Original Article

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Radiology Section

Ultrasound versus Magnetic Resonance Imaging for the Detection of Early Rheumatoid Arthritis in a Sub-Himalayan Region of North India: A Cross-sectional Study

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ABSTRACT

Introduction: Rheumatoid Arthritis (RA) is a disability disease with predominant involvement of hands and feet. It is highly important to detect early findings of the disease, so that treatment can be started as early as possible. The high cost, poor accessibility and long waiting time for Magnetic Resonance Imaging (MRI) as compared to Ultrasonography (USG) results in delayed pick up of early RA findings.

Aim: To compare the radiological parameters of wrist and hand by USG and MRI in clinically diagnosed patients of early RA.

Materials and Methods: A cross-sectional study was conducted from January to December 2020 in the Department of Radiology, Indira Gandhi Medical College and Hospital, Shimla, India. A total of 25 diagnosed patients of early RA were enrolled in the study. USG and MRI were used to evaluate distal Distal Radioulnar (RU), Radiocarpal (RC), Ulnocarpal (UC), Metacarpo phalangeal (MCP) and other hand joints with clinical symptoms. The following parameters were assessed on both MRI and USG: Joint space, joint effusion, synovitis, tenosynovitis, bone erosions. Bone marrow oedema was assessed only on MRI. The categorical variables of the two groups were compared using the chi-square test.

Results: The mean age of the study group was 44.96±11.58 years. There were 18 female and seven male patients with preponderance of female patients. MRI was better than USG in picking up findings of joint space narrowing, synovial thickening, synovial vascularity and bone erosions with p-value of <0.001, which was statistically significant. For tenosynovitis, USG and MRI were equally good with p-value of <0.001 which was statistically significant. Joint effusion was diagnosed in more number of joints 26 (6.5%) on USG as compared to 15 (3.5%) on MRI, however, the p-value was 0.078 suggesting that it was statistically insignificant. Bone marrow oedema was detected only on MRI.

Conclusion: The USG can be used to detect changes of early RA especially joint effusion and tenosynovitis when MRI is contraindicated/not available/waiting period for MRI is too long.

Keywords: Bone erosion, Joint effusion, Synovitis, Tenosynovitis

INTRODUCTION

Rheumatoid Arthritis (RA) is a systemic autoimmune disease with a overall worldwide prevalence of 0.8% and steadily increases to 5% in women over the age of 70 years. It is two to three times more common in women compared to men [1]. The disease is characterised by symmetric joint inflammation and destruction that often involves the small joints of the hand and feet, with progressive destruction, deformity and disability of the joints [2].

Early disease recognition markedly benefits response to treatment with favourable outcomes. Delay in the initiation of therapy could adversely affect treatment outcomes such as disease activity, remission, functional capacity and radiographic progression [2]. Research has shown that treatment in the window period of RA may prevent further joint damage and may reverse it [3]. Early RA most commonly involves wrist, Metacarpophalangeal (MCP), and Interphalangeal (IP) joints [2]. The major abnormalities in early RA appear in synovial joints in the form of synovial hypertrophy, synovial effusion, bursal and tendons sheath swelling [4].

The various radiological modalities available for picking abnormalities of RA are conventional radiography (X-ray), Ultrasonography (USG), and Magnetic Resonance Imaging (MRI). X-rays detect late bony structural abnormalities such as erosions, periarticular osteopenia and joint space narrowing. Early changes, periarticularly soft-tissue abnormalities and synovitis are also not well seen on X-rays. It can only provide indirect information on synovial inflammation and is also insensitive to early inflammatory bone involvement and bone damage [5].

The MRI has high accuracy and strong diagnostic and prognostic value for picking early RA findings. It allows a more global approach to the small synovial joints of the appendicular skeleton and can be used to predict future bone damage. It allows direct visualisation of synovitis and bone marrow, which provides crucial evidence of bone erosion and bone marrow oedema. MRI detects progression of erosion earlier and more often than conventional radiography [6]. MRI can even predict the onset of RA with high sensitivity (100%) and specificity (78%) [7].

