Concise report

Does joint position affect US findings in inflammatory arthritis?

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Abstract

Objective. Musculoskeletal US is being increasingly used for the assessment of synovitis, although questions remain about its reliability. One potential factor affecting reliability is the lack of consensus of image acquisition methods such as using different joint positions. This may have an implication on the reproducibility of studies that use US as an outcome measure. The aim of this study was to determine whether a change in joint position might significantly alter the quantification of US-detected synovitis in patients with inflammatory arthritis (IA).

Methods. IA patients with clinically swollen wrists, MCP and/or knee joints were recruited. These joints were assessed quantitatively for the presence of synovitis when they were placed in different positions.

Results. Seventy-five patients with IA were assessed. The greatest grey scale (GS) and power Doppler (PD) scores for the MCP joints were found in the flat (0°) position (91 and 100% of cases, respectively) compared with other positions ($P < 0.001$). Similar results were found in the wrist joints. The greatest GS and PD scores for the knee joint were found in 30° flexion [100 and 95.6% of cases, respectively, compared with other positions ($P < 0.001$)]. The inter- and intra-reader reliability was good to excellent.

Conclusion. The position in which a joint is scanned for synovitis appears to significantly influence the US assessment of synovitis. Our study suggests that the standardized scanning of the hand joints in a flat position and the knees in a 30° position are associated with the highest GS and PD scores.

Key words: musculoskeletal ultrasound, power Doppler, joint position, grey scale, knee.

Introduction

One of the most common and important applications of musculoskeletal US in rheumatology is the assessment of joint synovitis in inflammatory arthropathies. A major limitation to the widespread use of US, however, has been its operator dependency and perceived poor reliability particularly when compared with other imaging modalities such as MRI. In 2004, an OMERACT US Task Force was formed to assess the metric qualities of US in relation to clinical trials. With an initial focus on synovitis, a systematic review highlighted a significant lack of data covering all aspects of reliability, particularly with respect to the standardization of US definitions and the method of image acquisition [1]. In response, the Task Force has been carrying out an ongoing work aiming to produce definitions and grading systems for synovitis [2, 3].

Image acquisition is arguably the most important aspect of US scanning. A previously published report by the OMERACT group demonstrated that intra- and inter-reader reliability was much greater when static US images were interpreted without acquisition being involved [3]. In the same study, the inter-reader reliability for scanning static images was ‘good to excellent’ but dropped to ‘poor to fair’ for real-time image acquisition, indicating the significant effect of the acquisition aspect of US reliability. The acquisition of a US image is dependent on a number of machine, operator and patient-related factors. The effects of many of these factors have been underinvestigated but anecdotal reports have suggested that joint position may be important [4].
There are a number of published recommendations on how to scan joints, each with their own methods [5–7]. However, there are limited published data to support which scanning method is best. Most available data relate to the knee. However, whether a scan should be done while knee is extended or flexed, with or without quadriceps contraction, is unknown. Less data are available for the other joints. The objective of this study, therefore, was to determine if a change in the positioning angle of joint has a significant effect on the grey scale (GS) and power Doppler (PD) findings in patients with inflammatory arthritis (IA), which might inform an optimal scanning position for each joint.

Patients and methods

Patients

Patients with clinically active IA in the hands and/or knee (defined by the presence of swelling, tenderness and stiffness) were recruited from the rheumatology outpatient clinics at Chapel Allerton Hospital, Leeds, UK. All patients were required to have an acceptable range of movement, which meant that they had to fulfil all the required joint positions for the study. The study was approved by the local ethics committee (Leeds East Ethics Committee) and informed written consent was obtained from all patients.

Ultrasonographic examination

Ultrasonography (GS and PD) was carried out using an HDI Philips 5000 scanner (Phillips, Eindhoven, The Netherlands) with a multi-linear 15–7-MHz hockey stick probe for small joint and a 12–5-MHz linear probe for large joint assessment. An investigator (A.S.Z.) trained in musculoskeletal US performed all examinations. PD was assessed using the highest gain level without background noise, pulse repetition frequency of 750 Hz and medium wall filter. The settings were adjusted at the beginning of the examination with no further adjustment permitted with the exception of the depth and focus adjustment. The most symptomatic (based on pain and stiffness) or dominant joint (if no difference in symptoms between sides) was examined.

