

The role of musculoskeletal ultrasonography in rheumatoid arthritis and spondyloarthritis

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The use of musculoskeletal ultrasonography in rheumatological practice has increased rapidly over the past years, as a result of both technological developments and a need to diagnose and treat inflammatory lesions early. Musculoskeletal ultrasonography completes the clinical examination in a rapid and accurate manner and allows the very early identification of a wide range of pathological findings involving different anatomical structures in the musculoskeletal system. Physical assessment and conventional radiography, currently the most widely used first-line approaches, showed low accuracy as lesion diagnostic methods. Moreover, the radiographic changes take long time to develop, which leads to much delay in diagnosis.

Keywords:

musculoskeletal ultrasonography, rheumatoid arthritis, spondyloarthritis

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Introduction

Ultrasonography (US), sometimes referred to as US imaging or sonography, is an imaging technique that uses reflected pulses of sound waves, of high frequency (US), to assess cartilage, bone surfaces, soft tissues, and fluid-containing structures [1]. This reflection converts sound waves to an electrical current, which is the source of the produced US image [2].

Over the past years, the usage of musculoskeletal ultrasound (MSUS) in rheumatological practice has increased rapidly as a result of technological developments and a desire to identify inflammation and structural damage, monitor the disease, and predict therapeutic responses [3].

US is an imaging modality that continues to gain attention among rheumatologists owing to its high power in the evaluation of a wide spectrum of abnormal finding in rheumatic diseases [2,4].

MSUS provides fundamental clinical data regarding the early anatomical abnormalities, signs of aggressive inflammation, disease activity, and efficacy of treatment that helps the physician for a correct assessment of the disease process and to choose the best treatment option to give optimal care to the patients [5,6].

The clinical importance of US is closely related to many advantages compared with other imaging techniques such as safety; a patient-friendly, noninvasive modality; limited contraindications; no ionizing radiation; and relative low cost in comparison with MRI or computed

tomography. Furthermore, it allows a dynamic evaluation with a multiplanar view, direct comparison between clinical and sonographic findings, and a real-time assessment without the need for external referral [7].

In addition, MSUS is of great value as a bedside tool for guiding accurate and safe fluid aspiration or biopsies and intralesional or perilesional injections for diagnostic and therapeutic purposes [8].

MSUS is a helpful aiding tool over clinical examination of the joints, especially deeper joints like the hip, shoulder, ankle, and sacroiliac joints. For example, it is particularly useful in the assessment of shoulder joint; this is owing to the complex and wide range of pathological findings seen at this joint and the capability to provide dynamic evaluation. It can assess rotator cuff pathology calcific tendonitis with high sensitivity and specificity. Moreover, accurate evaluation of bicipital tendon pathology and subacromial–subdeltoid bursitis is readily identified. Moreover, sonography-guided injections can be done at the same time of examination [9].

An essential issue regarding MSUS is its reliability, as it is considered a highly operator–depending

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modality. Its accuracy depends on both acquisition and interpretation of US pictures. This has raised the need for a uniform assessment of US-detected abnormalities. Therefore, to optimize MSUS as a diagnostic and monitoring tool, universal guidelines would be needed for pathology evaluation. However, to establish this point, a progress has been made. The Outcome Measures in Rheumatology (OMERACT) MSUS group defined the main US findings in inflammatory arthritis, that is, synovitis, including synovial fluid (effusion) and synovial hypertrophy, tenosynovitis, bone erosions, and enthesopathy [10]. Moreover, the European League Against Rheumatism has published standardized procedures for US imaging in rheumatology, which stated the following [11]:

