

Role of MRI and Ultrasound in the Assessment of Rheumatoid Arthritis in Hand and Wrist Joints

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Abstract: Objectives: discuss and compare the role of ultrasound and MRI of the hand and wrist joints in diagnosis of RA and to evaluate its role in detecting the activity of RA disease. **Methods:** This study included 30 adult RA patients (23 females and 7 males) with a mean age of 45.28 ± 10.467 years and with a mean disease duration of 6.2 ± 4.188 years. All patients were subjected to: history taking, clinical examination, laboratory investigations to detect disease activity and plain x-ray for the hands. US and enhanced MRI were used for the evaluation of the clinically dominant hand joints including [30 wrists, 120 2nd to 5th metacarpophalangeal (MCP) joints, for detection of synovial inflammation (pannus and/or effusion), tenosynovitis and signs of bone destruction, as well as vascularization of the synovial membrane was assessed. **Results:** We found significant correlation and agreement between both modalities in the assessment of synovial inflammation in the hand and wrist joints. Both power doppler scores and OMERACT RAMRIS scores of synovitis are comparable. Both imaging modalities detected signs of inflammation and bone destruction in the wrist and hand joints showing different aspects of inflammatory process of rheumatoid arthritis. **Conclusion:** This significant correlation indicates the potential importance of power Doppler study in the assessment and monitoring of disease activity as reliable non invasive method in the hands of skilled operators.

The present study demonstrates a close relationship between power Doppler synovitis score and MRI OMERACT RAMRIS synovitis score. Both modalities are comparable.

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1. Introduction:

Early diagnosis and personalized treatment is the cornerstone of an effective strategy aimed at inducing clinical remission and preventing irreversible anatomical damage. Imaging is crucial for fulfilling these tasks. Both US and MRI allow for a careful confirmation of the clinical suspicion of RA by revealing even minimal pathologic changes indicative of soft tissue inflammatory involvement and/or joint damage. Ultrasound has been demonstrated to be superior to clinical examination in detecting synovitis because of its capability to identify otherwise undetectable fine, soft tissue changes. The main advantages of US, with respect to other imaging techniques, include absence of radiation, good visualization of the joint cavity, low running costs, multiplanar imaging capability, quantifications of soft-tissue abnormalities and real-time imaging. Moreover, it is rapidly performed and readily accepted by patients and may be used to assist needle positioning within the selected target area and facilitate joint aspiration, biopsy and local injections. In RA patients, US can detect a core set of basic findings which indicate either the disease activity or its severity, these

include: joint cavity, tendon sheath and bursal enlargement (due to an abnormal amount of synovial fluid and/or synovial hypertrophy), Doppler signal, cartilage damage, tendon tear and bone erosion. A variable combination of these basic findings may be detected, giving reason for the wide range of pathological changes detectable even in a single RA patient. Each of these findings can be graded using different scoring systems and data obtained in different anatomic sites can be added together to gather information at patient level.

MRI plays an important role in RA, providing diagnostic and prognostic information. MRI can visualize both the inflammation and the structural damage in RA patients. One of the major advantages of MRI compared to other techniques is the ability to assess bone edema/osteitis, which is visualized only by MRI.

The aim of this work is to discuss and compare the role of ultrasound and MRI of the hand and wrist joints in diagnosis of RA and to evaluate its role in detecting the activity of RA disease.

2. Patient and method

Thirty rheumatoid Arthritis (RA) patients were recruited for this study, from the Rheumatology and Rehabilitation outpatient clinic, Faculty of Medicine, Sayed Galal University Hospitals. This study was conducted during the period December 2017 to October 2018 and included 23 females and 7 males with a mean age of 45.3. all patients fulfilled *The American Rheumatism Association 1987 revised criteria for the classification of rheumatoid arthritis, with No apparent deformities of the wrist and hand joints clinically, X ray revealed either subtle changes or normal study All patients in whom MRI was contraindicated due to implanted medical devices or claustrophobic and patients having renal impairment were excluded.* All patients included in this study were subjected to full history taking, clinical examination by the referring rheumatologist, laboratory investigations as well as plain radiography, ultrasonography as well as pre and post contrast MRI study.

Clinical examination

Disease activity score in 28 joints (DAS28) was calculated based on counts of tender and swollen joints and ESR.

