# Ultrasound *versus* low-field magnetic resonance imaging in rheumatic diseases: a systematic literature review

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*Received on October 18, 2013; accepted in revised form on November 26, 2013.*

*Clin Exp Rheumatol 2014; 32 (Suppl. 80): S91-S98.*



**Key words:** dedicated MRI, ultrasonography, arthritis, osteoarthritis, imaging

*Competing interests: none declared.*

**ABSTRACT**

**Objective.** *US and MRI play a significant role in the diagnosis of rheumatic diseases and in monitoring treatment response. This systematic review summarises and evaluates available evidence on the value of low-field MRI compared to US in rheumatic diseases.*

**Methods.** *A computerised literature search was conducted by a single reviewer to identify relevant published articles on the diagnostic accuracy of low-field MRI compared to US in rheumatic diseases. The literature search comprised the period from January 1998 to September 2013.*

**Results.** *The search yielded a total of 1055 articles that were reviewed by title or abstract; finally, 23 articles fulfilling all inclusion criteria were included in the analysis. Our results show that low-field MRI is probably more sensitive than US in the detection of erosions, due to its higher multiplanar capacity. In OA there was a good correlation between US and MRI measurements for cartilage thickness and for effusion in the superior and in the lateral recesses.*

**Conclusion.** *There are still few studies comparing US and low-field MRI for their diagnostic and prognostic value in rheumatology and it is currently difficult to draw any firm conclusions on the preferred imaging technique to answer specific clinical questions.*

## Introduction

Many exciting advances have been made over the last decade within the field of imaging in rheumatic diseases. Although radiographs continue to be the most widely used tool, magnetic resonance imaging (MRI) and ultrasonography (US) offer advantages through more sensitive depiction of inflammatory and destructive changes (1). In addition, MRI and US allow disease diagnosis in its early stage, with the important advantage of initiating appropriate therapy and tightly controlling the course of the disease. The concept of low-field dedicated MRI (D-MRI) and US in rheumatology is more similar than usually thought. Both devices can be used mainly for peripheral joints, evaluating synovitis and, at least in part, structural damage. They can be used as an adjunct to diagnosis and follow-up, in some instances as continuation of the clinical examination. D-MRI equipment is far cheaper than high-field MRI in terms of acquisition and maintenance, and patients can stay in a more comfortable position during image generation. This fact implies a higher compliance with the possibility of performing follow-up studies with multiple examinations. Dedicated MRI of hands and feet has been shown to perform comparably well as high-field MRI in terms of sensitivity and specificity to detect synovitis and bone erosions in rheumatoid arthritis (RA) (2, 3). However, low-field MRI is less sensitive than high-field MRI to evaluate bone marrow oedema (2). It also needs a longer time for image acquisition and often has a rather small field of view, which makes impossible to depict the whole hand including wrist and finger joints with one single positioning in the gantry (9). US can also demonstrate synovial proliferation and effusion within joints, tendon sheats and bursae as well as cortical bone changes, but is not as sensitive as MRI in detecting bony erosions in areas where a good acoustic window cannot be obtained (4, 5).

A direct comparison between D-MRI and US has only rarely been performed. This study is concerned with a systematic review of the papers where these techniques were compared in patients with musculoskeletal diseases.

## Methods

A computerised literature search was conducted by a single reviewer to identify relevant published articles on the diagnostic accuracy of low-field MRI

compared to US in rheumatic diseases. Articles were retrieved through an extensive PubMed search using the MeSH terms "arthritis", "osteoarthritis", "rheumatic" in combination with "magnetic resonance" and "US". The literature search comprised the period from January 1998 to September 2013. Only publications in English were considered. Review papers, case reports, editorials, letters and comments were excluded. References from the selected articles were also examined in search of additional studies meeting the inclusion criteria. For the purpose of this study, low-field MRI was defined as MRI obtained with a machine with a magnetic field strength ≤0.6 Tesla.