Eight joints in the hand and wrists were examined: radio-carpal (RCJ), inter-carpal (ICJ), ulnar-carpal (UCJ) and first to fifth MCP joints. Wrist and MCP joints were scanned in the following four positions: extension to −30°, flat (0°) and flexion to 30 and 90° positions. Knee examination included assessment of the supra-patellar pouch (SPP), medial and lateral recesses and medial and lateral joint spaces. The medial and lateral recesses are the gutters of the supra-patellar bursa. The lateral and lateral joint spaces represent the articulation between the lateral and medial condyles of the femur and tibia. The knee joints were scanned in flat (0°), flat with quadriceps contraction, 30 and 90° flexion positions. Joints were examined in both longitudinal and transverse planes. The GS and PD scores were decided after scanning in the longitudinal plane. However, the transverse plane was used for confirmation of the findings.

GS and PD were scored using the EULAR–OMERACT semi-quantitative 0–3 scale [2, 8–11]. For the knee recesses, GS scoring was subdivided into total GS score, SF effusion and synovial membrane hypertrophy. Effusion and synovial membrane hypertrophy were distinguished according to the OMERACT definitions [2]. For the quantitative measurements (expressed in millimetres) of total SPP thickness, synovial membrane and fluid depth, the readings were taken with the probe in the midline longitudinal position. Specially designed positioning devices for both the hand (Fig. 1) and knee examinations were used to ensure accurate and standard positioning of these joints. The knee positioning device had a different design from the hand, one which included an adjustable foot piece to accommodate different limb lengths.

Statistical analysis

Statistical analysis was performed using the SPSS statistical package, version 16.0 (SPSS, Chicago, IL, USA). As this was a pilot study, we aimed to recruit a minimum of 60 patients (30 for each joint) which is sufficient to power the study [12]. To facilitate the analysis of different joint areas, the scores were summed within the following areas: MCPs (five MCP joints); wrist (three joints including RCJ, ICJ and UCJ); knee supra-patellar recesses (three recesses including SPP, medial and lateral recesses); and knee joint space (two spaces including medial and lateral joint spaces). The frequency of producing the maximum GS and PD score by any joint position was calculated. As it was possible for the same score to be given at two or more joint positions, all positions with the same maximum score were considered to be the joint maximum score. Cochran’s Q-test was used to compare the proportions of cases in which a particular position produced the maximum or joint-maximum score. Scores were compared between positions using Friedman tests.

To test the inter-reader reliability of US, 17 hands and knees were rescanned at the same visit by a second rheumatologist (J.E.F.) blinded to the readings of the first reader. Twenty hands and knees were also rescanned by the first reader (A.S.Z.) within 48 h to test intra-reader reliability. The inter- and intra-reader reliability was assessed using the quadratic-weighted Kappa (κ) statistic for the semi-quantitative measurements. The total agreement and the agreement for each position were calculated. Interclass Correlation Coefficients (ICCs) were used to test the reliability of the quantitative measurements.

Results

Patient characteristics

Seventy-five patients (54 female) with a mean age of 56 (range 19–82) years were included. The patients represented a spectrum of IA diagnoses. Sixty-one percent (n = 46) had RA, 36% (n = 27) had seronegative arthritides and 3% (n = 2) had gout. In some of the patients (n = 12), both the knee and hand were examined because they were both fulfilling the inclusion criteria. A total of 45 knees and 42 hands were examined.
Ultrasonographic examination
The greatest GS and PD scores in the MCP and wrist joints were found when the joints were flat (0° position). The scores were significantly lower when the joints were placed in other positions (Figs 1 and 2). The greatest GS and PD scores in the knee SPP recesses and joint spaces were found when the joints were flexed to 30° (Fig. 2). The mean (S.D.) total thickness of the SPP was 10.02 (9.50) in 30° flexion in comparison with 5.84 (5.52) in 0° position, 7.04 (6.75) in 0° position with quadriceps contraction and

**Fig. 1** Changes in GS and PD semi-quantitative grading following alterations in MCP joint position in an RA patient.

**Fig. 2** The frequency of maximum or joint maximum GS and PD scores in different joint positions ($P < 0.001$). (A) MCP joints. (B) Wrist joints. (C) Knee SPP recesses. (D) Knee joint spaces.
5.76 (3.60) at 90° flexion. Similar results were found regarding the synovial and fluid thickness measurements.

