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Original Research Article

EVALUATION OF ROLE OF ULTRASOUND VERSUS MAGNETIC RESONANCE IMAGING IN RHEUMATOID ARTHRITIS

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ABSTRACT

Background: Rheumatoid arthritis (RA) is a chronic inflammatory disease characterized by synovial proliferation that can progress to irreversible cartilage destruction and bone erosion if not detected and treated early. Conventional radiography has limited sensitivity in identifying early inflammatory changes. Advanced imaging modalities such as ultrasonography (USG) and magnetic resonance imaging (MRI) have therefore gained importance in the early diagnosis and assessment of disease activity in RA. While MRI is considered highly sensitive for detecting both inflammatory and structural changes, ultrasonography offers advantages of accessibility, lower cost, and real-time assessment. A systematic comparison of these modalities is essential to define their respective roles in routine clinical practice. The objective is to evaluate the sensitivity and specificity of ultrasonography in comparison with magnetic resonance imaging in patients with rheumatoid arthritis and to compare the detection rates of joint effusion, synovitis, tenosynovitis, and structural joint damage.

Materials and Methods: A prospective observational study was conducted in the Department of Radiology at a tertiary care teaching hospital. Thirty patients with clinically suspected rheumatoid arthritis underwent both ultrasonography and magnetic resonance imaging of the affected joints. Ultrasonography was performed using a high-frequency linear transducer, and MRI was carried out on a 1.5 Tesla system using standard imaging sequences. MRI was considered the reference standard. Diagnostic accuracy parameters of ultrasonography were calculated, and comparisons between modalities were performed using appropriate statistical tests.

Results: Ultrasonography detected joint effusion and synovitis with a sensitivity of 100%, showing strong agreement with MRI. Tenosynovitis was detected more frequently by MRI, although ultrasonography demonstrated high specificity. Bone erosions and enthesitis were identified in a significant proportion of patients on MRI but were not detected on ultrasonography. The differences between the two imaging modalities were statistically significant ($p < 0.001$).

Conclusion: Ultrasonography is a reliable and effective modality for detecting inflammatory changes in rheumatoid arthritis, whereas MRI remains superior for identifying structural joint damage. A complementary imaging approach using ultrasonography as the first-line modality and MRI for detailed structural assessment is recommended.

Keywords: Rheumatoid arthritis; Ultrasonography; Magnetic resonance imaging; Synovitis; Bone erosions; Diagnostic accuracy

INTRODUCTION

Rheumatoid arthritis (RA) is a chronic, systemic inflammatory disease characterized by progressive synovitis leading to cartilage destruction, bone erosion, and irreversible joint deformity if left untreated.[1] Early diagnosis and prompt initiation of disease-modifying therapy are critical to prevent structural damage and long-term functional disability.[2]. However, conventional clinical examination and plain radiography often fail to detect early inflammatory and pre-erosive changes, necessitating the use of advanced imaging modalities.[3]

Magnetic resonance imaging (MRI) has emerged as a highly sensitive technique for the evaluation of RA due to its ability to provide multiplanar visualization of synovium, cartilage, bone marrow, and periarticular soft tissues.[4]MRI can detect synovitis, bone marrow edema, and erosions at a very early stage, often before radiographic abnormalities become evident.[5] Several studies have demonstrated that MRI-detected synovitis and bone marrow edema are strong predictors of future erosive disease and radiographic progression.[6,7] Despite these advantages, MRI is limited by higher cost, limited availability, longer acquisition time, and patient-related constraints.[8].

Musculoskeletal ultrasonography (USG) has gained increasing acceptance as a practical and accessible imaging tool in RA evaluation. High-resolution grey-scale ultrasound allows detailed assessment of synovial hypertrophy, joint effusion, and tenosynovitis, while power Doppler imaging provides additional information regarding synovial vascularity and inflammatory activity.[9,10] Ultrasound is non-invasive, lacks ionizing radiation, allows dynamic and multi-joint assessment, and is well tolerated by patients.[11] Several comparative studies have shown good agreement between ultrasound and MRI in the detection of synovitis and effusion, particularly in small joints of the hands and wrists.[12,14]

However, the diagnostic performance of ultrasound relative to MRI varies across different pathological features. While ultrasound demonstrates high sensitivity for inflammatory changes, MRI remains superior for the detection of bone erosions and bone marrow edema.[15,17] Given these complementary strengths, a comparative evaluation of ultrasound and MRI is essential to define their respective roles in routine clinical practice.