Complete blood count (CBC), Erythrocyte Sedimentation Rate (ESR), Serum Rheumatoid Factor, C-reactive protein (CRP) quantitatively, and Serum creatinine were obtained.

Plain radiographs for both hands including wrists were taken for each patient in PA view, Ultrasound examination Ultrasonography of the wrist joint, 2nd, 3rd, 4th & 5th MCPs, were performed using GE LOGIQS6 ultrasound machines using a near focused linear array transducer with a centre frequency of 7.5-12 MHz. During examination of hand joints and wrists: The patient was examined while sitting upright, with the hand placed on a cushion and fully pronated then supinated.

For the wrist: dorsal longitudinal scan followed by dorsal transverse scan were done followed by palmar examination in supination.

For MCPs: Dorsal and palmar longitudinal and transverse scan, with lateral longitudinal scan for the 2nd & 5th MCPs.

US examination for joint effusion and synovitis was carried out by grey-scale imaging, and synovial vascularization was assessed by PD in the 12 joints according to OMERACT definitions of pathology.

Evaluation of US images Grey-scale imaging evaluation confirmed the presence or absence of synovial hypertrophy (SH) and/or joint effusion, which was graded using a semiquantitative scoring method consisting of a scale of 0–3, where 0 represented no SH, 1 mild hypertrophy, 2 moderate hypertrophy and 3 severe hypertrophy. PD was graded using a semiquantitative scoring method, which

consists of a scale of 0–3, where 0 represented no PD signal, 1 one or two vessels in joint, 2 less than half of the synovial area and 3 more than half of the synovial area. Scores were expressed per joint.

MRI study

Magnetic resonance examination of the dominant wrist as well as the 2nd to 5th MCPs was performed using Philips Achiva 1.5 T (closed) patients were placed in prone position with the hand above the head and dedicated wrist coil was used. The position was maintained and movement avoided with the aid of sand bags.

Three dimensional coronal and axial pre and post contrast T1WIs of the wrist as well as the 2nd to 5th MCPs using the following parameters repetition time (TR)540 m-sec, echo time (TE)22 m-sec, flip angle 90°, matrix size 216x152, and field of view (FOV)150 mm (coronal) 80 mm (axial). STIR WIs of the following parameters TR1700 m-sec TE 60 m-sec flip angle 90°matrix size240x143, and FOV150 mm (coronal) 80 mm (axial). While the patient remained motionless in the MR unit 0.05 mmoles/ kg body weight of Gadoteric acid (DOTAREM, Guerbet, France) injected intravenous in the contra lateral arm via cannula that has been inserted before the examination acquisition of 3D coronal and axial T1WIs of the wrist and MCPs performed.

Evaluation of MRI images Synovitis in a joint on MRI was defined as an area in the synovial compartment that showed enhancement on the post contrast image. The degree of synovitis in each joint examined was graded on a scale of 0–3 according to the OMERACT definitions. **0: normal, 1-3 (mild, moderate, severe)** as estimated by thirds of presumed maximum volume of enhancing tissue in synovial compartment.

Synovitis is assessed in the following wrist regions (distal radiolunar, radio-carpal, intercarpal joints & on each metacarpal joint). The first capometacarpal & the first MCP joints are not scored.

Statistical analysis:

Data were statistically described in terms of mean standard deviation (SD), and range, or frequencies (number of cases) and percentages when appropriate. Comparison between MRI and US results was done using McNemar test and Chi square (χ^2) test when appropriate. Agreement was tested using kappa statistic. Correlation between various variables was done using Spearman rank correlation equation for non-normal variables. *p* values less than 0.05 was considered statistically significant. All statistical calculations were done using computer programs SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 15 for Microsoft Windows.

3. Results

Comparison between US & MRI in the detection of hand joints pathology:

Ultrasound detected synovial hypertrophy (pannus) in 25 wrist joints while MRI detected it in 28 wrist joints (Fig 1), both modalities agreed in 25 patients, and ultrasound missed synovial hypertrophy in 3 joints detected by MRI. (Table 1)

Statistical analysis of these results showed no significant statistical difference (p value 0.125) and significant agreement between the two modalities in the detection of synovial hypertrophy. Comparison between US and MRI yielded a weighted Kappa value of 0.627.