Reliability
The inter- and intra-reader agreement was good to excellent for all joints examination. The weighted $\kappa$ for MCP joint GS and PD scores were 0.69 and 0.87, respectively ($P < 0.001$), and for knee SPP recesses, GS and PD scores were 0.89 and 0.93, respectively ($P < 0.001$). The intra-reader agreement was also excellent. The intra-reader weighted $\kappa$ for MCP joint GS and PD scores were 0.94 and 0.92, respectively, and for SPP recesses GS and PD were 0.94 and 0.97, respectively ($P < 0.001$). Inter- and intra-reader agreements for each position also ranged from good to excellent. The inter- and intra-reader agreements over the quantitative measurements were also good to excellent.

Discussion
We believe that this is the first study which rigorously assessed the effect of joint position on US acquisition in the assessment of synovitis. The results have demonstrated that joint position does have a significant influence on GS and PD signal and quantification. Scanning the hands and wrists in a flat (0°) position and the knees in a 30° flexion appear to be the optimal scanning positions as they provide the highest GS and PD scores.

Our results could be explained by the theory that joints do develop higher intra-capsular pressures in some positions [13, 14]. The change in the intra-capsular pressure associated with changing position may lead to change in the dynamics of SF and synovial membrane, affecting the GS signal. This change may result in compression of the small neo-vasculature within the synovium leading to reduction or even obliteration of the PD signal. An example of this is examining the hand joints in overextension or flexion that leads to tightening of the joint capsule and collateral ligaments, which potentially increase the intra-capsular pressure. This explanation may be supported by the findings of Gershuni et al. [15], who found that a change in joint position led to changes in the intra-compartmental pressure in the leg.

Does quadriceps contraction make a difference? With quadriceps contraction, the median total SPP thickness (fluid + synovial hypertrophy) was found to be higher than in the flat, relaxed state. This confirms the results of a previous work by Ike et al. [16]. However, in our study, less PD was found in knee quadriceps contraction in comparison with other joint positions. This may be due to the increase in the knee recess intra-compartmental pressure as a result of the squeezing effect of the quadriceps muscle contraction.

The current study has a number of limitations. One potential criticism is that the use of a positioning device might not be representative of real life and that a joint may be abnormally relaxed as a result. However, it is our observation that many sonographers in clinical practice will use a pillow for hand examination or a cushion for the knee. Indeed, holding the knee in a 30° position without support is often difficult for some patients, particularly for prolonged examinations.

The effect of other positions of all joints such as 45 and 60° were not examined due to feasibility concerns regarding the increased length of the US examination. This may be relevant with respect to knee examination in particular. While there is a potential difference in the joint dynamics between fully relaxed (0°), flexion (30°) and extreme flexion (90°) where there is tension on the joint, it is not expected to be of same significance with positions of closer degrees such as 30, 45 and 60°.

In the current study, the optimal position was considered as the position that provided the highest GS and PD scores. However, in practice, other factors such as the position that is the easiest or most comfortable for the patient should be considered. The range of movement of the patient that is being examined in clinical practice should also be considered as this study was performed on people with only an acceptable range of movement.

In conclusion, joint position has been shown to have a significant influence on synovitis assessment by US. Some positions are consistently better than others in producing higher GS and PD scores, such as the flat (0°) position in the hands and wrists and 30° flexion for the knees. Although quadriceps contraction provided better sonographic visualization of SPP fluid, it was otherwise not superior to simple knee flexion at 30°. Reaching a consensus regarding joint positioning may improve the reliability of musculoskeletal US as an outcome measure in clinical practice and trials.

Rheumatology key messages
- Joint position appears to significantly affect GS and PD signal in IA patients.
- We recommend scanning knees in 30° flexion and hands on a flat surface.

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References
Joint position affects US findings