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Technical Brief

Limitations of Diagnostic Ultrasound Use in Rheumatoid Arthritis Rehabilitation: Technical Report

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Abstract

Aim: The purpose of this technical note is to critically evaluate the role of ultrasound in the diagnosis and management of rheumatoid arthritis (RA).
Material and Method: In this study joint distance, effusion area and degree of inflammation were assessed using the GE Color Doppler device. Participants diagnosed with RA are positioned comfortably and the area under examination is completely relaxed.
Results: The primary constraint on the utilisation of ultrasound imaging in the management of RA pertains to the necessity for expertise and experience on the part of the ultrasonographer. In addition, the imaging capacity to visualise deep structures is inadequate, a problem that is exacerbated in obese patients due to inadequate penetration. Thirdly, ultrasound (US) exhibits lower resolution compared to alternative imaging modalities such as Magnetic Resonance Imaging (MRI), resulting in its inability to distinguish subtle bone changes. The fourth limitation relates to the difficulties associated with imaging small joints, such as the hands, due to their size and anatomical complexity. Finally, the effectiveness of ultrasound in identifying synovial thickening and erosions is well documented; however, its inability to differentiate between active inflammation and chronic fibrotic changes may hinder treatment decisions in some cases.
Conclusion: US is a valuable tool in managing RA, but its effectiveness is limited by operator dependency, imaging challenges, and difficulty distinguishing active inflammation from chronic changes. Enhancing training, standardizing protocols, and integrating advanced technologies like artificial intelligence (AI) and hybrid imaging can improve its diagnostic precision and utility in rheumatological care.

Keywords: Diagnostic ultrasound, rheumatoid arthritis, hand rehabilitation, imaging

INTRODUCTION

Rheumatoid Arthritis (RA) is a chronic, systemic autoimmune disorder, primarily involving the synovial joints, and causing inflammation, pain and progressive joint damage (1). In the absence of adequate treatment or management, RA has the potential to result in severe disability, diminished quality of life, and an elevated risk of morbidity (2). A correct diagnosis is vital for effective treatment, preventing complications, and ensuring continuous monitoring of disease activity (3). This has prompted the exploration of advanced imaging techniques as complements to clinical evaluations and traditional radiography in the management of RA.

Ultrasound (US) imaging has become a cornerstone in the assessment of RA due to its ability to provide detailed, real-time visualization of soft tissues, synovial structures, and inflammatory processes (4). Unlike conventional radiographs, which are limited to detecting bone damage, US can identify subclinical synovitis, joint effusions, and early erosive changes (5). Moreover, the integration of Doppler technology allows for the evaluation of vascularity within inflamed synovial tissue, offering a reliable surrogate marker for disease activity and response to treatment. These features make US particularly valuable in the early stages of RA, where prompt intervention can prevent irreversible joint damage (6).

Despite its numerous advantages, the use of US in RA is not without challenges. The technique is operator-dependent, requiring a high level of expertise and standardized protocols to ensure reproducibility and accuracy (7).

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Additionally, its limited ability to assess deeper structures and its lower sensitivity in detecting bone erosions compared to advanced modalities like magnetic resonance imaging (MRI) raise concerns about its standalone use in comprehensive disease evaluation (8).

This technical report is based on the problems encountered during the execution of the PhD thesis entitled "Comparison of The Effects of Exercise and Preventive Approach and Mobility Applications on Work, Daily Life Activity and Quality of Life in Patients With Rheumatoid Arthritis". This technical report aims to critically evaluate the role of US in the diagnosis and treatment of RA, focusing on its advantages and limitations. By examining the usefulness of US in early diagnosis, disease monitoring and treatment guidance, as well as its challenges in clinical practice, this report will provide a perspective on the problems that physiotherapists may encounter in the use of US in rheumatological rehabilitation.

Technical Report

This study was conducted between October 2023 and December 2024 at Kırşehir Ahi Evran University School of Physical Therapy and Rehabilitation. Ethical approval of the study was obtained from Haliç University Non-Interventional Studies Ethics Committee with the number 2023/64. Voluntary consent form was signed by the participants. Joint distance, effusion area and degree of inflammation were assessed using the GE Versana US device. Doppler adjustments were made as shown in the table below. The assessment results were recorded in the US results report (Table 1). The patient is positioned comfortably and the area under examination is completely relaxed, as tension in the muscles and tendons will cause a slight tremor, which can lead to movement disorders. Patient position and probe placement were determined as previously described in the literature (9).