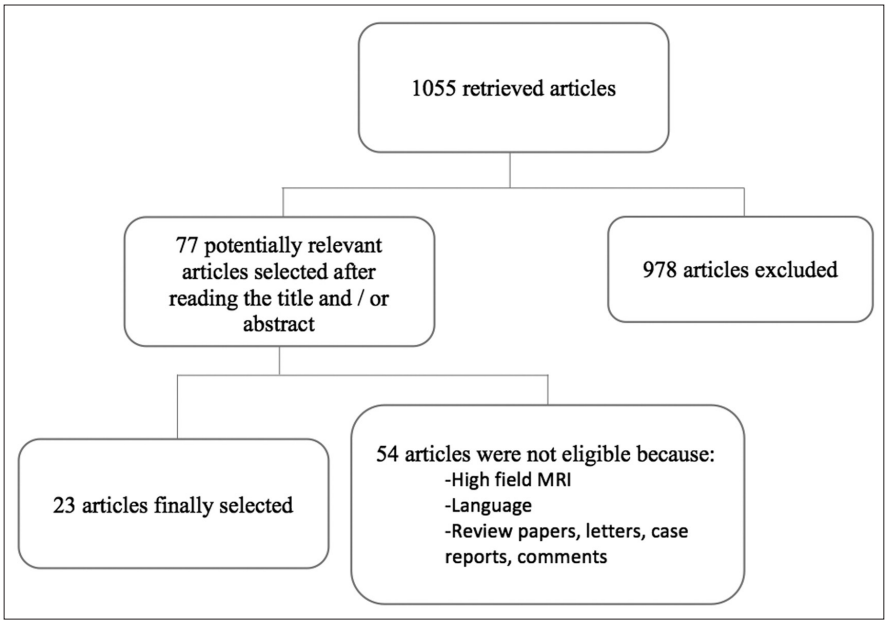


**Fig. 1.** Flowchart of the articles selected for the review.

## Results

*Study characteristics*

The search yielded a total of 1055 articles, which were reviewed by title or abstract; of these, 77 were found eligible and retrieved as full-text articles for complete analysis (Fig. 1). Finally, 23 articles fulfilling all inclusion criteria were included in the analysis. Table I summarises some of the characteristics of the results of the study**.** Details of MRI, including type of device and use of intravenous contrast agents, and US, including type of device, transducer and use of Doppler, were recorded and compared. Clinical data included in the table were number of patients, type of rheumatic conditions, target lesions and joints evaluated. The 23 selected studies were strikingly different as far as design and rheumatic condition are concerned; as a result, a formal meta-analysis was not attempted.

*Erosions*

Eight studies, including a total of 241 patients and 9 controls, compared the accuracy of US and dedicated MRI in the detection of erosions. Backhaus *et al*. compared conventional radiography, bone scintigraphy, US and MRI with precontrast and dynamic postcontrast examinations in 60 patients (840 finger joints) with various forms of arthritis. The authors showed that US is suboptimal for the detection of erosions compared to MRI. In fact, US identified erosions in 33 patients (66 joints), while 3D MRI with slice thickness of 1 mm detected erosions, especially in MCP joints, in 53 patients (261 joints). Erosions with enhancement were evident in 10 patients (35 joints), while erosions without enhancement were found in 51 patients (220 joints) (6). All 60 patients received DMARDs after completion of this initial diagnostic investigation. Forty-nine/60 patients underwent a follow-up assessment two years later with an increased number of erosions seen with both methods. This is an expected result because erosive lesions tend to increase in size over time and thus become detectable for both modalities. The efficacy of DMARDs treatment on synovitis was demonstrated by the fact that erosions with enhancement decreased in number whereas those without were significantly increased two years later (7).

These findings were not confirmed by a seven-year follow-up study of RA patients by Scheel *et al*. In this study, 12 (9%) of 128 eroded joints were detected by US at baseline with a subsequent increase to 62 (49%) at follow-up examination. A possible reason for the small number of erosions detected by US at baseline is the suboptimal quality of the US devices, which had a low resolution and needed an acoustic standoff pad. In addition, neither the ulnar nor the radial aspects of the joints were evaluated by US. A high number of erosions were already detected at baseline by MRI, explaining the lack of significant further progression at follow-up (8).

In a recent study by Schmidt *et al*., 26 patients with mild or moderate RA were examined clinically, by US and by gadolinium-enhanced low-field MRI at baseline, and after 6 and 12 months. US and MRI were significantly more sensitive than conventional radiography to detect patients with erosive disease. However, when comparing all 78 examinations, significantly more MRI than US examinations detected erosive disease. The number of patients with erosive disease found by MRI or US increased slightly, but not significantly, over time (9).

Wiell *et al*. evaluated the sensitivity and specificity of US in the detection of erosions, with MRI as the reference standard method (10). US exhibited a sensitivity of 56% for the MCP joints, 57% for the PIP joints, 0% for the DIP joints with a specificity of 93%, 88% and 99%, respectively. US and MRI showed high concordance (85% to 100%) for erosive changes.

In a series of 50 patients studied by Broll *et al*., US showed a sensitivity and specificity for bone erosions of 38% and 100%, with conventional radiography as the reference method.