The present study was undertaken to evaluate the sensitivity and specificity of ultrasonography in comparison with MRI in patients with rheumatoid arthritis, and to compare the detection rates of synovitis, joint effusion, tenosynovitis, and structural joint damage, thereby providing evidence-based guidance for optimal imaging selection in clinical settings.

MATERIALS AND METHODS

A prospective observational study was conducted in the Department of Radiology at Saveetha Medical College and Hospital after obtaining approval from the Institutional Ethics Committee. Patients referred for radiological evaluation with a clinical suspicion of rheumatoid arthritis were consecutively enrolled in the study after obtaining written informed consent. A total of 30 patients were included using purposive sampling.

Patients with a clinical diagnosis of rheumatoid arthritis who were referred for imaging formed the study population. Patients with contraindications to magnetic resonance imaging, including those with cardiac pacemakers, prosthetic heart valves, cochlear implants, or other metallic implants, as well as those with a history of claustrophobia or those unwilling to provide consent, were excluded from the study.

All enrolled patients underwent both ultrasonography and magnetic resonance imaging of the affected joints. Ultrasonographic evaluation was performed using a high-frequency linear array transducer (9–15 MHz) on a color Doppler ultrasound system (Affinity 70, Philips). Examinations were carried out with the patient in a comfortable sitting position, with the affected joint appropriately supported to allow optimal visualization. Grey-scale ultrasonography was used to assess joint effusion, synovial hypertrophy, and tenosynovitis, while power Doppler imaging was employed when required to evaluate synovial vascularity.

Magnetic resonance imaging was performed using a 1.5 Tesla MRI system (Philips Achieva). Patients were positioned according to standard imaging protocols, and imaging was obtained in axial and coronal planes. The MRI protocol included T1-weighted spin-echo sequences, T2-weighted turbo spin-echo sequences, and short tau inversion recovery (STIR) sequences. Contrast-enhanced imaging was performed when indicated to better delineate synovial inflammation and structural changes.

Imaging findings on ultrasonography and MRI were evaluated for the presence of joint effusion, synovitis, tenosynovitis, bone erosions, and enthesitis. Magnetic resonance imaging was considered the reference standard for comparison. The diagnostic performance of ultrasonography was assessed by calculating sensitivity, specificity, positive predictive value, and negative predictive value for each lesion.

Data were entered into Microsoft Excel and analyzed using SPSS version 22.0 (IBM SPSS Statistics, Somers, NY, USA). Categorical variables were expressed as frequencies and percentages. Comparison between ultrasonography and MRI findings was carried out using McNemar's chi-square test or Fisher's exact test, as appropriate. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 30 patients with clinically suspected rheumatoid arthritis were included in the study. The mean age of the study population was 42.0 ± 13.3 years, with the majority of participants belonging to the 30–50-year age group. Females constituted 70% of the study population.

Joint effusion was detected on magnetic resonance imaging in 26 patients, all of whom were also identified on ultrasonography, with no false-negative cases. Ultrasonography additionally detected joint effusion in two MRI-negative cases, resulting in two false-positive findings and a statistically significant association between the two imaging modalities ($p < 0.001$) [Table 1].

Synovitis or synovial thickening was identified on MRI in 25 patients, all of whom were correctly detected on ultrasonography. One MRI-negative case was falsely classified as positive on ultrasound, and the agreement between ultrasonography and MRI for synovitis was statistically significant ($p < 0.001$) [Table 1].

Tenosynovitis was detected on MRI in 18 patients. Ultrasonography correctly identified tenosynovitis in 14 of these cases, while four MRI-positive cases were missed, and no false-positive cases were observed. The association between the two modalities for tenosynovitis was statistically significant ($p < 0.001$) [Table 1].

Bone marrow edema and erosions were detected on MRI in 20 patients, whereas ultrasonography failed to identify these lesions in any patient. Similarly, enthesitis was identified on MRI in 14 patients but was not detected by ultrasonography in any case, and Fisher's exact test was applied due to zero cell counts [Table 1].

Using MRI as the reference standard, ultrasonography demonstrated a sensitivity of 100% and specificity of 50% for the detection of joint effusion, with positive and negative predictive values of 92.86% and 100%, respectively [Table 2].