Table 1. Device settings

Setting	Value
Pulse repetition frequency	0.5*
Color priority	All priorities are given to color.
Wall filter	40-53*
Persistence	18*
Gain	Noise threshold-0.5
Focus	Placed where the highest precision is required

*Set as low as possible

A significant limitation of US imaging in the management of RA is its considerable reliance on the expertise. Variations in image acquisition and interpretation can result in misjudgement of synovitis and erosions, underscoring the necessity for standardised training programmes and certification processes to ensure accurate assessments. Integration of physiotherapists into diagnostic processes can help reduce operator-related variability. The integration of artificial intelligence (AI)-assisted tools may help to improve the skills of physiotherapists, especially those with limited experience in image interpretation.

An important difficulty encountered during the study was that the first US images obtained were distorted because the ultrasonographer with limited experience was assigned to various hospitals during rotation assignments (Figure 1). While measures have been implemented to mitigate data loss, the involvement of an experienced US assessor, under the supervision of a designated individual, is recommended in subsequent studies to enhance the reliability of the results (Figure 2).

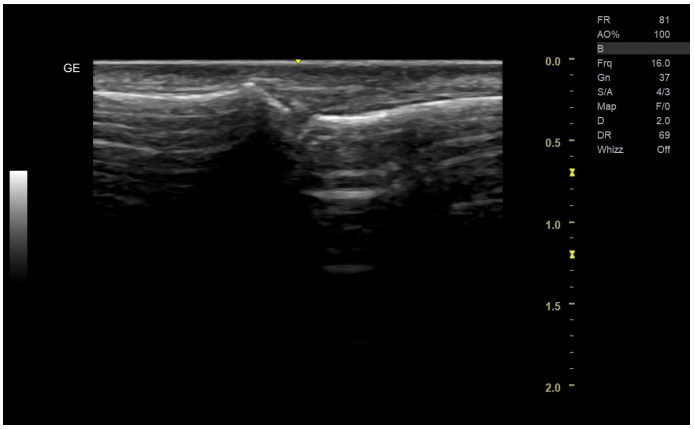

Figure 1. Distorted ultrasound image

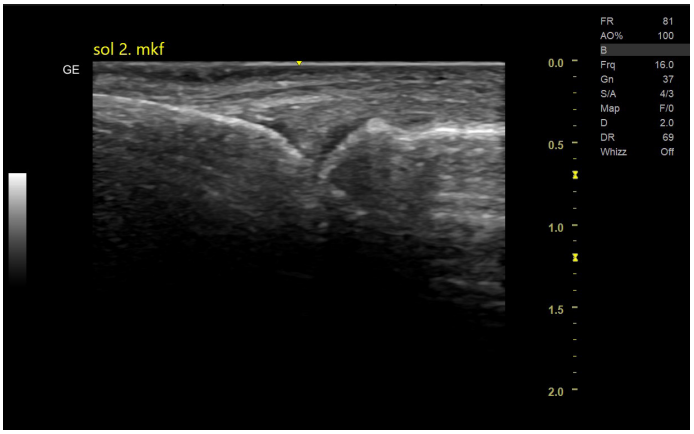

Figure 2. Image captured by an expert

A secondary limitation inherent in US is its inadequate capacity to visualise deep structures; this problem is exacerbated in obese patients due to insufficient penetration. The data from obese patients in our study revealed a significant difficulty in visualising the wrist joint in particular (Figure 3).

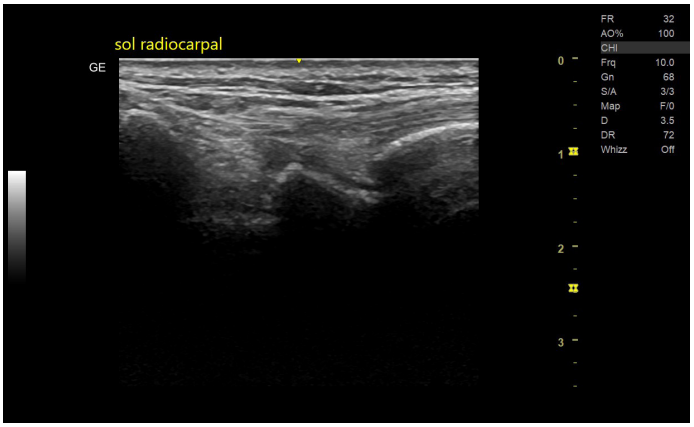

Figure 3. The image of obese patients

Moreover, US exhibits inferior resolution when compared to alternative imaging modalities, such as MRI, resulting in its inability to discern subtle bone changes. İn the present study, no parameters related to bony structures were examined; therefore, no limitations were encountered in this regard. However, improvements in transducer technology and software may enhance resolution and penetration, leading to superior visualisation of deep structures and small joints.