With low-field MRI, sensitivity and specificity were 58% and 83%, respectively (11). The detection of erosions by US was also highly specific, but lacked sufficient sensitivity. The low sensitivity for erosions in this study may be due to their low incidence in early arthritis patients.

Møller Døhn *et al*., with multidetector CT as the reference method, evaluated whether bone erosions in RA MCP joints detected with MRI and US represent true erosive changes (12). In this analysis MRI exhibited a sensitivity, specificity and accuracy of 65%, 96%, 90%, respectively. For US the corresponding figures were 30%, 92%, and 80%. Both techniques showed high specificity in detecting bone erosions, even in radiographically non-eroded joints. The moderate sensitivity indicates that more erosions than those detected using MRI and US were present. The same authors combined MRI and US in a follow-up study of 52 TNF antagonist-treated patients at 6 and 12 months. The proportion of patients with regression, progression or no change of erosion scores/volumes at 12 months on radiography and CT was 0.06, 0.82 and 0.12 for MRI, and 0.27, 0.48 and 0.24 for US (13).

*Synovitis*

Fourteen articles, for a total of 503 patients and 15 controls, compared US and low-field MRI in the evaluation of synovitis.

In the study by Backhaus *et al*., synovitis was detected by US in all 60 RA patients (438 finger joints) whereas MRI enhancement was present in 54 patients (381 finger joints). At follow-up, synovitis was significantly reduced in all patients with both techniques (6, 7).

A similar significant reduction in synovitis was seen in another study by both US and MRI (8). The number of joints with US synovitis decreased after 7 years from 106 to 66. The corresponding figures for MRI were 80 and 53 joints.

In the study by Schmidt *et al*., both US and MRI had a comparable sensitivity when examining synovitis (9). US detected synovitis in 22 patients at baseline, in 21 patients after 6 months and in 21 patients after 12 months, while the corresponding figures for MRI were 26, 22 and 18. PD-US signals were present in 14 patients at baseline, in 14 patients after 6 months and in 10 patients after one year.

In the study by Wiell *et al*., US showed a sensitivity for synovitis, with MR as the reference standard method, of 70% on MCP joints, 50% on PIP joints and 40% on DIP joints with a specificity of 88%, 88% and 87%, respectively (10).

In the 50 patients studied by Broll *et al*., US showed a sensitivity of 94% and a specificity of 50% in the detection of synovitis, while PD-US showed a sensitivity of 72% and a specificity of 94% (11). The values of sensitivity and specificity of low-field MRI in the detection of synovial thickening were respectively 76% and 75% with contrast enhancement and 80% and 20% without use of contrast agent.

Horikoshi *et al*. compared MRI and US in the detection of joint inflammation in 6 RA patients. Joint inflammation was detected in 74/156 joints by GS-US, 10/156 joints by PD-US, and 38/132 joints by MRI. Using PD-US as a reference, sensitivity of MRI in detection of synovitis was 80%. Using MRI as a reference, sensitivity of PD-US was 21%. Specificity of PD-US was higher than that of MRI. Overall agreements between GS-US and MRI and between PD-US and MRI were 0.56 and 0.76, respectively. Using MRI as a reference, sensitivity and specificity of GS-US were 0.71 and 0.5 and those of PD-US were 0.21 and 0.98, respectively (17).

In a recent study, Foltz *et al*. demonstrated that in a sample of 85 RA patients with low level of disease activity who were followed up prospectively over a period of one year, the baseline PD synovitis count (the number of joints at baseline for which the power Doppler signal indicated synovitis) predicted relapse incidence and the baseline PD synovitis grade predicted disease progression, while MRI was not predictive of these outcomes (16). This finding was explained by the high sensitivity of MRI, which may identify non-pathogenic synovitis.

Of the 1540 hand joints examined by Ogishima *et al*., 294 (19.1%) were diagnosed with clinical synovitis, 218 joints (14.1%) with subclinical synovitis, and the remaining 1,028 joints (66.8%) were synovitis-free on clinical examination and imaging. For the diagnosis of subclinical synovitis, MRI was significantly more sensitive than PD-US and the combination of PD-US and MRI was more useful than PD-US or MRI alone. Follow-up radiographic examination of 30 patients demonstrated that joints with subclinical synovitis detected by MRI or PD-US are more likely to show bone erosions (18). The discrepancy between the results of Foltz's and Ogishima's studies may be due to the different magnetic field strengths of the MRI machines and the use of contrast medium agent only in Foltz's study.

