Comparative Study between Power Doppler Ultrasound with OMERACT RAMRIS Synovitis Score in the Wrist Joint of Patients with Rheumatoid Arthritis

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Abstract

Objective: To compare the role of power Doppler ultrasound and enhanced MRI in the assessment of synovitis of the wrist joints in Rheumatoid arthritis patients.

Patients and Methods: This study included fifty patients (39 females and 11 males) with rheumatoid arthritis. They were subjected to power Doppler ultrasound study and enhanced MRI examination of the clinically dominant wrist joints. Mean age was 45.3 years and mean disease duration was 6.2 years. Power Doppler score of synovitis was correlated and compared with MRI OMERACT score.

Results: Our results showed that both modalities are comparable and closely related in the assessment of inflammatory process of hand and wrist joints in rheumatoid arthritis.

Key Words: Rheumatoid arthritis – Power doppler ultrasound – MRI – Synovitis.

Introduction

RHEUMATOID arthritis is chronic disease characterized by inflammatory synovial proliferation and hypervascularity synovitis with subsequent bone erosion, cartilage damage and joint destruction. New effective treatments to prevent joint destruction increased the need for more sensitive imaging techniques especially at an early stage of the disease to monitor the therapeutic effect of those drugs and predict disease progression [1].

RA affects over 1% of the world’s population [2]. The importance of early diagnosis is highlighted by many research studies to prevent major joint damage by early treatment and subsequently reduce the burden on patients [3].

Assessment of disease activity in the joints of RA patients includes clinical examination as well as measurement of the levels of markers such as serum C-reactive protein (CRP). Plain radiography is a common imaging modality for assessment of RA, yet it shows changes only late in the course of the disease [4].

Evaluation of hand arthritis being the most common site of rheumatoid arthritis (RA) is important for diagnosis and evaluation of disease activity. As new imaging methods, magnetic resonance imaging (MRI) and joint ultrasonography (US) are currently used in RA [5]. Synovitis and bone marrow edema can be confirmed with MRI, being superior to plain radiographs [6]. The correlation between synovial membrane thickness and joint destruction has been reported, and several methods to quantify thickness with contrast-enhanced MR images have been reported [7].

Power Doppler US (PDUS) used to be a good tool for diagnosis of synovitis in RA joints [8]. PDUS could be applied to monitor the response of RA patients treated with tumor necrosis factor-alpha inhibitors [9]. Dynamic Magnetic resonance imaging (MRI) has been used to evaluate the joints of RA patients showing strong correlation with histologic synovitis of the knee joint [10].

PDUS and dynamic MRI are both sensitive methods of assessing synovitis in RA joints according to some studies comparing these imaging modalities [11].

Aim of the work:

The purpose of the present study is to compare the role of power Doppler ultrasonography and enhanced MRI in assessment of synovitis of the wrist joints in Rheumatoid arthritis patients.
Patients and Methods

Fifty rheumatoid Arthritis (RA) patients were recruited for this study, from the Rheumatology and Rehabilitation outpatient clinic, Faculty of Medicine, Cairo University Hospitals from March 2012 – July 2014. This study included 39 females and 11 males with a mean age of 45.3.

Inclusion criteria:
- Clinical diagnosis of rheumatoid arthritis (RA) according to The American Rheumatism Association 1987 revised criteria for the classification of rheumatoid arthritis [12] (Table 3).
- No apparent deformities of the wrist and hand joints clinically.
- X-ray revealed either subtle changes or normal study.

Exclusion criteria:
- Advanced deformities of the wrist and hand joints were detected clinically.
- Renal impairment.
- Contraindications to MRI (e.g.: Claustrophobia, pacemakers).

All patients included in this study were subjected to ultrasonography examination as well as pre and post contrast MRI study.

I- Ultrasonography (US):

Ultrasonography of the wrist joints were performed by GE LOGIQ P6 Pro ultrasound machines using a near focused linear array transducer with a center 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.

Dorsal longitudinal scan followed by dorsal transverse scan were done followed by palmar examination in supination to evaluate Presence of pannus (synovial hypertrophy) and assessment of synovial vascularity (synovitis) using power Doppler.

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 [13].

Grey-scale imaging evaluation confirmed the presence or absence of synovial hypertrophy, which was graded using a semi quantitative 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 semi quantitative 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.

Each patient evaluation took no more than 20min, including documentation, and the images demonstrating maximal abnormalities were archived.

II- MRI study:

Magnetic resonance examination of the dominant wrist joint was performed using Philips Intera 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 T1WIs & STIR WIs were acquired and axial T1WIs of the wrist using the parameters in Table (1).

Table (1): MRI technical parameters.

