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Update on musculoskeletal ultrasonography

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ABSTRACT Rheumatologists are increasingly utilising MUS in both the research setting and in clinical practice. Factors such as improvements in image quality and decreasing cost of machines have made MUS more accessible in the routine clinical care setting.

Musculoskeletal ultrasonography is an attractive tool, as it is portable and can be used in the outpatient clinic, allowing multiple joints to be imaged in a single visit. In contrast to conventional radiography, it allows multiplanar imaging of soft tissue structures, such as tendons and synovium, as well as providing information about articular integrity. As MUS does not require ionising radiation or contrast agents, it can be used repeatedly to monitor temporal changes. However, as with all imaging techniques, there are technical limitations which, to some extent, may vary between machines; access to some joints may be limited, and the quality of image obtained may depend on the size of joint and the frequency of the MUS transducer employed.

Whilst MUS shows much promise in aiding and optimising the practice of rheumatology, there is still a relative paucity of evidence to fully demonstrate the utility of MUS. In addition, a number of practical issues need addressing. These include educational aspects relating to the competence of physicians performing MUS, confirming MUS definitions of pathology, establishing validity and reliability, and further understanding the utility of this modality in managing rheumatological diseases. Work is underway to address many of these issues.

LIST OF ABBREVIATIONS Conventional radiography (CR), erosion (ER), European League Against Rheumatism (EULAR), extensor carpi ulnaris tendon (ECU), metacarpophalangeal (MCP), metatarsophalangeal (MTP), magnetic resonance imaging (MRI), musculoskeletal ultrasonography (MUS), outcome measures in rheumatology clinical trials (OMERACT), rheumatoid arthritis (RA), synovial hypertrophy (SH)

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INTRODUCTION

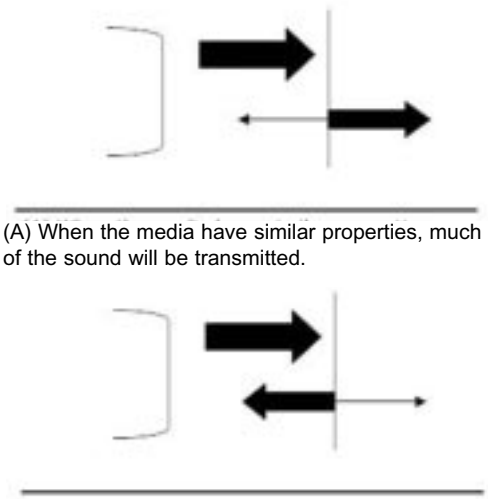
For many years, MUS was predominantly used by radiologists, especially for evaluating shoulder pathology. Rheumatologists are increasingly utilising MUS in both routine clinical practice and the research trial setting, and the focus now includes small joint pathology (see Table 1). Musculoskeletal ultrasonography is an attractive tool because it doesn't involve ionising radiation or contrast agents, it enables the visualisation of many joints at a time, and it is portable. These factors, along with improvements in technology resulting in improved image quality, decreasing cost of machines, and their improved portability, have all made MUS more user-friendly in the routine clinical care setting. As MUS can be performed in the outpatient clinic it enables direct correlation with the clinical presentation and provides immediate information to aid diagnosis and management. This article will focus on practical issues of MUS, related to its current use in rheumatology.

TABLE 1 Potential uses of MUS in rheumatology.

Diagnosis	• Potential for early diagnosis of rheumatoid arthritis • Aiding diagnosis • Site-specific diagnosis • Overall diagnosis
Management	• Guiding injections • Aiding with prognostication • Identifying subclinical inflammatory disease
Clinical trials	• Aiding with prognostication • Monitoring outcomes

HOW DOES ULTRASOUND WORK?

Ultrasound waves are, by definition, sound waves with a frequency greater than is audible by humans. In contrast to X-rays, sound waves require matter for transmission, and the speed at which sound travels depends on the density and compressibility of the matter through which it is travelling. High density, poorly compressible matter



(A) When the media have similar properties, much of the sound will be transmitted.

(B) When the media have very different properties, much of the sound will be reflected.

FIGURE 1 When the ultrasound beam meets a boundary between two materials of different composition, some of the ultrasound will be reflected and some transmitted.