Boesen *et al*. studied the MRI and US changes in the wrist of 25 RA patients 4 weeks after an US guided intrarticular injection of etanercept or methylprednisolone (14). Both the global MRI synovitis score and PD-US (calculated as colour fraction) did not significantly differ at the 4-week follow-up.

Also in a study by Fiocco *et al*., 27 patients with resistant knee synovitis due to seronegative spondyloarthritis underwent four bi-weekly IA injections of etarnecept (19). At the study end, clinical and imaging outcomes were significantly reduced compared to baseline. There were significant correlations between clinical and biological markers and the synovial thickness measures by MRI and US.

Ohrndorf *et al*. evaluated wrist and finger joints in 15 RA patients by grey-scale, PD and contrast-enhanced ultrasonography (CE-US) and compared these findings with MRI (20). US was performed at baseline and after three, six and twelve months, before and after a change of medical treatment. MRI was carried out at baseline and 12 months and used as reference method. CE-US and MRI were significantly correlated, more than CE-US and grey-scale US.

In 2006 Scheel *et al*. evaluated a new US score suitable for evaluation of PIP and DIP joint synovitis in RA patients, using MRI as gold standard (15). The detection of synovitis by US in the palmar and dorsal sides showed a good concordance with MRI, with an AUC of 0.85 for MCP joints and 0.96 for PIP joints.

**Table I.** Technical and clinical characteristics of the examined studies (RA: rheumatoid arthritis; PsA: psoriatic arthritis; SpA: spondylo-arthropathy; OA: osteoarthritis; US: ultrasonography; PD: power Doppler; CE-US: contrast-enhanced ultrasonography; MR: magnetic resonance; MCP: metacarpophalangeal joint; PIP: proximal interphalangeal joint; DIP distal interphalangeal joint; MTP: metatarsophalangeal joints).