Other modality that can be used for picking early changes of RA is USG which is readily available, safe, cost-effective and reproducible with high patient acceptability. It is used to scan soft tissue and small joints with the added advantage of assessing multiple joints at the same time. In early RA, it is used to detect joint space, joint effusion, synovitis, tenosynovitis and bone erosions. As it is sensitive in the detection of rheumatoid erosions, it allows early diagnosis of progressive RA [8].

The MRI and USG are increasingly being used in the assessment of RA in clinical practice due to their ability to provide insight about the pathogenesis of inflammatory joint disease. These two modalities also identify the key pathological features of the disease entity at

presentation and much earlier than seen on conventional radiography [5]. However, in Himachal Pradesh, MRI is not widely available, is expensive and has long waiting period as compared to USG.

Previous studies have compared USG with MRI and suggested that the visualised inflammatory changes in RA were similar using both modalities or MRI is superior in estimation of severity of structural changes and detecting bone marrow edema [9-11]. However, similar study was not done in Himachal Pradesh till date as per literature. Hence, present study was conducted to compare USG findings with MRI and also to assess the role of USG as a modality to pick early changes of RA in our institute, so that the treatment is initiated early based on USG findings rather than waiting for MRI and thus decreasing late complications.

MATERIALS AND METHODS

This cross-sectional study was conducted over a period of one year, from January to December 2020 in the Department of Radiodiagnosis, Indira Gandhi Medical College and Hospital, Shimla, Himachal Pradesh, India. The research procedure was done in accordance with the approved standards of the Institutional Ethics Committee (IEC) and informed consent was obtained from all patients.

Inclusion criteria: Patients more than 18 years of age with early RA (Duration: <1 years of symptoms and presence of >3 of the following criteria: Morning stiffness >30 minutes, arthritis of three or more joint areas, arthritis of hand joints, positive Rheumatoid factor (RF), positive Anti-Citrullinated Peptide Antibody (ACPA) and consenting to participate in the study were included in the study [9,12].

Exclusion criteria: Patients having RA for >1 year, with absolute contraindications to MRI and severe claustrophobia, patients having inability to lie in the gantry and patients with history of trauma/bacterial infections/surgery of wrist and hands were excluded.

Sample size calculation: Sample size was calculated taking two sided significance level at 95%, power of the study at 90%, ratio of the unexposed/exposed as 1, percentage of the synovial thickening detected by MRI 8% and USG as 15% by Wang MY et al., [11]. The final sample size came out to be 437 joints in each group. The sample size was calculated using open epi software.

Study Procedure

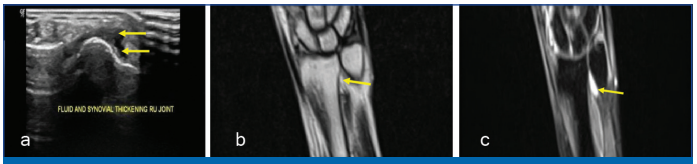
After taking clinical history, patients underwent baseline investigations: Complete hemogram, Erythrocyte Sedimentation Rate (ESR), C-Reactive Protein (CRP), Rf, ACPA. After taking informed consent, all the patients were subjected to USG and MRI.

Ultrasonography: The patients were then subjected to Grey Scale USG (GS-US) and colour doppler. Using GE LOGIQ P6 USG machine with probe frequency 10-13 Mz, USG was done on the dominant hand and wrist or hand with clinical symptoms. B-mode (GS-US) and Power Doppler USG (PDUS) were used to evaluate inflammatory changes.

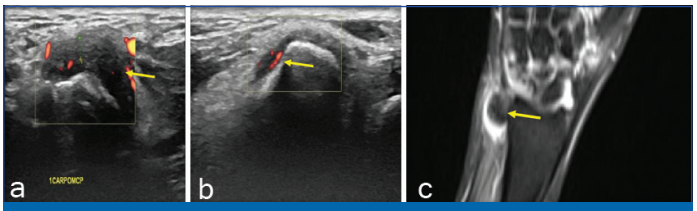
MRI procedure: The MRI was done on SIEMENS MAGNETOM AVANTO 1.5 T machine. The patient was positioned in the prone position with both forearms extended and internally rotated at the elbow and hands mildly flexed and placed above head level. The sequences taken were as follows: Axial and coronal TI (TSE), Axial T2 (TSE), coronal STIR, coronal PD+T2, pre and post contrast T1FS (Contrast used was gadoterate meglumine 0.5 mmol/mL, in dose of 10 mL, intravenous route). The scan duration was approximately 15-30 minutes.

