 29%</td>
</tr>
</tbody>
</table>

Overall agreement 11.4/14 81%
Sensitivity 76.2% Specificity 89.3%

---

### Table 2b Wrist/finger joints (right)

<table>
<thead>
<tr>
<th>Anatomic structure</th>
<th>Pathology</th>
<th>MRI*</th>
<th>Ultrasound findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>-wrist</td>
<td>synovitis/effusion</td>
<td>yes</td>
<td>12/14 86%</td>
</tr>
<tr>
<td></td>
<td>dorsal tenosynovitis</td>
<td>yes</td>
<td>11/14 79%</td>
</tr>
<tr>
<td></td>
<td>palmar tenosynovitis</td>
<td>yes</td>
<td>7/14 50%</td>
</tr>
<tr>
<td></td>
<td>extensor carpi ulnaris tenosynovitis</td>
<td>yes</td>
<td>10/14 71%</td>
</tr>
<tr>
<td>-MCP II</td>
<td>synovitis/effusion</td>
<td>yes</td>
<td>7/14 50%</td>
</tr>
<tr>
<td></td>
<td>erosion</td>
<td>no</td>
<td>13/14 93%</td>
</tr>
<tr>
<td></td>
<td>osteophyte</td>
<td>no</td>
<td>12/14 86%</td>
</tr>
<tr>
<td>-flexor tendon II</td>
<td>tenosynovitis</td>
<td>yes</td>
<td>8/14 57%</td>
</tr>
<tr>
<td>-extensor tendon II</td>
<td>tenosynovitis</td>
<td>no</td>
<td>12/14 86%</td>
</tr>
</tbody>
</table>

Overall agreement 10.2/14 73%
Sensitivity 65.5% Specificity 88.1%

---

* serving as gold standard
Table 2c Knee joint (right)

<table>
<thead>
<tr>
<th>Anatomical structure</th>
<th>Pathology</th>
<th>MRI*</th>
<th>Ultrasound findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>suprapatellar recessus</td>
<td>effusion</td>
<td>yes</td>
<td>14/14 100%</td>
</tr>
<tr>
<td></td>
<td>synovial hypertrophy</td>
<td>yes</td>
<td>11/14 79%</td>
</tr>
<tr>
<td>bone surface at joint space</td>
<td>osteophyte medial</td>
<td>no</td>
<td>11/14 79%</td>
</tr>
<tr>
<td></td>
<td>osteophyte lateral</td>
<td>no</td>
<td>10/14 71%</td>
</tr>
<tr>
<td></td>
<td>erosion medial</td>
<td>no</td>
<td>11/14 79%</td>
</tr>
<tr>
<td></td>
<td>erosion lateral</td>
<td>no</td>
<td>11/14 79%</td>
</tr>
<tr>
<td>patella tendon</td>
<td>tendinitis</td>
<td>no</td>
<td>14/14 100%</td>
</tr>
<tr>
<td></td>
<td>enthesitis</td>
<td>no</td>
<td>13/14 93%</td>
</tr>
<tr>
<td>anterior bursae</td>
<td>prepatellar bursitis</td>
<td>no</td>
<td>14/14 100%</td>
</tr>
<tr>
<td>posterior bursae</td>
<td>Baker’s cyst</td>
<td>yes</td>
<td>13/14 93%</td>
</tr>
</tbody>
</table>

overall agreement 12.4/14 88%
sensitivity 90.5%  specificity 87.5%

Table 2d Ankle and foot joints (right)

<table>
<thead>
<tr>
<th>Anatomical structure</th>
<th>Pathology</th>
<th>MRI*</th>
<th>Ultrasound findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>ankle (tibiotalar)</td>
<td>synovitis/effusion</td>
<td>yes</td>
<td>8/14 57%</td>
</tr>
<tr>
<td>talonavicular joint</td>
<td>synovitis/effusion</td>
<td>yes</td>
<td>8/14 57%</td>
</tr>
<tr>
<td></td>
<td>erosion</td>
<td>no</td>
<td>12/14 86%</td>
</tr>
<tr>
<td></td>
<td>osteophyte</td>
<td>no</td>
<td>12/14 86%</td>
</tr>
<tr>
<td>extensor tendons</td>
<td>tenosynovitis</td>
<td>yes</td>
<td>5/14 36%</td>
</tr>
<tr>
<td>flexor tendons</td>
<td>tenosynovitis</td>
<td>yes</td>
<td>12/14 86%</td>
</tr>
<tr>
<td>peroneus tendons</td>
<td>tenosynovitis</td>
<td>yes</td>
<td>10/14 71%</td>
</tr>
<tr>
<td>achilles tendon</td>
<td>tendinitis</td>
<td>no</td>
<td>14/14 100%</td>
</tr>
<tr>
<td></td>
<td>paratenonitis</td>
<td>no</td>
<td>14/14 100%</td>
</tr>
<tr>
<td></td>
<td>retrocalcaneal bursitis</td>
<td>no</td>
<td>13/14 93%</td>
</tr>
<tr>
<td>posterior aspect of calcaneus</td>
<td>erosion/irregularity</td>
<td>no</td>
<td>12/14 86%</td>
</tr>
<tr>
<td>plantar aspect of calcaneus</td>
<td>calcaneal spur</td>
<td>no</td>
<td>11/14 79%</td>
</tr>
<tr>
<td></td>
<td>erosion/irregularity</td>
<td>no</td>
<td>13/14 93%</td>
</tr>
</tbody>
</table>

overall agreement 11.5/14 82%
sensitivity 61.4%  specificity 92.1%

overall total agreement (45 sonographic findings) 81.6% (specificity 89.7%, sensitivity 71.4%) * serving as gold standard
References


Interobserver reliability of rheumatologists performing musculoskeletal ultrasonography: results from a EULAR "Train the Trainers" course


Ann Rheum Dis published online January 7, 2005

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