Using Extremity Magnetic Resonance Imaging to Assess and Monitor Early Rheumatoid Arthritis: the Optimal Joint Combination to Be Scanned in Clinical Practice

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ABSTRACT. ***Objective.*** To identify the optimal combination for detecting erosions in early rheumatoid arthritis using extremity magnetic resonance imaging (eMRI).

Methods. In 44 patients, eMRI of 1 hand identified 77% who were erosive, 2 hands 89%, and 2 hands and feet 91%.

Results. eMRI identified 4 times as many erosions as radiography. At 6 months, eMRI of 1 hand identified an increase in erosions in 50% subjects, 2 hands in 55%, and 2 hands and feet in 55%. When only subjects with a change in erosion score above the smallest detectable difference were considered, these numbers were 30%, 25%, and 20%, respectively.

Conclusion. eMRI provides superior erosion identification compared to radiography. Imaging 2 hands can be used as a screening tool and 1 hand to monitor erosions over time. (First Release Mar 1 2008; J Rheumatol 2008;35:580–3)

Key Indexing Terms:
EXTREMITY MAGNETIC RESONANCE IMAGING — RHEUMATOID ARTHRITIS
EROSION — RADIOGRAPHY

Conventional radiography has been utilized as the gold standard for assessing joint damage in rheumatoid arthritis (RA)[1,2]. However, conventional radiography is relatively insensitive to erosion detection in early RA, whereas magnetic resonance imaging (MRI) allows identification of erosions prior to detectable changes on conventional radiography[3,4].

Extremity MRI (eMRI)[5], with the advantages of affordability and increased patient comfort, has recently become available and cross-sectional work has shown superiority of eMRI over conventional radiography with respect to detecting bone damage in established RA[6,7], but there is a paucity of data in longitudinal, early RA cohorts[8,9].

There is currently only 1 study, using the C-scan[8], following erosion progression in an established RA cohort over 1 year, that addresses how many joints should be imaged to maximize the advantages of eMRI. These results, however, are not readily applicable to the MV1000 device because of its reduced field of view (FOV) compared to the C-scan.

Our aim was to assess the following combinations for erosion detection using eMRI in patients with early RA: 1 hand [unilateral right (R) metacarpophalangeal (MCP) joints 2–3 and wrist], 2 hands (bilateral MCP 2–3 and wrists), and 2 hands and feet (bilateral MCP 2–3, wrists, and metatarsophalangeal (MTP) joints 2–5).

MATERIALS AND METHODS

Forty-four consecutive early arthritis clinic patients with RA (modified American College of Rheumatology criteria[10]) and less than 2 years' disease duration agreed to participate in the study. eMRI using a 0.2-Tesla machine (MagneVu, Carlsbad, CA, USA) was performed on all 44 patients at baseline and the first 20 patients had repeat eMRI at 6 months. Three-dimensional T1-weighted spin-echo images were obtained [TR/TE, 100/27 ms; FOV 50 × 75 mm × 15 mm; 2 excitations; 0.625 mm individual slice thickness (Z plane), 1 mm coronal (X and Y in-plane) resolution]. The FOV can include only 2 MCP or MTP joints or 1 carpus and therefore multiple acquisitions were required. Acquisition time for 1 area was about 15 min and for all imaged joints 2 h. Hand and feet radiographs were performed only at baseline and scored for the presence/absence of erosions.

The MRI were scored by 2 rheumatologists (EO, DY) for the number of erosions (each erosion scored as 1) at 4 MCP and MTP quadrant sites (MCP 2–3 and MTP 2–5 joints, proximal and distal radial/ulnar aspects) and standard wrist bone sites (excluding pisiform and metacarpal bases that

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were not visualized), with a consensus reached for each subject. The images were read in known time sequence; that is, the readers were blinded to patients' details, but not to baseline results when scoring and rescoring followup images. The number of patients who had had an increase in their erosion score ("progressors") was calculated. The 6-month followup eMRI were rescored in order to calculate the smallest detectable differences (SDD) for each joint combination (using the Bland-Altman 95% limits of agreement method[11]) and then the number of progressors with an erosion score change greater than the SDD was calculated accordingly. Comparisons of erosion progression between the 3 main joint combinations were performed using appropriate statistical tests (Cochran's Q test, Bonferroni-corrected post hoc Wilcoxon test).

RESULTS

Our study group consisted of 33 women and 11 men with a mean age 52.5 years (range 20–77) and median disease duration 8.5 months (range 1–24) (Tables 1 and 2). Subjects were receiving various treatments, with 95% of patients receiving disease modifying agents and roughly 40% biologic therapy.