For synovitis or synovial thickening, ultrasonography showed a sensitivity of 100% and specificity of 80%, with positive and negative predictive values of 96.15% and 100%, respectively [Table 2].

In the detection of tenosynovitis, ultrasonography demonstrated a sensitivity of 77.78% and specificity of 100%, with corresponding positive and negative predictive values of 100% and 86.67% [Table 2].

Ultrasonography showed no sensitivity for the detection of bone marrow edema/erosions and enthesitis, although specificity remained 100% for both lesions. The negative predictive values for bone marrow edema/erosions and enthesitis were 33.33% and 53.33%, respectively [Table 2].

Table 1: Comparison of Ultrasound and MRI Findings among Patients with Rheumatoid Arthritis (n = 30)

Diagnosis	USG	MRI		p-value
		Present	Absent	
Joint effusion	Present	26	2	<0.001*
	Absent	0	2	
Synovitis/ Synovial thickening	Present	25	1	<0.001*
	Absent	0	4	
Tenosynovitis	Present	14	0	<0.001*
	Absent	4	12	
Bone marrow edema/erosions	Present	0	0	NA#
	Absent	20	10	
Enthesitis	Present	0	0	NA#
	Absent	14	16	

McNemar's chi-square test # Fisher's exact test

Table 2: Diagnostic Performance of Ultrasonography for Detection of Rheumatoid Arthritis Lesions Using Magnetic Resonance Imaging as the Reference Standard

Diagnosis	Sensitivity	Specificity	PPV	NPV
Joint effusion	100%	50%	92.86%	100%
Synovitis/ Synovial thickening	100%	80%	96.15%	100%
Tenosynovitis	77.78%	100%	100%	86.67%
Bone marrow edema/erosions	0%	100%	NA	33.33%
Enthesitis	0%	100%	NA	53.33%

DISCUSSION

In the present study, ultrasonography demonstrated high detection rates for inflammatory features of rheumatoid arthritis, particularly joint effusion and synovitis, with sensitivities of 100% when MRI was used as the reference standard. These findings reinforce the role of ultrasound as a reliable modality for identifying active synovial inflammation, consistent with previous studies that have shown strong agreement between ultrasound and MRI for synovitis detection.[12,13] The ability of ultrasound to detect synovial hypertrophy and effusion with high sensitivity is attributed to its superior spatial resolution for superficial soft-tissue structures and real-time dynamic assessment.[10]

Tenosynovitis was detected more frequently by MRI than by ultrasound in the current study, although ultrasonography demonstrated excellent specificity. Similar observations have been reported by Dohn et al. and Terslev et al., who noted that while ultrasound is highly specific for tenosynovitis, MRI may detect

deeper or less accessible tendon sheath involvement.[14,16] This supports the complementary role of MRI in evaluating complex or equivocal cases.

A notable finding of the present study was the inability of ultrasonography to detect bone erosions and enthesitis, both of which were identified in a substantial proportion of patients on MRI. This observation aligns with earlier reports indicating that MRI is significantly more sensitive than ultrasound for detecting early erosive changes and bone marrow pathology.[15,17] McQueen et al. demonstrated that MRI can identify erosions within months of symptom onset, often preceding radiographic detection.[6] The superior performance of MRI in identifying structural damage underscores its importance in prognostication and disease monitoring.

Overall, the findings of this study highlight that while ultrasonography is a highly effective, accessible, and cost-efficient tool for evaluating inflammatory changes in RA, MRI remains indispensable for comprehensive assessment of structural joint damage. The results support a pragmatic imaging approach wherein ultrasound serves as the first-line modality for disease activity assessment, with MRI reserved for cases requiring detailed evaluation of erosions, enthesitis, or inconclusive ultrasound findings.

CONCLUSION

Ultrasonography demonstrated high sensitivity and excellent diagnostic performance in detecting inflammatory manifestations of rheumatoid arthritis, particularly joint effusion, synovitis, and tenosynovitis, showing strong agreement with magnetic resonance imaging. However, magnetic resonance imaging was superior in identifying structural joint damage, including bone erosions and enthesitis, which were not detected by ultrasonography. These findings indicate that ultrasonography serves as a reliable, accessible, and cost-effective first-line imaging modality for assessing disease activity in rheumatoid arthritis, while magnetic resonance imaging remains essential for comprehensive evaluation of structural damage and disease severity, thereby supporting a complementary and targeted imaging approach in clinical practice.

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