Rheumatoid Arthritis of the Hand: Monitoring with a Simplified MR Imaging Scoring Method—Preliminary Assessment[1]

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Purpose: To assess a simplified scoring method (Simplified Rheumatoid Arthritis Magnetic Resonance Imaging Score [SAMIS]) developed to shorten interpretation time, while retaining both correlation with Rheumatoid Arthritis Magnetic Resonance Imaging Score (RAMRIS) and same or better intra- and interreader reliability.

Materials and Methods: Ethics board approval and written patient consent were obtained. The study was HIPAA compliant. Thirty-eight patients with rheumatoid arthritis and 20 patients with no or early unclassified arthritis underwent magnetic resonance imaging of both wrists and hands. RAMRIS was used to evaluate erosions (scale, 0–10), edema (scale, 0–3), and synovitis (scale, 0–3). SAMIS assessed only one hand and was based on the radiographic Simple Erosion Narrowing Score, thus reducing the number of study areas from 116 to 36. Erosions were scored with a scale from 1 to 10. Edema and synovitis were, respectively, scored with scales from 0 to 1 and 0 to 2. SAMIS correlation with RAMRIS was tested by using the Spearman test. Last, the intra- and interobserver reproducibility of both scores were calculated.

Results: SAMIS was closely correlated with RAMRIS for the entire series (r = 0.91, 0.79, and 0.94, respectively, for erosion, edema, and synovitis), as well as in patients with rheumatoid arthritis (r = 0.93, 0.81, and 0.92) and those with no or unclassified arthritis (r = 0.83, 0.73, and 0.94). The time needed to assess examination results with RAMRIS ranged from 5 to 20 minutes (13 minutes ± 3.90 [standard deviation]), whereas it ranged from 2 to 7 minutes (5 minutes ± 1.45) with SAMIS. For each of the three features (erosion, edema, and synovitis), intraobserver agreement (RAMRIS: κ = 0.67, 0.94, 0.81, respectively; SAMIS: κ = 0.66, 1.0, 0.91) and interobserver agreement (RAMRIS: κ = 0.61, 0.58, 0.74, respectively; SAMIS: κ = 0.59, 0.81, 0.81) were good to excellent.

Conclusion: This simplified reproducible scoring scheme could be used to monitor joint damage in rheumatoid arthritis.

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Radiography is the traditional reference standard for diagnosing and monitoring structural joint damage in patients with rheumatoid arthritis (1,2). With the development of new therapeutic strategies for rheumatoid arthritis, such as anti–tumor necrosis factor α, there is now a need for close monitoring for signs of synovitis and treatment failure (3), as is provided with magnetic resonance (MR) imaging.

The issue is how best to harness and quantify the large amount of information generated at MR imaging. The Outcome Measures in Rheumatology Clinical Trials (OMERACT) Rheumatoid Arthritis Magnetic Resonance Imaging Score (RAMRIS) system was developed (4,5) as the useful standard for assessment of rheumatoid arthritis. However, use of the RAMRIS system is time-consuming and tedious and requires a long learning curve (5).

The aim of this pilot study was to develop an easier MR imaging scoring method for rheumatoid arthritis. We assess a simplified scoring method (Simplified Rheumatoid Arthritis Magnetic Resonance Imaging Score [SAMIS]) developed to shorten interpretation time, while retaining both correlation with RAMRIS and same or better intra- and interreader reliability.

Advances in Knowledge

- We report a simplified MR imaging scoring method (Simplified Rheumatoid Arthritis Magnetic Resonance Imaging Score [SAMIS]) for assessing wrist and metacarpal joint damage in rheumatoid arthritis.
- The simplified score is closely correlated with the MR imaging score standard Rheumatoid Arthritis Magnetic Resonance Imaging Score (RAMRIS).
- SAMIS requires less examination time than RAMRIS (5 minutes vs 20 minutes) and shows good or excellent intra- and interobserver agreement.

Materials and Methods

Patients

Ethics board permission and written informed patient consent were obtained for this study. The study was Health Insurance Portability and Accountability Act compliant. From 2004 to 2008, 58 patients (44 women [mean age, 53 years; age range, 18–71 years] and 14 men [mean age, 45 years; age range, 27–64 years]) with painful, swollen wrists were prospectively included in the study and underwent MR imaging of both wrists and up to just distal to the metacarpal phalangeal joints. Thirty-eight patients from two centers within the framework of a French multicentric cohort study of adults with early arthritis (Study and Follow-up of Undifferentiated Early Arthritis [ESPOIR] cohort) had at least two swollen joints for a duration of 6 weeks to 6 months and were not receiving treatment with disease-modifying and antirheumatic drugs (6). Twenty of the patients, from the Montpellier Teaching Hospital, had wrist pain for more than 2 years: 11 patients already had a diagnosis of established rheumatoid arthritis, seven had unclassified arthritis, and two did not have arthritis. After a 3-year follow-up, 27 of the ESPOIR cohort patients were given a diagnosis of rheumatoid arthritis according to the 1987 American College of Rheumatology criteria (7), and 11 were classified as patients with unclassified inflammatory arthritis. We divided our patients into two groups: group 1 consisted of 38 patients with rheumatoid arthritis and group 2 included 20 patients with no or unclassified arthritis (Table 1).