| Author | Disease | Patients/ controls (n) | Target lesion | Studied joint or tendon | US device | Array, MHz | PD | CE-US | MR device | Field | Sequences | MR contrast | Reference/ other imaging methods |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Backhaus *et al.*, 1999 | RA, PsA, SpA, arthritis associated with connective tissue disease | 60 | synovitis, erosions tenosynovitis | MCP, PIP, DIP | Ultramark 4, ATL, Bothell, WA, USA | 7.5 MHz linear array transducer | No | No | Magnetom Open, Siemens, Erlangen, Germany | 0,2 T | T1 3D fast low-angle shoot (FLASH) | gadodiamide 0.3 mmol/kg | conventional radiography, scintigraphy |
| Backhaus *et al.*, 2002 | RA, PsA, SpA, arthritis associated with connective tissue disease | 49 | synovitis, erosions, tenosynovitis | MCP, PIP, DIP | Ultramark 4, ATL, Bothell, WA, USA | 7.5 MHz linear array transducer | No | No | Magnetom Open, Siemens, Erlangen, Germany | 0,2 T | T1 3D fast low-angle shoot (FLASH) | gadodiamide 0.3 mmol/kg | conventional radiography, scintigraphy |
| Scheel *et al.*, 2005 | RA | 46/10. MRI performed on 10 patients | novel US synovitis scoring system in finger joints. | MCP 2-5, PIP 2-5 | HDI 3500, ATL, Bothell, WA, USA | 5–10 MHz hockeystick linear array transducer | No | No | C-Scan, Esaote SpA, Genova, Italy | 0,2 T | T1, STIR GE, T1 3D GE | gadolinium DTPA 0.2 mmol/kg | No |
| Scheel *et al.*, 2006 | RA | 16 | synovitis, erosions | MCP 2-5, PIP 2-5 | Ultramark 4, ATL, Bothell, WA, USA / HDI 3500, ATL, Bothell, WA, USA | 7.5 MHz linear array transducer / 10-5 MHz hockeystick linear array transducer | No | No | Magnetom Open, Siemens, Erlangen, Germany / C-Scan, Esaote SpA, Genova, Italy | 0,2 T / 0,2 T | T1 3D GE | gadodiamide 0.3 mmol/kg gadolinium DTPA 0.2 mmol/kg | conventional radiography |
| Møller Døhn *et al.*, 2006 | RA | 17/4 | erosions | MCP 2-5 | Philips 500-HDI, Philips Medical Systems, Bothell, WA, USA | 7–15 MHz hockeystick linear array transducer | No | No | Philips Panorama, Philips Medical Systems, Helsinki, Finland | 0,6 T | T1 3D fast field echo | No | computer tomography, conventional radiography |
| Wiell *et al.*, 2007 | RA, PsA | 20/5 | synovitis, erosions, tenosynovitis | MCP 2-5, PIP 2-5, DIP 2-5, MTP 1-5 | LOGIQ9, General Electric Medical Systems, Little Chalfont, Bucks, UK | 9–14 MHz linear array trasducer | Yes | No | Philips Panorama Philips Medical Systems; Helsinki, Finland | 0,6 T | T1 3D fast field echo, STIR, T1 fat sat | gadodiamide 0.1 mmol/kg | conventional radiography |
| Boesen *et al.*, 2008 | RA | 25 | synovitis | wrist | Sequoia, Becton Dickinson, Mountain View, CA, USA | 8–13 MHz linear array transducer | Yes | No | E-scan, Esaote SpA, Genova, Italy | 0,2 T | T1, Turbo 3D T1 GE | gadolinium-DTPA 0.2 mmol/kg | No |
| Horikoshi *et al.*, 2010 | RA | 6 | synovitis | wrist, MCP 1-5, PIP 2-5; PIP 1, DIP 1 only by US | Aplio SSA-700A, Toshiba Medical Systems Corporation, Tokyo, Japan | 12 MHz linear array transducer 12 MHz hockeystick array transducer | Yes | No | CompacTscan, Cross Tech Corporation, Tokyo, Japan | 0,3 T | T1 3D, STIR | No | No |
| Møller Døhn *et al.*, 2010 | RA | 52 | erosions | wrist, MCP 2-5 by MRI; MCP 1-5 only by US | LOGIQ9, General Electric Medical Systems, Little Chalfont, Bucks, UK | 14–9 MHz linear array transducer | No | No | Philips Panorama Philips Medical Systems, Helsinki, Finland | 0,6 T | T1 3D fast field echo, T1 3D fast-field echo fat sat, STIR | No | computed tomography, conventional radiography |
| Boesen *et al.*, 2010 | RA | 50 | synovitis | wrist | Acuson Sequoia, Siemens, Mountainview, CA, USA | 14 MHz linear array transducer | Yes | No | E-scan, Esaote SpA, Genova, Italy | 0,2 T | STIR, turbo 3D T1 GE | gadolinium DTPA 0.1 mmol/kg | No |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ohrndorf *et al.*, 2011 | RA | 15. MRI performed on 9 patients | synovitis | wrist, MCP 2-5, PIP 2-5 | Technos MPX, Esaote SpA, Genova, Italy | 7–15 MHz linear array transducer / for CE-US 4–8 MHz linear array transducer | Yes | Yes | Unspecified machine, Esaote SpA, Genova, Italy | 0,2 T | T1 3D GE | gadopentetate 0.2 mmol/kg | conventional radiography |
| Broll *et al.*, 2012 | suspected arthritis | 50 | synovitis, erosions | wrist, MCP | MyLab 70, Esaote SpA, Genova, Italy | 6–18 MHz linear array trasducer | Yes | No | C-Scan, Esaote SpA, Genova, Italy | 0,2 T | Not specified | gadolinium DTPA on 29 patients, not specified mmol/kg | conventional radiography |
| Foltz *et al.*, 2012 | RA | 85 | synovitis | wrist, MCP 2,3,5, MTP 2,3,5 | Technos MPX, Esaote SpA, Genova, Italy | 7.5–13 MHz linear array transducer | Yes | No | C-Scan, Esaote SpA, Genova, Italy | 0,2 T | T1 3D, STIR | Yes | conventional radiography |
| Fiocco *et al.*, 2012 | SpA | 27 | synovitis | knee | Elegra, Siemens, Erlangen, Germany | 10 MHz linear trasducer | No | No | C-Scan, Esaote, Genova, Italy | 0,2 T | T1, T1 GE, STIR, | Yes | No |
| Schmidt *et al.*, 2013 | RA | 26 | synovitis, erosions, tenosynovitis | MCP 2–5, MTP 1–5; MCP 2,5, MTP 5 only by US | Technos MPX, Esaote SpA, Genova, Italy | 5–13 MHz linear array trasducer | Yes | No | C-Scan, Esaote SpA, Genova, Italy | 0,2 T | T1 turbo spin echo, STIR, T1 3D, T1 3D GE | gadolinium 0.2 mmol/kg | conventional radiography |
| Ogishima *et al.*, 2013 | RA | 77 | synovitis | wrist, hand | Aplio XG, Toshiba Medical Systems Corporation, Ohtawara, Japan | 7–14 MHz linear array transducer | Yes | No | CompacTscan, Cross Tech Corporation, Tokyo, Japan | 0,3 T | STIR, other sequences not specified | No | conventional radiography |
| Kamel *et al.*, 2003 | SpA | 32 | enthesitis | Achilles tendons and plantar aponeurosis | HDI 3000, ATL, Camden, NJ, USA | 12 MHz linear array transducer | No | No | Toshiba Flexart, Toshiba, Tokyo, Japan | 0,5 T | T1, T2, STIR | No | No |
| Boesen *et al.*, 2006 | Achilles tendinopaty | 3 | tendinopathy | Achilles tendons | Acuson Sequoia, Mountainview, CA, USA | 14 MHz linear array trasducer | Yes | No | E-scan, Esaote SpA, Genova, Italy | 0,2 T | GE STIR, T1, TME | No | No |
| Wiell *et al.*, 2012 | SpA and non-SpA | 35/10 | enthesitis | Achilles tendons and entheses | LOGIQ9, General Electric Medical Systems, Little Chalfont, Bucks, UK | 9–14 MHz linear array transducer | Yes | No | Philips Panorama Philips Medical Systems; Helsinki, Finland | 0,6 T | T1 3D GE, STIR, T1 fat sat | gadolinium DTPA 0.1 mmol/kg | No |
| Tarhan *et al.*, 2002 | OA | 58/16 . MRI performed on 54/13 | synovitis, effusion, cartilage abnormalities | knee | Image Point, Hewlett Packard California, USA | 5–10 MHz linear array transducer | No | No | Gyroscan Panorama, Philips Medical Systems, Helsinki, Finland | 0,2 T | T2, fast spin echo proton density | No | conventional radiography |
| Song *et al.*, 2008 | OA | 46. MRI performed on 36 patients | synovitis, effusion | knee | Technos MPX, Esaote SpA, Genova, Italy | 12.5 MHz linear array transducer / for CE-US 3–8 MHz linear array transducer | Yes | Yes | C-Scan, Esaote SpA, Genova, Italy | 0,2 T | T1, T2, T2 multi-echo, T1 3D GRE | gadolinium DTPA 0.2 mmol/kg | No |
| Song *et al.*, 2009 | OA | 41. MRI performed on 36 patients | synovitis. | knee | Technos MPX, Esaote SpA, Genova, Italy | 12.5 MHz linear array transducer / for CE-US 3–8 MHz linear array transducer | Yes | Yes | C-Scan, Esaote SpA, Genova, Italy | 0,2 T | T1, STIR, T2, T2 multi-echo, T1 3D GRE | gadolinium DTPA 0.2 mmol/kg | No |
| Iagnocco *et al.*, 2011 | RA, OA | 9 | Fusion imaging | wrist, MCP, PIP, DIP. Foot in RA patients | MyLab 70, Esaote SpA, Genova, Italy | 18 MHz linear array trasducer | No | No | C-Scan, Esaote SpA, Genova, Italy | 0,2 T | Turbo 3D T1, T1,T2, STIR | No | conventional radiography |