<table>
<thead>
<tr>
<th></th>
<th>TR</th>
<th>TE</th>
<th>Matrix</th>
<th>FOV</th>
<th>Flip angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1WIs</td>
<td>540</td>
<td>22</td>
<td>216x152</td>
<td>150 (coronal)</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>80 (axial)</td>
<td></td>
</tr>
<tr>
<td>STIR WIs</td>
<td>1700</td>
<td>60</td>
<td>240x143</td>
<td>150 (coronal)</td>
<td>90</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>80 (axial)</td>
<td></td>
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<tr>
<td>Post contrast</td>
<td>540</td>
<td>22</td>
<td>216x152</td>
<td>150 (coronal)</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>80 (axial)</td>
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</tbody>
</table>

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 radioulnar, radio-carpal, intercarpal joints & on each metacarpal joint.)
**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 (χ²) 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.

**Results**

Fifty adult Rheumatoid Arthritis patients diagnosed as RA according to the 1987 revised American College of Rheumatology (ACR) criteria for classification of Rheumatoid Arthritis, [13] were included in the study.

Patients were 39 females (78%) and 11 males (22%), their ages ranged from 22 to 68 years with a mean age of 45.3 years ±10.5. The disease duration ranged from one year to 18 years with a mean of 6.20 years ±4.2 thirty nine patients (78%) were seropositive (RF) and eleven patients (22%) were seronegative (RF). Thirty one patients were positive for CRP (60%).

**Results of Doppler ultrasonography examination:**

- Forty two (42) wrist joints (84%) were found to have pannus (both active and inactive) among them 30 wrist joints (60%) were found to have increased vascularity by PDUS, 13 wrist joint (26%) with mild activity, 10 wrist joints (20%) with moderate activity, 7 wrist joints with severe activity (14 %) [Tables (2-3)].

<table>
<thead>
<tr>
<th>Normal</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
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<tbody>
<tr>
<td>40.0</td>
<td>26.0</td>
<td>20.0</td>
<td>14.0</td>
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<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percent</th>
</tr>
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<tbody>
<tr>
<td>Absent</td>
<td>8</td>
</tr>
<tr>
<td>Present</td>
<td>42</td>
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<table>
<thead>
<tr>
<th>Normal</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
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<tr>
<td>24.0</td>
<td>48.0</td>
<td>10.0</td>
<td>18.0</td>
</tr>
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</table>

**Results of Magnetic Resonance Imaging (MRI) examination:**

Fifty patients (50) were subjected to MRI examination (50 wrist joints) were scanned, interpreted according to the OMERACT RA MRI scoring system (RAMRIS) the following results were found:

- Forty six (46) wrist joints (92%) were found to have pannus (synovial hypertrophy), evaluation of synovial enhancement in the post contrast study (synovitis) revealed 38 wrist joints (76%) were active, among them 24 wrist joints (48%) had mild activity, 5 wrist joints (10%) had moderate activity and 9 wrist joints had severe activity (18 %) (Table 4).

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percent</th>
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<tbody>
<tr>
<td>Normal</td>
<td>12</td>
</tr>
<tr>
<td>Mild</td>
<td>24</td>
</tr>
<tr>
<td>Moderate</td>
<td>5</td>
</tr>
<tr>
<td>Severe</td>
<td>9</td>
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</table>

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

Ultrasound detected synovial hypertrophy (pannus) in 42 wrist joints while MRI detected it in 46 wrist joints (Fig. 1), both modalities agreed in 42 patients, and ultrasound missed synovial hypertrophy in 4 wrist joints detected by MRI (Table 5).

Statistical analysis of these results showed significant correlation (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.

- Eight (8) wrist joints (16%) were found to have effusion.

<table>
<thead>
<tr>
<th>Synovial hypertrophy by MRI:</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>Absent</td>
<td>Present</td>
</tr>
<tr>
<td>4</td>
<td>42</td>
</tr>
</tbody>
</table>

Table (2): Synovial thickening of wrist joints by ultrasound.

<table>
<thead>
<tr>
<th>Synovial hypertrophy by power Doppler ultrasound.</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>20</td>
<td>40.0</td>
</tr>
<tr>
<td>Mild</td>
<td>13</td>
<td>26.0</td>
</tr>
<tr>
<td>Moderate</td>
<td>10</td>
<td>20.0</td>
</tr>
<tr>
<td>Severe</td>
<td>7</td>
<td>14.0</td>
</tr>
</tbody>
</table>

Table (3): Synovitis (increased vascularity) of wrist joints by power Doppler ultrasound.

Table (5): Comparison between US and MRI in the detection of synovial hypertrophy (pannus) of wrist joints.