Table (1): Comparison between US and MRI in the detection of synovial hypertrophy (pannus) of wrist joints:

		Synovial hypertrophy by ultrasound		Total
		Absent	Present	
Synovial hypertrophy by MRI	Absent	2	0	2
	Present	3	25	28
Total		5	25	30

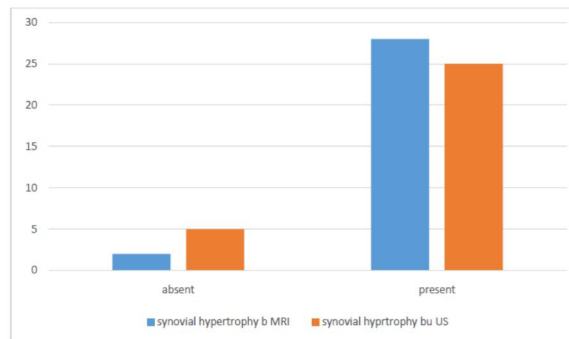


Fig. (1): Comparison between US and MRI in the detection of synovial hypertrophy (pannus) of wrist joints

Table (2): Comparison between power Doppler and MRI in assessment of synovial activity (synovitis) in wrist joints

			Synovial Activity score ultrasound				Total
			Normal	Mild	Moderate	Severe	
Synovial Activity score MRI	Normal	N	6	1	0	0	7
	Mild	N	4	6	3	1	14
	Moderate	N	0	1	2	0	3
	Severe	Count	1	0	1	3	6
Total		Count	12	8	6	4	30

Power Doppler ultrasound detected increased vascularity within 18 wrist joints (60 %) denoting active synovitis and MRI detected synovial enhancement within 23 wrist joints (76 %) denoting active synovitis, both scoring systems agreed in the assessment of synovitis degree in 12 wrist joints (Fig 2). PDUS missed detection of synovitis in 6 joints detected by MRI, 4 of them were estimated by MRI to be of mild activity (grade 1).

Statistical analysis of these results showed significant correlation (p value < 0.001) and agreement between the techniques in the assessment of synovial activity in wrist joints. Comparison of US and MRI yielded a Kappa value of 0.482.

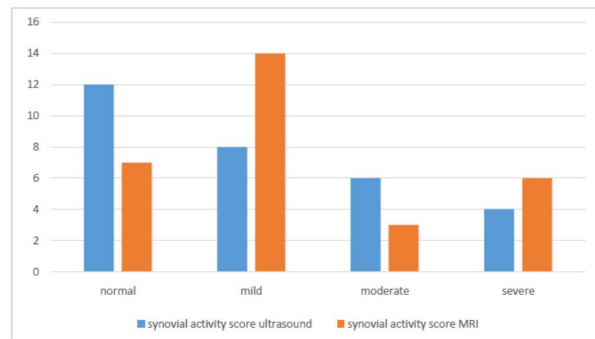


Fig. (2): Comparison between power Doppler and MRI in assessment

Table (3): Comparison between PDUS and MRI in the assessment of total MCP synovial activity score

		N	Synovial Activity score PDUS MCP		Total
			Normal	Mild	
Synovial Activity score MRI	Normal	N	17	7	24
	Mild	N	1	5	6
Total		N	18	12	30

Power doppler ultrasound detected synovial activity (increased vascularity in MCP joints of 12 patients, and MRI detected synovial activity (synovial enhancement) in MCP joints of 6 patients (**Fig 3**). Both modalities agreed in 5 patients as regards the total synovial activity score.

Statistical analysis of these results showed no significant difference (p value 0.002) and good agreement between the two modalities in the assessment of total MCP activity score. Comparison of US and MRI yielded a weighted Kappa value of 0.376, correlation between both of them revealed P value of 0.001 and correlation coefficient 0.445 which is relatively weak correlation.