The USG and MRI were assessed for RU, RC, UC, 1st, 2nd, 3rd, 4th, and 5th Carpometacarpal (CMC), 1st, 2nd, 3rd, 4th, and 5th (MCP) joints and hand IP joints with clinical symptoms [12]. The following parameters were assessed on both MRI and USG: Joint space, joint effusion, synovitis and vascularity, tenosynovitis and bone erosions [Table/Fig-1-3]. Bone marrow edema was assessed on USG only.

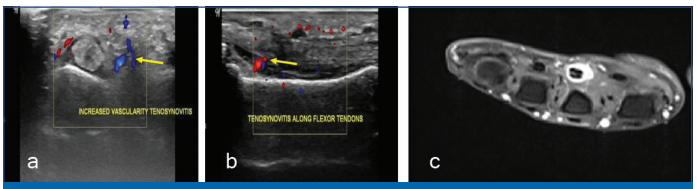
Synovial thickening is seen as hypoechoic synovium with increased vascularity on USG arrow in [Table/Fig-1a,2a,b] and hyperintensity on T2 [Table/Fig-1b] with post contrast enhancement on T1FS MRI [Table/Fig-1c,2c]. Joint effusion is seen as anechoic collection adjacent to synovial thickening shown in lower arrow in [Table/Fig-1a]. Tenosynovitis is seen as synovial thickening with increased vascularity along tendons on USG [Table/Fig-3a,b] with post contrast enhancement on T1FS on MRI [Table/Fig-3c].



[Table/Fig-1a-c]: (a) Transverse image of the wrist on USG) demonstrates synovial thickening (upper yellow arrow) with minimal joint effusion (lower yellow arrow) around RU joint, corresponding (b) (coronal T2) and (c) (T1 FS post contrast) MRI images are depicting synovial thickening and enhancement (yellow arrow).



[Table/Fig-2a-c]: (a,b) Transverse images of wrist and hand on USG depicting synovial thickening and increased vascularity (yellow arrow) in 1st carpometacarpal joint and radiocarpal joint on USG and power doppler, corresponding (c) Coronal T1 FS post contrast MRI image depicting synovial thickening and enhancement (yellow arrow).



[Table/Fig-3a-c]: (a) Transverse and (b) Longitudinal images of USG at the level of wrist demonstrates synovial thickening along flexor tendon with increased vascularity on power doppler which is confirmed on MRI axial T1 FS post contrast image (c) as shown in yellow arrow.

STATISTICAL ANALYSIS

Data were entered in a Microsoft excel spreadsheet. Epi info version 7.2.3.1 was used for statistical analysis. Quantitative data was expressed as mean+standard deviation (SD) and the categorical data was expressed as percentages and frequencies. The categorical variables of the two groups were compared using the chi-square test. p-value of <0.05 was considered as statistically significant.

RESULTS

The mean age of the study group was 44.96±11.58 years with the youngest study participant being 24 years old, while the eldest of 70 years. Maximum patients were aged between 41-50 years and 51-60 years with 8 (32%) patients in each group [Table/Fig-4].

Age groups	n (%)
18-30 years	3 (12%)
31-40 years	5 (20%)
41-50 years	8 (32%)
51-60 years	8 (32%)
61-70 years	1 (4%)

[Table/Fig-4]: Age distribution.

A total of 394 joints were studied in present study, out of which there were 25 distal RU, 25 RC, 25 UC, 25 intercarpal, 125 (25 each 1st, 2nd, 3rd, 4th, and 5th) CMC, 125 (25 each 1st, 2nd, 3rd, 4th, and 5th) MCP and 44 hand IP joints (11 reported clinical symptoms in 2nd, 3rd, 4th and 5th proximal IP) with clinical symptoms. There were 18 female and seven male patients with preponderance of female

patients. All the patients in the present study were positive for Rf and ANCA. Among 25 patients, the most common clinical finding was restricted movement seen in 17 (68%) of cases followed by swelling and tenderness of hand and wrist 10 (40%) each.