In a more recent study, Boesen *et al*. compared low-field MRI with US Doppler measurements in the wrist joint of patients with RA (21). The authors found a good correlation between US-colour fraction and MRI bone marrow oedema RAMRIS score but only a moderate correlation between US-CF and total MRI synovitis score. Both imaging modalities detect inflammation, although probably showing different aspects of the inflammatory process.
The correlation between US colour Doppler signals and MRI bone marrow oedema was also shown by Schmidt *et al*. (9).

*Tenosynovitis*
Four studies including a total of 111 patients compared the accuracy of US and dedicated MRI in the detection of tenosynovitis.
Backhaus *et al*. found MRI to be more sensitive than US in the detection of tenosynovitis. In their study tenosynovitis of at least one flexor tendon sheath was seen in 66 fingers by US and in 103 fingers by MRI. Extensor tendon tendonitis was detected in 15 fingers by US and in 33 fingers by MRI (6). At the two-year follow-up, tenosynovitis of the flexor tendon sheaths and tendonitis of the extensor tendon were decreased significantly in all patients by MRI, while US tendonitis was significantly increased (7). On the contrary, an increased sensitivity of US compared to MRI for the detection of tenosynovitis was seen by Schimdt *et al*. (9). US detected tenosynovitis in 12 patients at baseline, in 10 after 6 months and in 8 patients after 12 months, while the corresponding figures for MRI were 9, 4 and 2 patients.
In the study by Wiell *et al*., MRI was the reference standard method to calculate the sensitivity and specificity of US in the evaluation of tenosynovitis (10). Sensitivity was of 38% at the MCP joint level, 100% at PIP joints and 67% at DIP joints; specificity was 99%, 86% and 98%, respectively.

