A Multireader Reliability Study Comparing Conventional High-Field Magnetic Resonance Imaging with Extremity Low-Field MRI in Rheumatoid Arthritis

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ABSTRACT. The use of extremity low-field magnetic resonance imaging (E-MRI) is increasing, but relatively few data exist on its reproducibility and accuracy in comparison with high-field MRI, especially for multiple readers. The aim of this multireader exercise of rheumatoid arthritis wrist and metacarpophalangeal joints was to assess the intermachine (high vs low-field) agreement and to assess the interreader agreement on high and low-field images. Study findings suggested that E-MRI performs similarly to conventional high-field MRI regarding assessment of bone erosions. However, for synovitis and bone edema, considerable intermachine and interreader variability was found. Further studies are needed before recommendations on multireader E-MRI assessment of these pathologies can be given. (J Rheumatol 2007;34:854–6)

Key Indexing Terms:
EXTREMITY MAGNETIC RESONANCE IMAGING HIGH-FIELD MRI EROSIONS
SYNOVITIS BONE EDEMA RELIABILITY

Magnetic resonance imaging (MRI) is recognized as a feasible and reliable method for the assessment of bone erosions, synovitis, and bone edema in patients with rheumatoid arthritis (RA)[1]. Until recently, conventional high-field magnets have been used as assessment tools, but technical advances in MRI hardware have led to the development and increasing utilization of dedicated, low-field extremity MRI (E-MRI) units. E-MRI is an attractive alternative to conventional MRI; the chief advantages of this method over conventional MRI include lower cost, enhanced patient comfort, and reduced imaging time. The main perceived disadvantage of the low-field method is lower signal to noise ratio, which may affect joint scoring. Comparisons with conventional high-field MRI in patients with RA have been reported[2-4], but never in a multireader setting, which would also allow assessment of whether the reproducibility of low-field scores is comparable to that obtained using high-field images.

Our aims were to assess intermachine agreement between high-field and low-field images in patients with RA, and to assess the interreader agreements on high and low-field images.

MATERIALS AND METHODS

MR images of 15 patients with RA from a Danish cross-sectional study[4] were included. The median age and disease duration of the patients were 59 years (range 34–81) and 7 years (range 1–18), respectively. Median clinical and biochemical values for measures of disease activity and functional status at baseline were: number of swollen and tender joints 5 (0–16) and 8 (0–22), respectively, serum C-reactive protein ≤ 8 mg/dl (≤ 8–54), Disease Activity Score 28 score 4.2 (1.8–6.4), and Health Assessment Questionnaire score 0.5 (0–2.375). Eighty-six percent of the patients were IgM rheumatoid factor-positive.

MRI of the wrist and 2nd–5th MCP joints of the dominant hand was performed twice, on 2 subsequent days, on 2 different MRI units: a 1.0 T Siemens Impact high-field MRI unit equipped with a circular polarized transmit-receive coil, and a 0.2 T Artoscan (Esaote Biomedica) low-field dedicat-

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ed extremity MRI unit equipped with a dual phased array coil. On both units, a coronal short-tau inversion recovery sequence and T1-weighted images before and after intravenous contrast injection (1.0 T: coronal and axial spin echo sequence; 0.2 T: 3-D gradient echo sequence, with subsequent reconstructions in coronal and axial planes) were obtained (see Ejbjerg, *et al*[4] for details).

The images were circulated to 3 trained MRI readers (PB, BE, PGC) on CD-ROM. Readers completed scoring of the conventional MR images first, followed by the E-MR images using Merge eFilm™, a commercial imaging software package. All readers were familiar with the scoring system, but no calibration of readers took place prior to scoring. Bone erosions, bone edema, and synovitis were scored using the definitions stipulated in the EULAR-OMERACT MRI atlas[5,6].

Statistical analysis was undertaken using SPSS Version 11. Intraclass correlation coefficients (ICC) were calculated for the intermachine (single-measure ICC) and interreader agreement (single and average-measure ICC). The smallest detectable difference (SDD)[7], an absolute method of evaluating measurement error, based on the method described by Bland and Altman[8], was also calculated. The SDD was expressed as a raw value and as a percentage of the actual maximum score for each intermachine measure.