- (1) MSUS includes two principal modes: B-mode (gray scale 'GS'), which provides the morphological information of the anatomical structures, and Doppler mode [color Doppler (CD) or power Doppler (PD)], which allows evaluation of blood flow.
- (2) MSUS should be performed with high-resolution linear probes with frequencies between 6 and 14 MHz for deep/intermediate areas to at least 15 MHz for superficial areas.
- (3) Tissue harmonic imaging, spatial compound imaging, extended field of view, and virtual convex imaging are some of the software capabilities that may be useful in MSUS.
- (4) When scanning a joint, the probe should be oriented as perpendicular or parallel to the bony cortical surface (bony acoustic landmark), so that the cortical margin appears bright, sharp, and hyperechoic.
- (5) A dynamic scanning technique by means of slight movements of translation (side-to-side, back-to-front), angulation, and rotation of the probe should be done to allow the best visualization of the structure (s) of interest.
- (6) Musculoskeletal structures should be evaluated as they move smoothly either actively or passively. To avoid anisotropy (i.e. hypoechoic/anechoic appearance of a normally hyperechoic structure that mainly affects tendons) and the common pitfalls that accompany it, the probe should be continuously adjusted to maintain the beam perpendicular to the tendon fibers especially in insertional regions.
- (7) When the long axis of the structure of interest corresponds to the cranial-caudal orientation of the anatomic position, the most proximal aspect of the structure is usually placed on the left-hand side of the screen. For short axis, it is preferred to align the structure of interest on the screen as if the observer is looking at the patient.
- (8) Probe compression can be helpful in distinguishing a compressible liquid collection from a noncompressible solid. Little or no compression is important when performing Doppler examination to avoid cessation of flow in small vessels.
- (9) A large amount of gel should be used for superficial structures especially when little or no pressure is indicated.
- (10) The machine setting for B-mode and Doppler mode should be properly adjusted to optimize the US image acquisition process.

Role of musculoskeletal ultrasonography in rheumatoid arthritis

In the current plan for management of patients with rheumatoid arthritis (RA), obtaining clinical remission remains the most important goal, but achieving radiographic remission is another key aim of treatment. Several parameters detectable by MSUS can predict the development of severe RA, as well as monitor patients' responses to treatment; thus, MSUS is widely used for evaluating patients with RA, in both clinical trials and clinical practice [12].

Evaluation of inflammation

Detailed information about the status of the synovial membrane, tendons, cartilage, bursae, and cortical bones can be easily obtained. It has widely showed higher sensitivity than clinical assessment in detecting joint and tendon inflammation particularly in deeper anatomical areas such as the shoulder, hip, and ankle, which are more difficult to be assessed by physical examination [13,14].

MSUS allows not only the detection of inflammatory processes but also the quantification of intra-articular or periarticular inflammation. Moreover, it provides accurate information about the characteristic features of the swelling (i.e. effusion or synovial hypertrophy), which is essential for the correct evaluation of the pathological process. PD mode improves the sensitivity and specificity of US in the interpretation of the inflammatory process by detecting and quantifying the neovascularization in the pannus, which reflects a real-time activity [15,16].

Many studies have demonstrated the ability of MSUS to detect relevant subclinical synovitis. This allows patients' reclassification by improving the 'real' count of affected joints [17,18]. For example, in patients with RA with clinical remission, up to 95 and 60% showed GS synovitis and increased PD signal, respectively. Moreover, PD US was more accurate than Disease Activity Score 28 in evaluating disease activity, particularly regarding prediction of the joint destruction [19].

For the evaluation of tendons, US may be considered the 'criterion standard' imaging modality. It has wide scope of application and includes the detection of tenosynovitis and anatomical destruction, as shown by the loss of its normal fibrillary pattern and loss of demonstration of the tendon margins. The PD also provides an accurate information about the degree of activity of the inflammation [20,21].

To standardize the interpretation of the US changes, many different semiquantitative scoring systems have been developed to evaluate synovitis and erosions or tenosynovitis. The Global Scoring System has been proposed by the OMERACT US study group for the assessment of synovial inflammation in patients with RA. This scoring system combines synovial hypertrophy and PD signal in a single composite score [22].