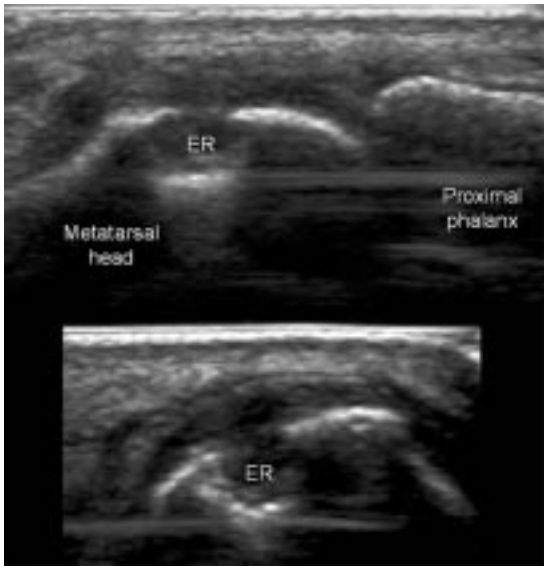


FIGURE 2 Ultrasonography (grey-scale) demonstrating an erosion of the lateral aspect of the fifth MTP joint in a patient with early rheumatoid arthritis, in longitudinal and transverse planes.

transmits sound at the highest speed. For example, the speed of sound through air (331 ms^{-1}) is much slower than through fat (1,450 ms^{-1}) or bone (4,080 ms^{-1}).

Sound transmits differently through materials of different composition – this is termed 'acoustic impedance'. Sound is reflected when it reaches an interface between materials of different acoustic impedance. The degree of reflection of sound waves at an interface is greatest when the two materials have very different impedance values (see Figure 1), and is also dependent on the angle of incidence of the ultrasound beam. Given this the interface between muscle and bone is highly reflective, as

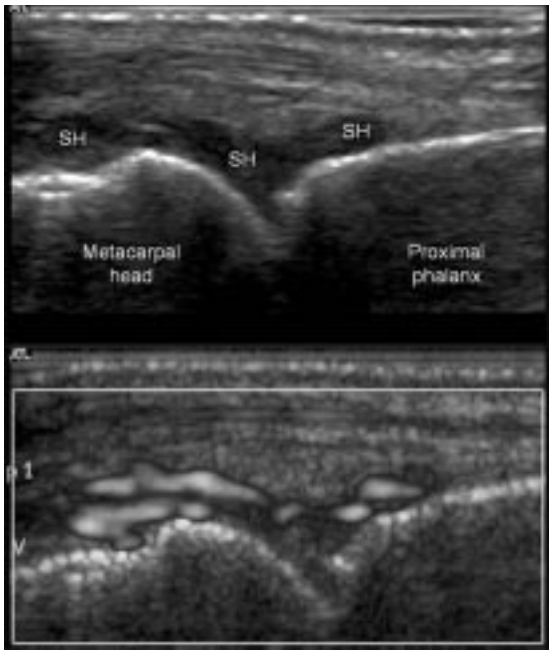


FIGURE 3 Ultrasonography (grey-scale and power Doppler) demonstrating synovial hypertrophy of the third MCP joint in a patient with early rheumatoid arthritis, in longitudinal and transverse planes.

is the interface between air and soft tissue. The amount of sound reflected provides information about the characteristics of the tissue being studied.

HOW CAN MUS BE USEFUL IN RHEUMATOLOGY?

Identification of pathology

Rheumatoid arthritis

In contrast to conventional radiography, MUS can provide multiplanar images of cortical bone, synovium, tendons, muscles, ligaments, and nerves. Rheumatoid arthritis is the most studied inflammatory disease in rheumatological MUS. Using MUS abnormalities such as bony erosions, synovitis, and tenosynovitis have all been described in rheumatoid arthritis (see Figures 2–4). Not surprisingly given its multi-planar capability, MUS has consistently been shown to be more sensitive than CR at detecting bony erosions in a given joint. Musculoskeletal ultrasonography may also be able to detect small erosions that would not be evident on CR (see Figure 2). Several studies have shown MUS to be more sensitive than clinical examination at detecting synovitis and effusions in RA, in both small and large joints (see Figure 3). For the last decade the paradigm for RA is to diagnose the condition as soon as clinically possible and then to treat with the aim of completely suppressing inflammation. The ability of MUS to detect joint damage with more sensitivity than CR, and also to detect subclinical synovitis, may be very important for improving the early diagnosis of RA.