Joint effusion was diagnosed in more number of joints 26 (6.5%) on USG as compared to 15 (3.5%) on MRI, however, the p-value was 0.078 suggesting it was statistically insignificant. On comparison between USG and MRI, MRI was better than USG in picking up findings of joint space narrowing, synovial thickening and synovial vascularity [Table/Fig-5].

Parameters	Number of joints	USG (% total joints)	MRI (% total joints)	Chi-square	p-value
Joint space narrowing	394	0	14 (3.5%)	14.252	<0.001
Joint effusion	394	26 (6.5%)	15 (3.8%)	3.112	0.078
Synovial thickening	394	31 (7.8%)	73 (18.5%)	19.525	<0.001
Synovial vascularity	394	27 (6.8%)	73 (18.5%)	24.218	<0.001

[Table/Fig-5]: Comparison between USG and MRI in detecting abnormalities in joints in early RA.
p-value 0.05 was considered significant

The radiological observation of flexor tenosynovitis was picked up by USG in 11 patients in comparison to 10 by MRI and extensor tenosynovitis in 11 patients on both USG and MRI with p-value of <0.001 which was statistically significant suggesting that either of the two modalities can be used to pick up findings of tenosynovitis [Table/Fig-6].

Tenosynovitis	USG finding	MRI finding, n (%)		Statistic*
		Present	Absent	
Flexor	Present	10 (40%)	1 (4%)	Spearman rho=0.921 χ^2 (p-value)<0.001 Kappa=0.918
	Absent	0 (0%)	14 (56%)	
Extensor	Present	11 (44%)	0 (0%)	Spearman rho=1.000 χ^2 (p-value)<0.001 Kappa=1.000
	Absent	0 (0%)	14 (56%)	

[Table/Fig-6]: Comparison of tenosynovitis findings on USG and MRI.
*Spearman rho was used to calculate p-value

The USG diagnosed 14 cases with bone erosion. MRI confirmed 13 of the forementioned cases, one of the erosions seen on USG was missed on MRI. MRI also diagnosed five more cases with bone erosion. On comparison between USG and MRI in detecting bone erosion, the p-value was 0.009 which was statistically significant suggesting that MRI was better than USG in picking up bone erosion [Table/Fig-7].

Almost three to fourth of the cases 18 (72%) had bone marrow oedema as shown in [Table/Fig-8].

Parameter	Bone erosion	MRI finding, n (%)		Statistic*
		Present	Absent	
USG finding	Present	13 (52%)	1 (4%)	Spearman rho=0.524 χ^2 (p-value)=0.009 Kappa=0.493
	Absent	5 (20%)	6 (24%)	

[Table/Fig-7]: Comparison of bone erosion findings on USG and MRI.
*Spearman rho was used to calculate p-value

Bone marrow edema on MRI	n (%)
Present	18 (72%)
Absent	7 (28%)

[Table/Fig-8]: Bone marrow edema on MRI.

DISCUSSION

Early detection of RA is a challenging field, however various imaging modalities may help to diagnose early RA before the onset of irreversible changes like joint destruction and deformities. Early detection of RA can benefit the patient by preventing disability and long-term morbidity, if the patient is treated aggressively as per the clinical and radiological status of the patient.

The mean age of patients was 44.96±11.58 years with a range of 24-70 years and maximum percentage of patients in the age group 41-60 years (64%). This was similar to the study done by Mousa MEA et al., where the age ranged from 20-72 years [10]. Issar P et al., also reported that patients with early stages of RA were in the age group of 18-76 years with maximum patients in the age group 51-60 years [13].

The female to male ratio was 7.2:2.8. In a study done by Sokka T, it was found that all core-set measures were higher in females representing 79% of the total patients [14]. In a study done by Issar P et al., female to male ratio was 7.3 :1 in the early stage of RA which was similar to this study [13]. This was in contrast to a study done by Wang MY et al., in which male to females ratio was 1:1 [11].

The most common clinical finding observed in the present study was restricted movements of hand and wrist (68%) followed by swelling and tenderness of hand and wrist (40%) of patients. This was in concordance with the study done by Mousa MEA et al., in which 72% had morning stiffness followed by pain (60%), swelling and tender joints (52%) [10].