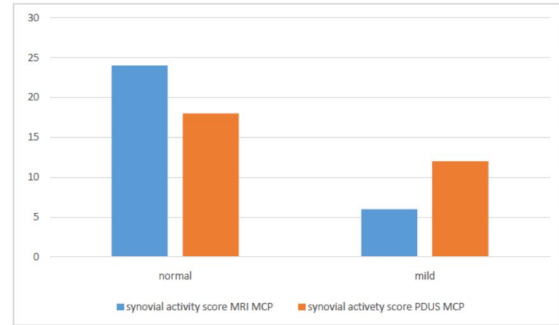


Fig. (3): Comparison between PDUS and MRI in the assessment of total MCP synovial activity score

Table (4): Comparison between US and MRI in the detection of erosions of wrist joints

		N	Erosions ultrasound		Total
			Absent	Present	
Erosions -MRI	Absent	N	5	3	8
	Present	N	7	15	22
Total		N	12	18	30

Ultrasound detected erosions in 18 wrist joints and MRI detected erosions in 22 wrist joints (**Fig 4**). Both modalities agreed in 15 wrist joints, ultrasound missed erosions in 7 joints detected by MRI and MRI missed erosions in 3 joints detected by ultrasound.

Statistical analysis of these results showed significant agreement between the two modalities in the detection of erosions. Comparison of US and MRI yielded a weighted Kappa value of 0.406.

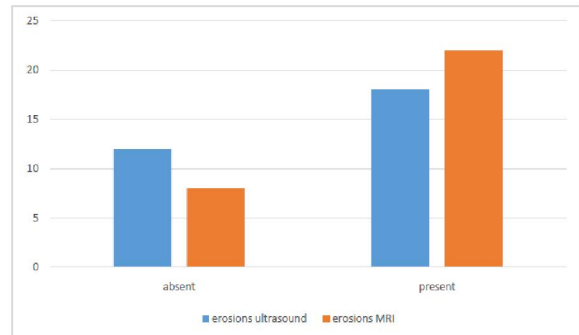


Fig. (4): Comparison between US and MRI in the detection of erosions of wrist joints

Table (5): Comparison between US and MRI in the detection of erosions of MCPs joints

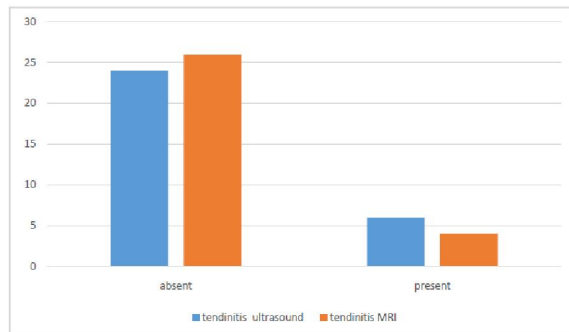
		N	Erosions ultrasound		Total
			Absent	Present	
Erosions -MRI	Absent	N	97	8	105
	Present	N	6	9	15
Total		N	103	17	120

Ultrasound detected erosions in 17 MCP joints and MRI detected erosions in 15 MCP joints. Both modalities agreed in 9 joints, ultrasound missed 6 joints detected by MRI.

Table (6): Comparison between US and MRI in the detection of tendinitis

			Tendinitis ultrasound		Total
			Absent	present	
Tendinitis MRI	Absent	N	23	3	26
	Present	N	1	3	4
Total		N	24	6	30

Ultrasound detected tendinitis in 6 extensor tendons and MRI detected tendinitis in 4 extensor tendons (**Fig 69**), both modalities agreed in 3 tendons. ultrasound missed 1 cases detected by MRI and MRI missed 3 cases detected by ultrasound.

**Fig. (5):** Comparison between US and MRI in the detection of tendinitis

Statistical analysis of these results showed no statistical significant difference between the two modalities (p value less than 0.001) and significant agreement in the detection of tendinitis. Comparison of US and MRI yielded a weighted Kappa value of 0.646.

4. Discussion

This study was performed to compare effectiveness of both power Doppler US and MRI of joints of the hand, in the assessment of synovial inflammation and erosions, and to try to correlate the OMERACT RAMRIS synovitis score with power Doppler activity score in RA patients.

Correlation and comparison between the power Doppler score and OMERACT RAMRIS score of synovial activity in wrist joints revealed significant correlation and agreement between both modalities in the assessment of synovial inflammation.

These results match with those of **Boesen and his co workers (2011)** who reported that the OMERACT RAMRIS scores of inflammation in RA patients (bone marrow edema and synovial enhancement) are comparable to US colour fraction measurements.