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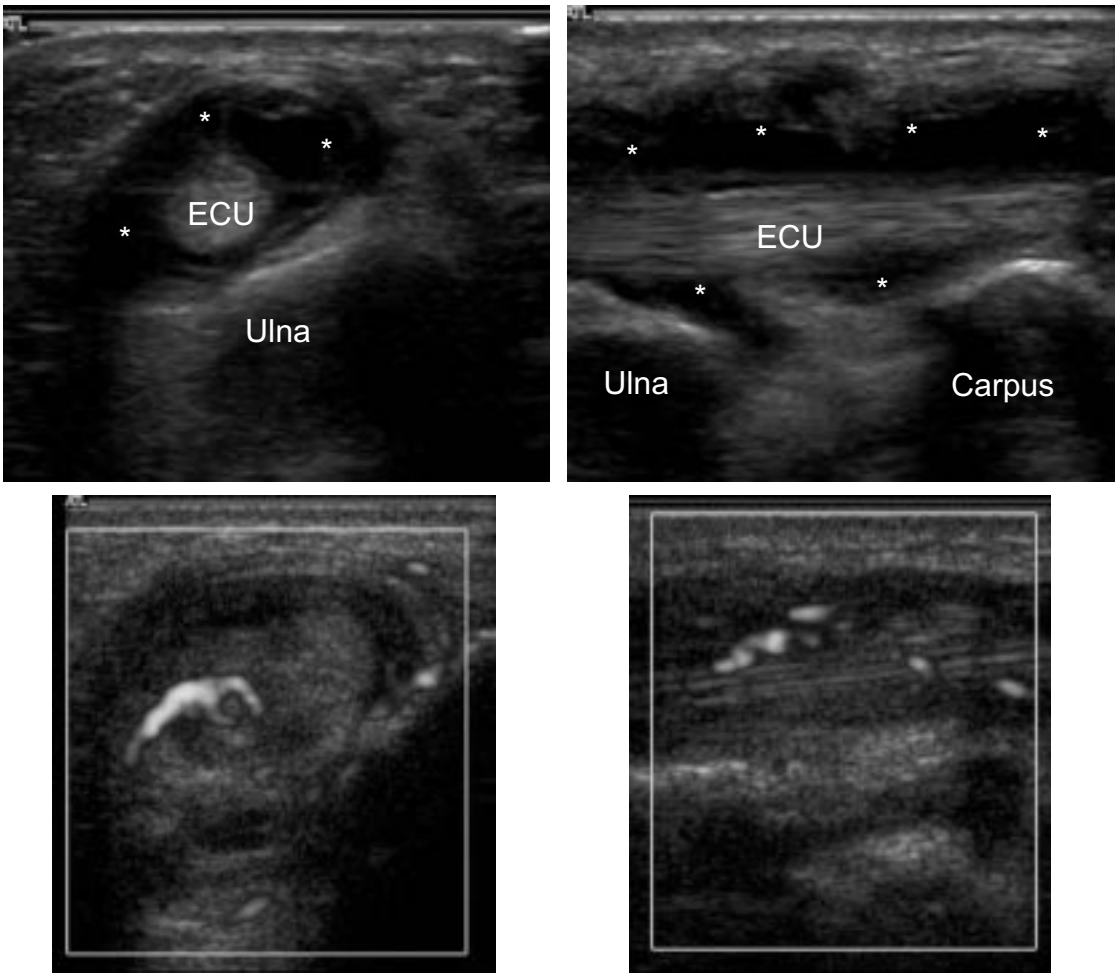

FIGURE 4 Ultrasonography (grey-scale and power Doppler) demonstrating tenosynovitis of the ECU in a patient with early rheumatoid arthritis, in transverse and longitudinal planes. (* = tenosynovitis.)

Spondyloarthropathies

Spondyloarthropathies are characterised by enthesitis, and MUS is well suited to imaging tendon and ligamentous insertions. A heterogeneous decrease in echogenicity and increased entheseal diameter, as well as bony irregularity, are characteristic of enthesitis. Enthesitis of the Achilles and quadriceps tendons have been demonstrated in psoriatic arthritis. In addition, MUS has been demonstrated to be more sensitive than clinical examination in detecting enthesitis in spondyloarthropathies. However at present there is no evidence to suggest that MUS can reliably differentiate between the diagnoses of spondyloarthopathy or RA at the individual joint level.

Osteoarthritis and mechanical pathologies

Musculoskeletal ultrasonography has been demonstrated to be more sensitive than clinical examination in detecting synovitis and effusions in osteoarthritis of the knee. There are some preliminary studies on the evaluation of cartilage with MUS, and this field may improve with improving technology. Osteophytes and joint space narrowing can also be detected. For many years, MUS has been used to identify mechanically induced pathologies, including tendon rupture, tenosynovitis, and bursitis.

Improving diagnosis

Information gained by performing MUS in the rheumatology clinic can result in revision of the clinical diagnosis, with regard to both site-specific and overall diagnosis.

In one study of 520 consecutive rheumatology outpatients, 100 were referred for MUS. Prior to MUS, the clinical site-specific diagnosis, overall diagnosis, and planned management were recorded by the referring physician. Following review of the MUS, the site-specific diagnosis was changed in 53 patients (53%) and the overall diagnosis confirmed in 8 (8%). The management plan was altered in 53 patients (53%).

Another study examined 68 patients with an inflammatory foot arthritis admitted for intra-articular steroid. Musculoskeletal ultrasonography provided information which led to the physician revising the site-specific diagnosis frequently. Strikingly, the management plan (usually with respect to steroid injections) was altered in 82·5% of patients.