RESULTS

Assessment of intermachine reliability results suggested excellent agreement for erosion scoring at the MCP joints between high and low-field images for all 3 individual readers (Table 1). For wrist erosion scores, intermachine agreement was excellent for Readers 1 and 2, with Reader 3 exhibiting greater variability. For synovitis, the SDD percentage suggested only moderate agreement for all readers at the wrist (19%–39%). At the MCP joints, intermachine agreement for synovitis was good for Reader 1 but poor for the other 2 readers (Table 1). Bone edema scores at the wrist demonstrated good agreement between the high and low-field images for all readers. At the MCP joints, Reader 1 displayed excellent intermachine agreement, but for Readers 2 and 3, there was poor agreement between high and low-field images for bone edema scores (Table 1).

Interreader agreements for erosion, synovitis, and bone edema at the wrist and MCP joints were comparable for high and low-field images (Table 2). Erosion scoring demonstrated the best agreement between readers and was higher for the MCP joints than for the wrist. Both synovitis and bone edema scores demonstrated considerable variability between readers.

DISCUSSION

The results of our study suggest that for the wrist and MCP joint regions, intermachine reliability is excellent for bone erosion scoring. Additionally, interreader reliability was excellent at MCP joints, and good to very good at the wrist for both the high and low-field images, strengthening the case for the use of low-field images in the assessment of erosive disease in patients with established RA.

For synovitis, there was considerable variation in the intermachine agreement both at the wrist and MCP joints for all readers (with one exception). This highlights 3 important points — First, the appearance of synovitis using low-field images can be quite different from the appearance on high-field images depending upon the sequence utilized. Second, it is possible that within the 24 h period between the high and low-field scans, the level of inflammatory activity within the joint may have altered. Finally, we hypothesize that the experience of the reader in assessing synovitis on low-field images may be important in scoring — in this study only one reader had extensive experience in reading synovitis on low-field images, while the other 2 readers were more experienced with high-field images.

The interreader reliability scores for synovitis were also interesting, in that there was considerable variability between readers for the synovitis scores for both the high and the low-field scans. This suggests that inherently synovitis may be more difficult to score and/or the lack of training/calibration of the readers prior to scoring may also have been an important factor in the synovitis results — leading to the relatively poor interreader agreement and contributing to the variability in intermachine agreement. Using higher field strengths than 1.0 T, e.g., 1.5 T, could potentially also have provided improved "high-field" interreader agreement. The results for bone edema demonstrated a similar pattern to the synovitis scoring results. A previous study has documented that excellent interreader agreements for bone erosions, synovitis, and

Table 1. Intermachine agreement for the MCP and wrist joints. Single measure intraclass correlation coefficients (ICC) and smallest detectable differences (SDD; expressed as a raw value and as a percentage of the actual maximum score for each measure) are presented.

	MCP Joints			Wrist Joints		
	Bone Erosion	Synovitis	Bone Edema	Bone Erosion	Synovitis	Bone Edema
Reader 1						
ICC	0.99	0.96	0.94	0.94	0.68	0.73
SDD	1.9, 7%	1.2, 10%	1.4, 11%	3.2, 6%	3.6, 39%	3.2, 12%
Reader 2						
ICC	0.97	0.72	0.05	0.83	0.85	0.78
SDD	2.2, 8%	4.1, 34%	4.8, 40%	4.6, 9%	2.3, 25%	5.3, 19%
Reader 3						
ICC	0.95	0.40	0.59	0.76	0.92	0.86
SDD	2.8, 10%	7.2, 60%	5.6, 46%	9.1, 18%	1.8, 19%	3.3, 12%

Table 2. Interreader reliability for the MCP and wrist joints. Single and average-measure intraclass correlation coefficients (ICC) are presented.

	MCP Joints		Wrist Joints	
	Conventional High-field	Extremity Low-field	Conventional High-field	Extremity Low-field
Bone erosion				
Single-measure ICC	0.91	0.87	0.52	0.42
Average-measure ICC	0.97	0.95	0.77	0.68
Synovitis				
Single-measure ICC	0.39	-0.27	0.73	0.39
Average-measure ICC	0.66	0.53	0.89	0.66
Bone edema				
Single-measure ICC	0.66	-0.32	0.73	0.59
Average-measure ICC	0.85	0.58	0.89	0.81

bone edema can be achieved on high-field MRI after pre-exercise reader training and calibration is performed[9].

In conclusion, high intermachine and interreader agreements suggested that extremity low-field MRI performs similarly to conventional high-field MRI regarding assessment of bone erosions. For synovitis and bone edema, considerable intermachine and interreader variability was found. Consequently, further studies are needed before recommendations on multireader E-MRI assessment of these pathologies can be given. In such studies, pre-exercise training and calibration of readers is suggested.

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