At baseline, out of 44 subjects, eMRI of 1 hand identified 34 (77%); 2 hands, 39 (89%); and 2 hands and feet, 40 (91%) subjects who were erosive. eMRI of 1 hand identified 4 times as many subjects who were erosive compared to conventional radiography.

At 6 months, eMRI of 1 hand identified an increase in erosions in 10/20 (50%) subjects, 2 hands in 11 (55%), and 2 hands and feet in 11 (55%) (Table 3). The SDD with the eMRI 1 hand, 2 hands, and 2 hands and feet approaches were 1.59, 2.81, and 3.13, respectively. When only subjects with a change in erosion score above the SDD were considered, eMRI of 1 hand, 2 hands, and 2 hands and feet approaches revealed 6 (30%), 5 (25%), and 4 (20%) subjects with progressive disease, respectively. No subject exhibited a decreased erosion score by any of the imaging methods.

The total number of erosions in all 44 patients was 277 (Tables 1 and 2). In the 20 patients who had a followup study, the total number of erosions at baseline was 124. At followup 36 new erosions were found (Table 1).

There were no significant differences between the number of progressors (subjects) identified by the 3 joint combinations (Cochran's Q test, p = 0.368). There were significant differences, however, between the raw erosion change scores for the 3 joint combinations. Bonferroni-corrected

Table 1. Longitudinal cohort: demographic, eMRI, and radiographic data at baseline and followup.

Patient	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sex	F	F	M	F	M	F	F	F	M	F	F	F	F	M	F	M	F	F	F	F
Age	68	62	67	55	49	43	47	51	72	52	58	73	32	46	20	67	38	27	38	58
Disease duration#	4	8	24	1.5	12	2	5	12	3	5	24	4	2	12	6	3	10	10	12	6
Radiography*	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	1	0	0	0	1
Baseline eMRI, score																				
MCP	1	1	7	4	6	1	2	2	5	0	0	5	5	7	0	8	4	4	8	3
Wrist	0	0	1	0	2	0	0	2	0	1	0	2	0	2	3	4	2	1	4	4
MTP	1	1	5	0	2	0	0	3	3	0	0	1	0	0	1	4	0	1	1	0
Total	2	2	13	4	10	1	2	7	8	1	0	8	5	9	4	16	6	6	13	7
Followup eMRI, score																				
MCP	1	1	7	4	7	5	2	5	5	0	0	5	5	8	2	8	7	6	8	3
Wrist	0	0	1	0	3	4	0	3	0	2	2	3	0	3	5	5	2	2	4	4
MTP	1	1	5	0	3	0	0	4	3	0	0	1	0	0	1	4	1	3	1	0
Total	2	2	13	4	13	9	2	12	8	2	2	9	5	11	8	17	10	11	13	7

Disease duration in months. * 0 = no erosions, 1 = erosions as identified on conventional radiography. eMRI: extremity magnetic resonance imaging; MCP: metacarpophalangeal; MTP: metatarsophalangeal.

Table 2. Study group excluding longitudinal cohort: demographic, eMRI, and radiographic data at baseline only.

Patient	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
Sex	M	F	F	M	F	F	F	F	F	F	F	M	F	F	M	F	F	F	F	F	F	M	M	F
Age	53	35	33	33	35	68	66	57	56	60	62	33	40	34	49	56	62	57	27	28	51	77	66	61
Disease duration#	20	24	24	9	24	24	12	6	2	7	6	2	12	5	13	7	2	2	6	21	6	17	24	3
Radiography*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	1	0
Baseline eMRI, score																								
MCP	2	2	3	12	3	4	9	6	6	2	3	0	0	0	8	0	4	1	8	0	0	4	6	2
Wrists	4	0	1	0	3	6	0	0	0	0	0	3	0	0	1	1	1	0	2	0	2	1	0	6
MTP	3	3	0	1	1	0	0	3	2	2	0	3	0	0	4	2	2	0	3	0	0	0	5	3
Total	9	5	4	13	7	10	9	9	8	4	3	6	0	0	13	3	7	1	13	0	2	5	11	11

Disease duration in months. * 0 — no erosions on CR; 1 — erosions identified on CR. Abbreviations, see Table 1.

Table 3. Numbers of patients with erosions at baseline and 6 month followup.