MR Imaging Protocol

Two 1.5-T units (Magnetom, Siemens, Munich, Germany; Achieva, Philips, Eindhoven, the Netherlands), both equipped with a dual phased-array wrist coil for wrist and metacarpophalangeal joint examinations, were used. MR imaging of the wrists and the second to the fifth metacarpophalangeal joints of the two hands was performed. Patients were placed in the prone or lateral position, with both hands held together within splints to minimize movement and standardize the position.

T1-weighted spin-echo images, T2-weighted fat-saturated spin-echo images, and axial and coronal T1-weighted postgadolinium fat-saturated spin-echo images were obtained with the following parameters: section thickness, 3 mm without any intersection gap; field of view, 130 × 130; and matrix, 230 × 256 pixels. For T2-weighted images, a repetition time of 3500 msec, an echo time of 60 msec, and an echo train of seven were used. For T1-weighted images, a repetition time of 500 msec and an echo time of 20 msec were used. Gadopentetate dimeglumine (Magnevist; Schering, Berlin, Germany) was administered by using hand injection at 0.1 mmol per kilogram of body weight. The total imaging time was 35 minutes.

Two trained musculoskeletal radiologists (C.C. and A.M., with 4 and 5 years of experience with RAMRIS) performed the procedure by using MR

Implication for Patient Care

- SAMIS is a simplified, quicker method for MR imaging scoring of joint damage in rheumatoid arthritis.

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Abbreviations:
CI = confidence interval
ESPOIR = Study and Follow-up of Undifferentiated Early Arthritis
OMERACT = Outcome Measures in Rheumatology Clinical Trials
RAMRIS = Rheumatoid Arthritis Magnetic Resonance Imaging Score
SAMIS = Simplified Rheumatoid Arthritis Magnetic Resonance Imaging Score

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Table 1

Representation of Patient Cohorts

Arthritis	Total No.	Rheumatoid Arthritis	Unclassified Arthritis	No Arthritis
Early	38	27	11	0
More than 2-year evolution	20	11	7	2
Total	58	38	18	2

Note.—Data are numbers of patients.

Figure 1

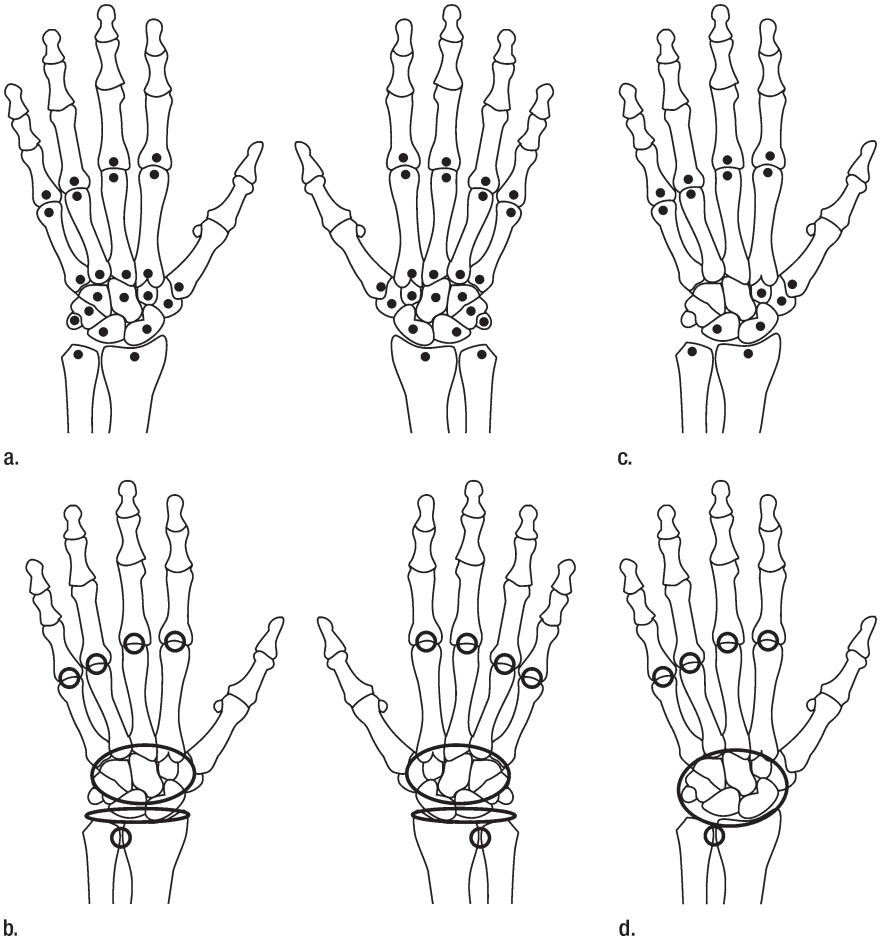

Figure 1: Areas analyzed in two hands with RAMRIS for **(a)** erosions and edema and for **(b)** synovitis and in one hand with SAMIS for **(c)** erosions and edema and for **(d)** synovitis.

imaging definitions of erosion, edema, and synovitis, in accordance with the OMERACT RAMRIS recommendations (4) (Fig 1a, 1b) (Table 2).