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With regards to overall diagnosis, subclinical synovitis has been demonstrated in two-thirds of patients in a rheumatology outpatient clinic with a clinical diagnosis of oligoarthritis, leading to revision of the diagnosis to polyarthritis in one-third.

These studies illustrate the potential for MUS to aid, and indeed alter, diagnosis and subsequent management plans.

Improving prognosis

Preliminary work has suggested MUS may have prognostic potential in RA. One study has shown the degree of synovial thickness and vascularity at baseline predicted radiographic damage scores at 12 months in a newly diagnosed RA cohort treated with methotrexate.

Improving therapy

Musculoskeletal ultrasonography can be utilised to aid intra-articular and soft tissue corticosteroid injections. Studies show that injections performed under guidance are more likely to be accurately placed in the targeted tissue. It has also been shown that using MUS for local site diagnosis alters the subsequent injection site. In addition, the previously mentioned study of 68 patients with inflammatory arthritis of the feet, showed that MUS guiding the decisions regarding steroid injections resulted in better functional and efficacy outcomes in the short term.

Whilst such studies may lead to improved short-term outcomes from corticosteroid injections, there is currently no data on prolonged benefits of such guided therapy.

As mentioned, MUS has demonstrated extensive subclinical synovitis in patients with established RA on conventional therapy who have been clinically assessed as having low levels of disease activity. Ultrasound detection of subclinical synovitis may therefore allow more aggressive therapy to be targeted to those with persistent but subclinical inflammation.

Improving outcome measurement

Traditional outcome measures in RA clinical studies include recording of joint swelling in multiple joints, in order to estimate the 'bulk' of synovitis. In addition, MUS can be used to document improvements in response to therapy. Synovitis objectively demonstrated by MUS has been shown to recede in response to both intra-articular steroids and biological therapies.

WHAT ARE THE PRACTICAL ISSUES IN SETTING UP AN MUS SERVICE?

Limitations of MUS

Musculoskeletal ultrasonography machines are improving rapidly in their capabilities, the quality of their images, and their portability. Although much cheaper than standard MRI machines, they still have a significant cost and care should be taken if considering the establishment of an MUS programme.

As mentioned, limitations in assessing some joint structures do exist. Some joints, such as the inter-carpal joints, may be difficult to image due to their anatomy, resulting in the MUS probe being unable to gain sufficient access to visualise completely these structures as joint surfaces may be obscured by adjacent bones. In addition, in contrast to MRI, MUS provides only limited information about subchondral bone, menisci, and cartilage.

Validation and reproducibility

Currently there are no standard definitions of pathology in MUS. Both the EULAR and the OMERACT Ultrasound Groups are currently addressing this issue. In addition they are continuing to work on establishing standardised techniques of acquiring images; clearly the number and orientation of planes that pathology is measured in will affect quantification. These validity issues need addressing before reliability of scoring methods can be assessed.

Physicians as ultrasonographers

Issues of training and assessing the competence of physicians who perform MUS will need to be addressed as the practice of MUS becomes more widespread. It has been shown that after a short period of training and ultrasonography under supervision, rheumatologists may accurately perform MUS on the small joints of the hand. It must be remembered that MUS is heavily user-dependent, although rheumatologists may quickly become 'competent' in scanning a particular anatomical region, there is as yet no accepted definition of competence. There is also no universally agreed curriculum, and no consensus as to what constitutes adequate training. It is likely that competence in MUS will require a significant amount of dedicated training time with adequate access to scanners and expert supervision, which will have implications for both patients and clinicians in the outpatient clinic.

The relationship between physicians and radiologists is also likely to alter as physicians begin using MUS. It is likely that there is room for both sorts of practitioners. Much work in rheumatological MUS has focused on the imaging of small joints, traditionally not imaged by radiologists. It will be important for physicians who practice MUS to be aware of their limitations and boundaries of competence.

SUMMARY

Musculoskeletal ultrasonography has the ability to improve diagnostic and management capabilities for

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clinicians. This potential has been recognised by its increasing uptake in rheumatology practice. However, a number of issues concerning validity, reliability and training exist. As well, there is only limited evidence for its impact on clinical practice. The rheumatology literature will reflect the focus on these issues over the next few years.

KEYPOINTS

- Musculoskeletal ultrasonography has been shown to improve the accuracy of standard clinical assessment.
- Musculoskeletal ultrasonography has been shown to improve site-specific diagnosis.
- Musculoskeletal ultrasonography has been shown to improve injection placement.
- Musculoskeletal ultrasonography may result in better outcomes for rheumatoid arthritis patients by improving early and accurate diagnosis.
- There are limited (but increasing) data on validity and reliability of MUS in assessing musculoskeletal conditions.
- Musculoskeletal ultrasonography is increasingly being undertaken by rheumatologists in routine practice to aid patient management.

FURTHER READING

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