A challenging issue is the presence of concomitant diseases such as fibromyalgia, which frequently interferes with clinical evaluation of RA, leading to overestimation of the disease activity. In this case, MSUS can be an objective disease activity estimator [23,24].

Detection of structural damage

MSUS is sensitive in detecting early bone erosions in the accessible joints such as those of the hands and feet, which are the target joints for early RA structural damage [25]. A wide range of cartilage pathologies can be detected by US, including loss of the sharpness of the margins, loss of clarity of the cartilaginous layer, cartilage thinning, and irregularities of subchondral bone contour [26].

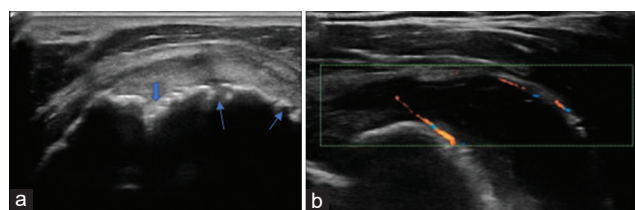
Amin *et al.* [27] have tested the values of US in detecting bone erosions at the humeral head. They published a prospective study demonstrating the accuracy of US in the early detection of shoulder bone erosions and monitoring disease activity in patients with RA using MRI as the gold standard tool [27]. In their study, conventional radiography detected erosions of the humeroscapular joint in 15 (30%), US in 41 (82%), and MRI in 46 (92%) of the examined shoulders. Their study suggested that US is a helpful imaging tool in RA to evaluate shoulder anatomical changes in the initial assessment when conventional radiography shows negative findings (Fig. 1).

Diagnostic utility

MSUS has been suggested to increase the diagnostic ability of routine clinical and laboratory measures in patients with preclinical RA or early undifferentiated arthritis [28].

An important issue in the clinical practice is whether MSUS can differentiate between articular inflammation

Figure 1



(a) Anterolateral transverse scan of left shoulder showing multiple large erosions (arrows). (b) Anterolateral transverse scan of the right shoulder showing large subacromial subdeltoid bursitis with Doppler signal.

owing to RA or other diseases such as osteoarthritis, which may be concomitant in several older aged patients. In this scenario, PD synovial inflammation was more frequently detected in patients with RA than in patients with OA apart from distal interphalangeal joints [29]. Furthermore, MSUS of cartilage is useful in the differentiation of crystal deposition disease from RA. A characteristic MSUS finding in gout is the double contour sign, whereby an echogenic line (representing Monosodium urate crystals) can be seen parallel to the cortex of bone (for example, a metatarsal head) with an anechoic area in between, representing the hyaline cartilage. In gout, the crystals appear as hyperechoic areas which sit on superficial articular surface, whereas in chondrocalcinosis, the hyperechoic lesions are seen in deeper areas of the cartilage [30].

Monitoring of treatment response

MSUS (GS and PD) detected residual inflammation in patients with RA considered to be in clinical remission [31]. US-detected synovitis has been accompanied (in varying degree) with other clinical and laboratory markers of inflammation or response to therapy in RA [32,33].

Predictive value

The predictive value of US-detected synovitis, mainly Doppler synovitis, in either patients with clinically active or those with inactive RA in relation to structural damage progression and disease flare or relapse, has been readily identified [34]. The presence of bone erosions at the time of diagnosis has been shown to be a poor long-term prognostic indicator; therefore, detecting persistent and erosive arthritis appears to be an important step in RA [7].

Role of MSUS in spondyloarthritis

Evaluation of the peripheral joint, tendon, and enthesal involvement in patients with spondyloarthritis (SpA) has been widely performed using US [35]. The standard imaging tool for assessment of sacroiliac joints and spine

is MRI because US does not currently have enough resolution or depth of penetration to visualize the axial skeleton [36]. However, previous MSUS studies of the sacroiliac joints have also demonstrate that blood flow around inflamed joints can be detected by CD and that contrast agents can enhance detection of inflammation and concluded that CD US is a practical and helpful modality in the detection of active sacroiliitis [37,38].