*Enthesopathy and tendinopathy*
Three articles for a total of 70 patients and 10 controls, analysed US and low-field MRI in the evaluation of enthesopathy and tendinopathy. Kamel *et al*. compared the diagnostic efficacy of US and MRI in subjects with seronegative spondyloarthropathies and heel enthesopathy without typical radiographic evidence (22). MRI was less sensitive than US in detecting the early changes of enthesopathy. Fatty degeneration of the affected tendon appeared late in MRI, while it was detected earlier using US. MRI was not able to detect any calcification at the insertion site, while US images clearly showed them. US showed loss of normal fibrillar echotexture of the tendon in all patients, lack of its homogeneous pattern with blurring of the tendon margins in 56.2%, and irregular fusiform thickening in 79.4%. MRI showed intermediate T1 signals, associated with irreversible fatty infiltration, in all patients, tendon enlargement in 62.5%, and loss of the normal flattened hypointense appearance, focal thickening and rounded configuration at the insertion site in 31.2%.
Wiell *et al*. described US and MRI findings at painful Achilles tendons and entheses in patients with and without spondyloarthropathy and in healthy controls (23). A total of 74 Achilles tendons and entheses were examined by grey-scale and PD-US, and 37 were also examined by MRI. US and MRI detected a similar frequence of inflammatory changes, but MRI discovered slightly more intratendinous changes (tendon enlargement, oedema and peritendonitis) than US. In contrast, US but not MRI detected calcifications and enthesophytes, while erosions were found with the same frequency by the two imaging modalities.
In order to demonstrate the intratendinous distribution of injected glucocorticoid, Boesen *et al*. examined three patients with Achilles tendonitis by MRI and US (24). Injections were placed in the pathologic areas of the tendon guided by US. MRI and US were performed before and 60 minutes after injection and a final, follow-up MRI was performed one month later. On colour Doppler, all patients initially had intratendinous hyperaemia, while no peritendinous hyperaemia was found. Prior to the injection, the median colour fraction was 20% and decreased to 0.5% at follow-up one month later. In all three cases, the tendons on grey-scale US were spindle-shaped with a heterogeneous internal echo pattern. These US grey-scale findings did not change during follow-up, although the clinical condition improved and the hyperaemia disappeared. Using MRI, all patients showed pathological high signal changes in the thickened area of the tendon on the STIR and TME sequences while none had bone marrow oedema. The injected substance was visualised with MRI intratendinously, both inside and proximal to the pathological area in all patients on the TME sequences, and the signal due to the injected steroid persisted on the follow- up scan approximately 60 minutes post-injection. One-month follow-up showed a total regression of pathological high signal on both the STIR and the TME sequences in all patients.

*Osteoarthritis*
Three articles, for a total of 145 patients and 16 controls, analysed US and low-field MRI for imaging osteoarthritis (OA). Tarhan *et al*. evaluated 58 patients with symptomatic knee OA and 16 controls (25). The knee joint was evaluated for femoral condylar cartilage changes, effusion, synovial thickening and popliteal cysts. Cartilage abnormalities were found by US examination in all patients and by MRI in 97% of them. The majority of OA knees had effusion (70% by US and 85% by MRI); synovial thickening was observed in 34% of patients by US and in 50% by MRI; popliteal cysts were detected in 40% of knees using US and in 35% using MRI. US and MRI measurements of the cartilage thickness were correlated with each other in the controls and the symptomatic knees.
Song *et al*. published two articles in 2008 and in 2009 using CE-US compared to contrast-enhanced MRI in patients with knee OA (26, 27). These authors demonstrated highly vascularised synovitis by CE-US, which was more sensitive than B-mode or PD-US, in comparison with contrast-enhanced MRI. By using the contrast medium agents and time/intensity analysis, pathological findings were observed by US in 95% of knees and by CE-MRI in 82%. Time/intensity analysis by US proved to be a valid method to assess inflammatory

processes in OA of the knee. MRI and US showed a similar efficacy in detecting effusion in the superior or lateral recess irrespective of whether contrast medium was used or not.