In this study power Doppler ultrasound detected active synovitis in 27 MCP joints (22 %) and MRI detected synovial enhancement in 9 MCP joints (7.5 %), both modalities agreed in 8 MCPs.

These results match with those of **Szkudlarek and his coworkers, (2001)** who studied the effectiveness of power Doppler for assessing inflammatory activity in the metacarpo-phalangeal joints of patients with RA compared with MRI as reference imaging method.

Terslev and his coworkers, (2003) found total agreement between the two imaging modalities with kappa values of 0.45 and 0.41 for the wrist and MCP joints respectively in detection of synovitis, and significant correlation (p value < 0.001) between color fraction in doppler ultrasound and synovial thickness in post contrast MRI, and those results agree with our study where we found good agreement between both imaging modalities with kappa values of 0.482 and 0.376 for the wrist and MCP joints respectively in detection of active synovitis and significant correlation (p < 0.001).

As regards signs of bone destruction, in this study ultrasound detected erosions in 57/250 joints (22.8 %) and MRI detected erosions in 62/250 joints (24.8%).

Scheel and his coworkers, (2006) studied the MCPs and PIPs II–V (128 joints) of the clinically dominant hand of 16 patients with RA, the number of erosions and the presence of synovitis were determined for each joint and graded as either normal (0) or abnormal (1). They demonstrated that US had detected erosions in 12 joints (9%) while MRI did so in 34 joints (27%) which is even lower than our results, however they explained the small number of erosions detected by US, by possibly the significantly low resolution of US device and the need to use an acoustic standoff pad. Also, by that neither ulnar nor radial aspects of the joints were evaluated by US, raising the possibility that some erosions might have been missed.

Another study conducted by **Magnani and his coworkers, (2004)** compared the Ultrasonography and MRI in their capability to detect bone erosions in RA patients, they examined thirteen patients with advanced RA, the wrist joints as well as the MCPs were examined by MRI with contrast and ultrasound, they found no significant difference between both modalities in detecting erosions in wrist joints, and this matches with our results, where both modalities agreed in detecting erosions in 30 wrist joints (81 %) out of 37 joints detected by MRI.

Conclusion

Evaluation of disease activity in rheumatoid arthritis (RA) is essential in the routine clinical management of RA patients and in RA clinical trials. Disease activity in RA joints is conventionally assessed clinically (e.g., assessment of joint swelling/tenderness) in combination with the measurement of levels of biochemical surrogate markers such as serum C-reactive protein. Newer imaging modalities such as contrast enhanced magnetic resonance imaging (MRI) and high frequency ultrasonography (US) may offer improved monitoring.

Both modalities have proven useful and more sensitive than conventional methods like radiographs and clinical scores and have a potential importance for guiding treatment of RA.

Ultrasound has the advantage to be a dynamic imaging technique capable to visualize both the morphology and the function (i.e., inflammatory activity) of the structure under evaluation.

PDUS is a useful imaging method to detect and determine early arthritis and to assess and monitor arthritic activity during the course of disease. Moreover, the initial amount of Doppler activity is a prognostic parameter for the development of subsequent bone destruction.

MRI has been shown to be a sensitive method of assessing the inflammatory activity in the synovium of RA joints. In particular, dynamic contrast enhanced MRI findings have been shown to correlate closely with histologic signs of synovitis in the knee joints of patients with RA.

The thirty patients included in this study were diagnosed with rheumatoid arthritis according to the ACR criteria 1987. The clinically dominant wrist and hand joints were examined by power doppler ultrasound study and enhanced MRI study. Synovitis scores of both modalities were compared and correlated; other signs of inflammation as well as signs of bone destruction were also collected and compared.

We found significant correlation and agreement between both modalities in the assessment of synovial inflammation in the hand and wrist joints. Both power doppler scores and OMERACT RAMRIS scores of synovitis are comparable. Both imaging modalities detected signs of inflammation and bone destruction in the wrist and hand joints showing different aspects of inflammatory process of rheumatoid arthritis.

This significant correlation indicates the potential importance of power Doppler study in the assessment and monitoring of disease activity as reliable non invasive method in the hands of skilled operators.

The present study demonstrates a close relationship between power Doppler synovitis score and MRI OMERACT RAMRIS synovitis score. Both modalities are comparable. Further studies are recommended to build a bridge between the MRI and ultrasound results.

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