Evidence-based recommendations for the use of imaging in the clinical management of both axial and peripheral SpA have been setted by European League Against Rheumatism [39]. According to these recommendations, detection of peripheral enthesitis is easily done by MSUS, which could support the diagnosis of SpA. Moreover, MSUS may be used to detect peripheral synovitis, tenosynovitis, and bursitis and to monitor synovitis and enthesitis in peripheral SpA [40,41].

Evaluation of inflammation

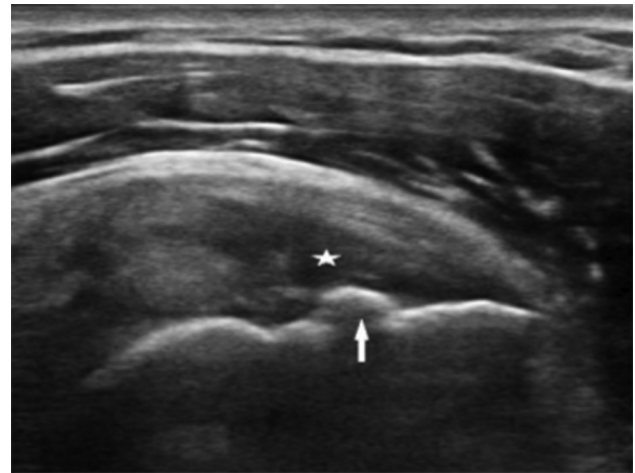
The hallmark for diagnosis of SpA is enthesitis. MSUS gives high-definition pictures of peripheral entheses with greater sensitivity over physical examination in the detection of enthesitis [39] (Fig. 2).

MSUS demonstrates good diagnostic sensitivity (but relatively less than MRI) in the diagnosis of SpA-related synovitis of the hands and feet [42]. Although MSUS is an ideal imaging technique for evaluation of tendons, there is a shortage of studies assessing the exact abnormalities visualized by US in dactylitis. OMERACT has provided recommendations for definition of the elementary MSUS lesions that may diagnose dactylitis leading to the development of a composite measure of activity and severity of MSUS dactylitis [43].

Diagnostic utility

MSUS plays an important role in the differential diagnosis of enthesitis, particularly differentiating mechanical or metabolic enthesopathy from inflammatory enthesitis. Besides in patients with SpA, enthesitis has been detected among athletes as a result of traumatic injuries. Distinguishing fibromyalgia tender points from enthesitis is another important challenge to be considered. However, in such cases, enthesitis is not associated with intra-articular inflammation (i.e. synovitis) [44]. MSUS has demonstrated enough accuracy to identify the different tissue compartments involved in dactylitis (such as joint synovitis, flexor tendon tenosynovitis, soft tissue edema, nail-bed abnormalities, bone extra-articular and intra-articular osteoproliferation, and bone edema) as compared with the findings obtained from MRI examination [45].

Figure 2



Anterolateral longitudinal scan of supraspinatus tendon showing supraspinatus enthesitis, with signs of increased thickening, enthesophyte (arrow), and hypoechogenicity (star).

Monitoring of treatment response

Several US scoring systems were used for quantification of the inflammatory activity allowing therapeutic monitoring of patients with SpA [7]. The sensitivity to the change of the different elemental US enthesal abnormalities in patients with SpA was evaluated in some studies. These studies have confirmed the capability of US to detect even minimal changes mainly at both soft tissue level (changes in echogenicity, thickness, bursitis) and abnormal enthesal vascularization by PD [46,47].

Predictive value

Assessment of entheses by GS as well as PD MSUS may have a role in distinguishing patients suspected to have SpA [7].

Conclusion

Nowadays, there is increasing evidence suggesting that MSUS adds specific information to the clinical, laboratory, and radiographic measures, providing support for diagnostic and management decisions in RA and SpA.

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Conflicts of interest

There are no conflicts of interest.

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