The aim of the second study was to evaluate CE-US as a tool to assess and monitor the degree of synovial hypervascularisation after intra-articular treatment with two different doses of icatibant (bradykinin receptor-2 antagonist). At baseline there were no significant differences between the three subgroups treated with placebo, and icatibant 500 mg or 2000 mg in terms of pain at rest and during activity, synovial hypertrophy in the lateral recess, CE-US (slope values), PD-US findings in the superior recess and effusion in the superior and lateral recess on MRI or CE-MRI. At follow-up, there was a good correlation between US and MRI concerning the presence of effusion in the superior recess, effusion in the lateral recess and contrast enhancement.

**Discussion**

US and MRI play a significant role in the diagnosis of rheumatic diseases and in monitoring treatment response (11). This systematic review summarises the available evidence on the value of low-field MRI compared to US in rheumatic diseases. The number of articles dealing with this topic is limited if compared to the number of articles comparing high-field MRI and US. In addition, this review has the limitation that a single observer searched and analysed the papers.

Our results show that low-field MRI is probably more sensitive than US in the detection of erosions, due to its higher multiplanar capacity. This occurs in spite of the fact that MRI cannot evidence bone but only the bone marrow, and eventually the water, within it. US detection of erosions in a bone phantom model is a valid and reliable method when the erosions are at least 1 mm deep and 1.5 mm wide (30, 31). One problem with US is that some parts of the joint may be relatively inaccessible, for example, the radial and ulnar aspects of some MCP joints (32). In addition, there are few sonographic features that enable absolute discrimination between cortical irregularities and erosions. Cortical defects may be present in normal individuals and are commonly seen in the capitate, hamate, and base of the 2$^{nd}$ metacarpal bone; some of them may be due to perforating nutrient vessels or insertion sites of interosseous entheses. Discriminating these normal findings from erosions may be difficult, particularly for the inexperienced sonographer (28).

In the majority of the studies there was a good agreement between US and MRI for the detection of synovitis. PD-US has improved sensitivity for synovial inflammation compared with colour Doppler US and is preferred for this reason. In addition, positive power Doppler signal on US has been shown to correlate well with clinical disease activity within a joint and can be used as a quantitative indication of synovial inflammation (29, 33-36). CE-MRI yields excellent information about synovitis (37). There is no definite answer on which method is more sensitive in evaluating tenosynovitis, whereas US was significantly more sensitive to detect early changes of enthesopathy. This is probably due to its superior anatomical representation of the soft tissues, to the difficulty to perform MRI dynamic examination of the tendons, and to the anatomical composition of the tendons that are virtually devoid of water.

In OA there was a good correlation between US and MRI measurements for cartilage thickness and for effusion in the superior and in the lateral recess. However, the number of articles is modest, probably because D-MRI is not the preferred technique for visualising the cartilage.

US and MRI have advantages and disadvantages that should be considered when deciding which modality to use in a particular patient. US allows the operator to make a clinical assessment of the patient at the time of imaging, and to examine the contralateral side or additional joints. It is more readily available in many centers and is cheaper than MRI. However, D-MRI machines are patient-friendly and not expensive. Among the potential difficulties with US assessment of the joints are the inability to compare temporal changes directly at the time of scanning, non-visualisation of the internal bone structure, inability to assess bone oedema, and inherent operator dependence of the technique. US can also be time consuming and has a long learning curve for the inexperienced operator. MRI has the advantage of providing a more global view of the joint, including the articular surfaces and internal bone structure. The disadvantages of using MRI include motion artifacts, the increased time necessary for the examination, and the potentially invasive administration of a contrast agent. Contraindications to MRI also remain a problem in some patients, and in these cases US and radiography will be required (32).

The dichotomy between MRI and US could be a past issue. A new technique that fuses MRI and US images has been developed. Iagnocco *et al*. investigated the role of a new hybrid imaging modality, integrated in the US equipment and derived from a real-time MRI and US fusion process, in the hand and wrist joints of a small group of rheumatic patients (38). They observed excellent agreement in the fused images'assessment of osteophytes in OA patients and bone erosions in RA patients. This new modality therefore enhances the information provided by the individual techniques, with the potential to improve anatomical and functional correlations. In particular, its major advancement could be the possibility of susbstituting the paramagnetic *i.v.* contrast agent with Power Doppler.

There are still few studies comparing US and low-field MRI for their diagnostic and prognostic value in rheumatology and it is currently difficult to draw any firm conclusions on the preferred imaging technique to answer specific clinical questions. In particular, most of the existing studies have been performed in RA and information on other forms of arthritis, such as psoriatic arthritis or gout, are lacking. In addition, only very few healthy controls were included in the examined papers, making difficult to understand the specificity of the findings. Further comparative studies are needed to understand the relative efficiency of these techniques in a larger spectrum of rheumatic conditions.

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