Statistical analysis of these results showed significant correlation (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.
Power Doppler ultrasound detected increased vascularity within 30 wrist joints (60%) denoting active synovitis and MRI detected synovial enhancement within 38 wrist joints (76%) denoting active synovitis, both scoring systems agreed in the assessment of synovitis degree in 20 wrist joints (Figs. 2,3,4). PDUS missed detection of synovitis in 9 joints detected by MRI, 7 of them were estimated by MRI to be of mild activity (grade 1) (Table 6).

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.

Table (6): Comparison between power Doppler and MRI in assessment of synovial activity (synovitis) in wrist joints.

<table>
<thead>
<tr>
<th>Synovial Activity score ultrasound</th>
<th>Normal</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synovial Activity score MRI</td>
<td>Normal</td>
<td>N</td>
<td>11</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Synovial Activity score MRI</td>
<td>Mild</td>
<td>N</td>
<td>7</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>Synovial Activity score MRI</td>
<td>Moderate</td>
<td>N</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Synovial Activity score MRI</td>
<td>Severe</td>
<td>Count</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>Count</td>
<td>20</td>
<td>13</td>
<td>10</td>
<td>7</td>
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</tbody>
</table>

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

Fig. (2): 42y female patient with RA for 7 years (A,B): Pre and post contrast axial T1WIs of the wrist joint showing severe synovial thickening and enhancement. (C,D): PDUS longitudinal image showing marked increased vascularity within synovial hypertrophy of the wrist denoting severe synovitis.
Ultrasound detected tendinitis in 9 extensor tendons and MRI detected tendinitis in 8 extensor tendons (Figs. 5,6), both modalities agreed in 6 tendons. Ultrasound missed 2 cases detected by MRI and MRI missed 3 cases detected by ultrasound (Table 7).

Statistical analysis of these results showed no significant correlation 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.
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.

Contrast-enhanced MRI is an imaging modality for visualization of the inflamed synovium in which there is increased blood flow and increased capillary permeability. A correlation between the thickness of the synovial membrane detected with contrast-

Fig. (5): (A): Coronal STIR WIs of the hand and wrist showing bright signal intensity along the extensor carpi ulnaris tendon, (B,C): Pre and post contrast axial T1WIs showing evidence of synovial hypertrophy and enhancement along the tendon sheath denoting tendinitis (D): PDUS showing synovial hypertrophy and increased vascularity within extensor carpi ulnaris tendon denoting tendinitis.

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

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.
enhanced MRI and joint destruction has been reported. Several assessments for synovitis have been used, such as rheumatoid arthritis MRI score (RAMRIS), which provides semi-quantitative assessments; measuring the maximum enhanced thickness of the synovium; and the total volume of the synovial membrane calculated by summation of each slice [14].

Synovial hypertrophy is evaluated primarily on GS images, while PD images are utilized to demonstrate activity related to synovial hypertrophy. The clinical significance of GS findings remains disputed, and there is also the problem of interobserver agreement (interobserver agreement of GS scores was moderate in this study). The presence of microvascular blood flow in synovial hypertrophy is interpreted as active synovitis and predicts ongoing joint damage even in patients in clinical remission [14].

In this study ultrasound detected signs of synovial inflammation (synovial hypertrophy) in 42 wrist joints (84%) among them 30 wrist joints (60%) were found to have increased vascularity upon power Doppler application denoting active synovitis. By MRI synovial hypertrophy was detected in 46 wrist joints (92%) among them 38 wrist joints (76%) showed evidence of synovial enhancement in the post contrast study denoting active synovitis.

We found significant correlation and agreement between the power Doppler score and OMERACT RAMRIS score of synovial activity in wrist joints.

These results match with those of Boesen and his co-workers [4] 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, they studied 50 wrist joints in patients with RA and their aim was to compare MRI scores with US Doppler measurements, MRI was scored according to OMERACT RAMRIS recommendations for synovitis, bone marrow edema and erosions, furthermore they subdivided the radio carpal joint into three compartments in the sagittal plane, and the Doppler activity was quantified using colour fraction calculation, they assessed synovitis along dorsal surface of wrist in three planes radio carpal and intercarpal joints as well as adjacent to ulnar head and the average CF was estimated.

Boesen M. and his co-workers [4] reported that they are the first to compare OMERACT RAMRIS score with US CF, they found a significant correlation between US CF and MRI synovitis score ($p<0.005$) and this matches with our results ($p<0.001$), they examined the dorsal aspect of the wrist joints and subdivided them into three compartments taking the average calculated CF and compared it to the total MRI synovitis score yet in our study we examined both the palmar and dorsal surfaces of the wrist joints as well as the radio carpal articulations in transverse and sagittal planes and taking the highest Doppler activity score detected to be compared with MRI and this may explain the stronger correlation between the two modalities in our study, they also stated that MRI score is static and will change only if synovitis changes up to 33% at least.