Imaging Modality	Joint Combinations Imaged	Baseline Patients, n = 44 Erosive Patients No. (%)	Longitudinal Cohort, n = 20 Baseline Erosive Patients, No. (%)	6 mo Progressors, No. (%)	SDD	6 mo Definite Progressors, No. with change > SDD (%)
Radiography	Hands and feet	8 (18.2)	5 (25)	ND	ND	ND
eMRI	R MCP 2–3	31 (70.5)	14 (70.0)	7 (35)	1.32	4 (20)
	L MCP 2–3	30 (68.2)	14 (70.0)	3 (15)	1.4	0 (0)
	R wrist	17 (38.6)	7 (35.0)	7 (35)	0.9	7 (35)
	L wrist	19 (43.2)	11 (55.0)	6 (30)	1.15	1 (5)
	R MCP 2–3 and wrist	34 (77.3)	16 (80.0)	10 (50)	1.59	6 (30)
	L MCP 2–3 and wrist	35 (79.6)	16 (80.0)	7 (35)	1.9	2 (10)
	Bilateral MCP 2–3	35 (79.6)	17 (85.0)	7 (35)	2.28	3 (15)
	Bilateral wrists	24 (54.6)	12 (60.0)	10 (50)	1.72	3 (15)
	Bilateral MCP 2–3 and wrists	39 (88.6)	19 (95.0)	11 (55)	2.81	5 (25)
	Bilateral MTP 2–3	24 (54.6)	8 (40)	2 (10)	0.64	2 (10)
	Bilateral MTP 4–5	25 (56.8)	11 (55)	1 (5)	0.6	1 (5)
	Bilateral MCP 2-3, wrists, MTP 2–3	40 (90.9)	19 (95)	11 (55)	3.15	4 (20)
	Bilateral MCP 2–3, wrists, MTP 4–5	39 (88.6)	19 (95)	11 (55)	2.86	5 (25)
	Bilateral MCP 2–3, wrists and MTP 2–5	40 (90.9)	19 (95)	11 (55)	3.13	4 (20)

SDD: Smallest detectable difference; ND: data not collected. Other abbreviations see Table 1.

post hoc Wilcoxon test results showed that there were significant differences between 1 hand and 2 hands (z = –2.46, p = 0.042) and 1 hand and 2 hands and feet (z = –2.71, p = 0.021), but not between 2 hands and 2 hands and feet (z = –1.90, p = 0.177).

DISCUSSION

The optimal combination for erosion detection at baseline was the 2-hands approach, which identified over 85% of erosions. The optimal combination for monitoring erosion progression was the 1-hand approach, which demonstrated erosions in 50% of the longitudinal cohort who were rescanned at 6 months, with the 2-hands combination identifying only 5% more erosions (and doubling the scanning time). The addition of the MTP 2–5 joints in our study identified only 2.3% more patients on eMRI who were erosive at baseline and no more progressors (compared to the 2-hands approach without MTP), despite a significant increase in scanning time, and on this evidence would not justify inclusion either at baseline screening or for monitoring over time.

Looking at raw erosion scores, statistical comparison of erosion progression between the 3 main joint combinations confirmed 2 hands as the most sensitive and time-efficient combination, as there was no statistical difference when the feet were added. Looking at the data in terms of subjects progressing, there was no statistically significant difference between any of the 3 combinations, allowing 1 hand to be used as the most feasible clinical monitoring tool.

At baseline, eMRI of 1 hand identified 4 times as many subjects who were erosive compared to radiography of both hands, confirming the superiority of eMRI over conventional radiography. These results are similar to those obtained using the C-scan with its larger FOV[8].

eMRI may be cost-effective in the longer term because of the ability to identify erosions earlier than conventional radiography[8], but the main disadvantage of eMRI is the time to acquire the images, which is significantly longer than for conventional radiography. Limitations of our study included the lack of conventional radiography at 6 months to enable a direct comparison of erosion progression between eMRI and conventional radiography. Recent studies, however, have confirmed that MRI erosions are true bony erosions as seen on conventional radiography, thus the need for longitudinal comparison with conventional radiography is less critical[12,13]. The radiographs were also evaluated in a usual clinical practice setting and were not scored by a single observer or consensually. Additionally, the eMRI images were analyzed only for number of bone erosions, not size, whereas using a scoring system incorporating the size of erosions such as the OMERACT RA MRI score may have added sensitivity to this assessment. Also, the SDD scores for the 2-hands and 2-hands and feet combinations were higher than for the 1-hand combination, which may have underestimated the erosion detection ability of these combinations.

eMRI is a promising technique for use in the clinic setting, providing superior erosion identification ability compared to conventional radiography, as well as a safe and convenient method of monitoring erosion progression. Imaging 2 hands can be conveniently used as a sensitive baseline screening tool and scanning 1 hand can be used to monitor erosions over time.

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