The USG was able to detect joint effusion in 26 (6.5%) out of 394 joints compared to MRI which was able to detect in 15 (3.5%) out of 394 joints. However, the p-value was 0.078 which was statistically insignificant suggesting that USG and MRI were comparable and either modality can be used for picking up Joint effusion. Study done by Wang MY et al., reported USG superior to MRI in detecting joint effusion [11]. Issar P et al., also reported that Gray-scale Ultrasound and Power Doppler Ultrasound (GSUS and PDUS) and contrast MRI were equally sensitive in detecting joint effusion [13]. However, Wang MY et al., reported a significant difference in joint effusion between high frequency USG 89 (10.4%) and MRI 52 (6%) with a p-value <0.05 which was discordant to the present study [11].

In the present study, MRI was better than USG in picking up synovitis in the form of synovial thickening and synovial vascularity. In the study done by Wang MY et al., USG vs MRI in detecting synovial proliferation [132 (15.4%) vs. 66 (7.7%), with p<0.05], USG was significantly better [11]. However, Mousa MEA et al., reported synovial thickening in 78% of RA patients by MRI and 72% of patients by USG [10]. Present study was in concordance with Issar P et al., who reported increased detection of synovitis by MRI as compared to USG in IC joints [13].

Tenosynovitis is considered the hallmark of early tendon affection as stated by Grassi W et al., in some cases [15], it predominates over synovitis in early RA as stated by Narvaez J et al., [8]. In the present study, flexor and extensors tendons were equally affected. In a study done by Xu H et al., USG and MRI had an equivalence in diagnosing tenosynovitis with p-value <0.05 [9]. However, in a study done by Issar P et al., USG and MRI were comparable with each other in the diagnosis of extensor tenosynovitis [13]. The most common tendon involved was extensor carpi ulnaris (ECU) in present study. It is in concordance with the study done by Lillegraven S et al., and Issar P et al., who also reported ECU to be the most commonly involved tendon in their study [16,13].

The MRI was better than USG in picking bone erosion in present study. Issar P et al., also reported less sensitivity of USG as compared to MRI in detecting bone erosion (14% in USG and 44.8% in MRI) [13]. However, Wang MY et al., reported no significant sensitivity between high frequency USG and MRI in picking up bone erosion 44 (5.1%) vs 35 (4.1%) respectively with p-value of >0.05 [11].

Bone marrow oedema is detected by MRI and is a sign of inflammatory arthritis which suggests active osteitis [13]. In the present study, it was detected in 18 (72%) cases suggesting that it presents as one of the radiological findings in early RA. Mousa MEA et al., in their study reported bone marrow oedema in 28% of cases

by MRI and none on sonographic evaluation [10]. The comparative findings are depicted in [Table/Fig-9] [9-11,13].

Authors name and ref no.	Place and year of the study	Joint effusion	Synovitis	Tenosynovitis	Erosions
Wang MY et al., [11]	Shandong, China, 2016	USG>MRI	USG>MRI		USG=MRI
Issar P et al., [13]	Bhilai, Chhattisgarh, India, 2016	USG=MRI	MRI>USG	USG=MRI	MRI>USG
Mousa MEA et al., [10]	Egypt, 2018		USG=MRI		
Xu H et al., [9]	Suzhou, China, 2017			USG=MRI	
Present study	Shimla, HP, India, 2020	USG=MRI	MRI>USG	USG=MRI	MRI>USG

[Table/Fig-9]: Comparative table depicting USG verses MRI findings [9-11,13].

Limitation(s)

The limitation to the present study was the small sample size (394 joints) due to Coronavirus Disease-2019 (COVID-19) pandemic and it was a time bound study for one year. All the bony erosions could not be picked up on USG due to lack of 3D illustration and only superficial cortical areas could be visualised with a linear superficial probe. The demographic and clinical conditions may have led to more detection of bone marrow oedema which is an early radiological finding of RA.

CONCLUSION(S)

In patients with early RA, USG can be used for detecting joint effusion and tenosynovitis. For detecting joint space narrowing, synovitis, tenosynovitis, and bone erosion, MRI is a better modality and proven to be superior in detecting bone marrow oedema. With limited resources and logistics, availability of MRI in our state and similar health care settings, the USG can be used for detecting early RA changes, preventing delayed diagnosis and would further be useful in saving precious time and cost incurred.

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