Taniguchi D. and his coworkers [14] assessed synovitis with MRI using MIP images and power Doppler (PD) findings to examine the clinical usefulness of MIP images for RA in the hand, they studied 60 wrist joints in 30 patients. They assumed a scoring method for the presence of articular synovitis on a semiquantitative method using a scale from 0 to 2 (grade 0 = no enhancement, grade 1 = partial enhancement of the joint, grade 2 = complete enhancement of the joint). For PD images, each joint was scored on a semiquantitative scale (0-3), they found statistically significant correlations between the scores for MIP images and PD images for both wrists ($p<0.001$). The agreement on synovitis between MIP and PD images was moderate at 0.73 ($\kappa=0.44$), and this agrees with our study as regards the strong correlation between both modalities yet we differed in the scoring methods.

Fukuba E. and his coworkers [15] compared the effectiveness of power Doppler ultrasonography (PDUS) with that of dynamic magnetic resonance imaging (MRI) for detecting active synovitis in the hands of rheumatoid arthritis (RA) patient, they studied 220 joints in ten patients, the relative synovial enhancement ratio map of dynamic MRI was compared to a semiquantitative score of PDUS, A significant correlation was observed between the detection of synovial blood flow signals on PDUS and detection of early synovial enhancement by dynamic MRI (correlation coefficient $p=0.001$).

Terslev L. and his coworkers, [16] compared the quantitative and qualitative information obtained by Doppler ultrasound of the wrist joints and the small joints of the hand with the information obtained by post contrast MRI in patients with RA, they studied 29 patients, 196 joints (29 wrist and 167 finger joints), the joints of the hand were examined by color Doppler ultrasound, a joint was considered inflamed if any color pixels are seen the image with maximum color activity was select-
ed for analysis, calculation of the RI (resistivity index) was determined in three arteries when possible within synovial membrane and the mean value was used as estimate of synovial inflammation, post contrast axial and coronal MRI images of the wrist and hand joints were obtained and evaluated for synovial enhancement and degree of synovitis graded on a scale of 0-3.

Terslev L. and his coworkers, [16] 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%).

As regards tendon affection, in this study ultrasound detected tendinitis in 9/200 fingers (4.5 %) and MRI detected tendinitis in 8/200 fingers (4%), significant correlation between both modalities was noted (p<0.001) and these results agreed with Backhaus and his coworkers, [17] who examined 840 finger joints comparing 4 methods, conventional radiography (CR), 3 phase bone scintigraphy, US and MRI with pre-contrast and dynamic post-contrast examination, they had found tenosynovitis of extensor tendons in 7/140 fingers (5%) by US and in 9/140 fingers (6%) by MRI with significant correlation between tenosynovitis of extensor tendon sheath detected by US and that detected by MRI (p-value <0.001).

PDUS is easy to perform, requires relatively cheap equipment, and is also less invasive than dynamic MRI, with no need for injection of contrast material. As a more accessible, cheaper, and more patient-friendly method than MRI, US (including PDUS) may become a routine bedside tool in the future.

In conclusion, the present study revealed correspondence between the results of PDUS and the findings of enhanced MRI, which have been shown to closely reflect synovial membrane inflammation in the overall-grade RA joints. PDUS might have comparable potential to enhanced MRI for assessing synovitis in RA patients.

References


المعيار العربي

دراسة مقارنة بين الرنين المغناطيسي بالصبغة ودوبو رطبة لتقدير التهاب السبائك بمقاس الالتباس في مرضى الروماتويد المفصلي.

يعتبر مرض الروماتويد المفصلي من الأمراض المزمنة التي قد تؤدي إلى تشوهات دائمة بالعظام مما يتبعه من تأثير سلبي على حياة المريض. ومع تقدم العلاج الطبي كان من الضروري التشخيص المبكر للمريض باستخدام تقنيات حديثة مثل الرنين المغناطيسي والموجات فوق الصوتية. وهذه الدراسة تقدم مقارنة بين هاتين الوسائلتين في تشخيص وتحديد درجة التهاب السبائك بمقاس الالتباس في مرضى الروماتويد المفصلي والذي يعتبر أحد العلامات المبكرة للمريض، وقد أجريت هذه الدراسة على جسم مريض بمرض الروماتويد المفصلي وتشخيص كلا من الرنين المغناطيسي بالصبغة ودوبو رطبة لمسايرة على تشخيص وتحديد درجة التهاب السبائك بمقاس الالتباس في مرضى الروماتويد المفصلي.