The third limitation pertains to the challenges associated with imaging small joints, such as the hands, due to their size and anatomical complexity. This can result in an underestimation or complete oversight of the degree of inflammation in these areas. Despite the existence of various scoring systems for US assessment in RA, such as the OMERACT US definitions, a universal standard remains elusive. This has given rise to inconsistencies in the assessment of disease activity across different healthcare providers. The potential exists for the development of a universally accepted scoring system through international cooperation between rheumatology and radiology associations. A semi-quantitative scoring system was employed in our study to assess the degree of inflammation as much as possible, in recognition of these problems (10).

Finally, the effectiveness of US in identifying synovial thickening and erosions is well documented; however, its inability to distinguish between active inflammation and chronic fibrotic changes may, in some cases, impede treatment decisions. The use of US in combination with other imaging modalities such as MRI or computed tomography (CT) will provide a more comprehensive evaluation. The present study included established RA patients with a DAS-28 score of less than 5.1, and durations are more thand 3 years, thus focusing on joints with fibrotic changes rather than active inflammation in this condition. Although Doppler technology is a more effective method for monitoring active inflammation in color, it was used for grading inflammation in the present study.

DISCUSSION

Ultrasonography is a reliable tool for estimating the size of the joint space and assessing synovial activity through vascularization and flow patterns. It is especially useful for monitoring synovial inflammation in RA (9). Correct interpretation of Doppler flow images requires knowledge of technical factors affecting the Doppler signal (11). Artefacts, which may result from physical limitations of the modality or inappropriate equipment settings, can significantly distort the imaging of flow conditions (12). In our study, some of the artefacts in the use of US were caused by the sonographer, especially in the initial assessments. Replacing the sonographer with an experienced sonographer prevented human error. Additionally, a negative Doppler signal does not exclude synovitis, while a positive signal indicates active synovial inflammation but does not correlate with the extent of the inflammation (13). Consequently, it is imperative to undertake regular checks of the calibration of US devices to ensure the reliability of evaluations. The equipment we used was received new and fully calibrated. Therefore, we did not lose any data due to a calibration error caused by the device.

A 2018 study compared conventional Power Doppler Ultrasound (PDUS) with three-dimensional PDUS and noted that although PDUS offers superior sensitivity for detecting synovial vascularity, challenges remain in standardising and quantifying its results (14). Another study proposes the integration of automated algorithms with the objective of reducing variability in flow pattern interpretation and identifying artefacts. For instance, the utilisation of AI for image analysis has been proposed as a means of enhancing the accuracy of Doppler signal detection and reducing operator dependency (15). Moreover, hybrid imaging combining US and MRI has shown promise in providing a comprehensive view of joint pathology by overcoming US's depth limitations (16). US enables the detection and grading of destructive and inflammatory changes in the MTP joints of patients with RA (17). Compared with MRI, US has been found to be significantly more sensitive and accurate than clinical examination and conventional radiography. Given the early and frequent involvement of metacarpophalangeal joints, evaluation of these joints with US may be of great clinical importance in RA (18). In addition, imaging plays an important role in the diagnosis of PsA which is an another rheumatological problem. Classical radiography allows the identification of late stages of the disease when bone tissue is affected (19). However, US, CT and MRI have been developed and have become important diagnostic tools in the evaluation of rheumatoid diseases. They allow the evaluation and monitoring of early inflammatory changes (20). While conventional radiographs show only late signs of past disease activity, there is evidence that MRI and US are highly sensitive for early inflammatory and destructive changes in RA joints, and that MRI findings are sensitive to change and have predictive value for future progressive radiographic damage. On this basis, the use of MRI and US for the detection of arthritic joint pathology and MRI for the monitoring and prognosis of early RA can be recommended (21).

In order to advance the field, it is essential to conduct additional studies with a focus on the development of methodologies for the prevention of artifacts and the establishment of standards for the calibration of devices. It is vital that physiotherapists and clinicians adhere to the guidelines set out for musculoskeletal US (10,22,23), integrating these principles into rheumatological rehabilitation assessments. In order to enhance the accuracy of diagnoses, collaborative efforts between rheumatologists, physiotherapists, and radiologists are required.

CONCLUSION

This study highlights several limitations that impact its effectiveness, including operator dependency, challenges in

imaging deep and small joints, and difficulty distinguishing between active inflammation and chronic fibrotic changes. The findings underscore the importance of standardized training programs, device calibration, and the development of universal scoring systems to enhance the reproducibility and accuracy of US evaluations in RA.

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