Erosion was a sharply marginated, juxtaarticular bone lesion, with typical signal intensity characteristics, seen in two planes with a cortical break in at least one plane (Fig 2a). Its evaluation scale (0–10) is based on the proportion of eroded bone compared with the assessed bone volume, determined on all available images (0 = no erosion, 1 = 1%–10% of bone eroded, 2 = 11%–20% of bone eroded, etc). For long bones, the assessed bone volume extends from the articular surface (or if absent, its best-estimated position) to a depth of 1 cm. For carpal bones, the whole bone is assessed.

MR imaging bone edema was considered as a lesion within the trabecular bone, with ill-defined margins and signal intensity characteristics consistent with increased water content (high signal intensity on T2-weighted images) (Fig 2c). Its evaluation scale (0–3) is based on the proportion of bone with edema (0 = no edema, 1 = 1%–33% of bone edema, 2 = 34%–66% of bone edema, 3 = 67%–100% of bone edema).

Synovitis was visible as an area in the synovial compartment that shows higher than normal postgadolinium enhancement of a thickness greater than the width of the normal synovium. Enhancement was assessed by comparison of T1-weighted images obtained before and after intravenous administration of gadolinium-based contrast material (Fig 2d, 2e). Its evaluation scale ranges from 0 to 3. Score 0 is normal, and scores 1 to 3 (mild, moderate, severe, respectively) are thirds of the presumed maximum volume of enhancing tissue in the synovial compartment.

A simplified score, SAMIS, was developed as follows (Table 2). *(a)* Only one hand was evaluated, either the most painful or the dominant one if both hands were equally painful. *(b)* Some bones were ruled out for erosion and edema analysis, according to van der Heijde et al's radiographic assessments (8). The following 15 bones were studied: metacarpal head and phalangeal base of the second to the fifth metacarpophalangeal joints, first metacarpal base, trapezium, scaphoid, lunate, and distal end of both the ulna and radius. *(c)* Both intracarpal and radiocarpal joints were combined for synovitis scoring. The analysis was performed in the distal radioulnar joint, the second to fifth metacarpophalangeal joints, and combined carpal joints. *(d)* The scales for synovitis and edema were reduced (Fig 1c, 1d). The synovitis scale ranged from 0 to 2: Score 0 was normal, 1 was mild, and 2 was severe. For marrow edema, bones were scored with a scale from 0 to 1 for the presence of the feature.

Table 2

Description of RAMRIS and SAMIS Scoring Methods

	Erosion		Edema		Synovitis	
Method	Location	Scale	Location	Scale	Location	Scale
RAMRIS (two hands)	23 areas × 2—wrists: distal radius, distal ulna, carpal bones, metacarpal bases; second to fifth MCP joints: metacarpal heads, phalangeal bases	0–10	23 areas × 2—same areas as those for erosions	0–3	Distal radioulnar joint, radiocarpal joint, intracarpal joints, second to fifth MCP joints	0–3
SAMIS (one hand)	15 areas—wrists: distal radius, distal ulna, trapezium, scaphoid, lunate, first metacarpal base; MCP joints: metacarpal head and phalangeal base of the second to fifth MCP joints	0–10	15 areas—same areas as those for erosions	0–1	Distal radioulnar joint, global evaluation of the radiocarpal joint and intracarpal joints, second to fifth MCP joints	0–2

Note.—MCP = metacarpophalangeal.

Figure 2

Figure 2: **(a–e)** MR images show sharply marginated bone lesions detected with a hypointense signal on T1-weighted images, with juxtaarticular localization and a cortical break, visible in two planes of the third-finger metacarpal head, consistent with an erosion. **(a)** Coronal plane and **(b)** axial plane show erosion of the index metacarpal (arrow in **a**) (grade 1) and erosion of the ulnar side of the third metacarpophalangeal joint (arrow in **b**) (grade 4). **(c)** Coronal plane shows abnormal signal of ill-defined margins with increased water content (high signal intensity on T2-weighted images) within the trabecular bones of the wrist, consistent with bone edema. **(d)** Coronal and **(e)** axial planes show thickened enhanced synovium (arrows in **d** and **e**) on T1-weighted images after intravenous administration of gadolinium-based contrast material, consistent with synovitis.

To determine interobserver variability, trained radiologists (C.C., A.M.), who were blinded to clinical information and the other reader's scoring, independently evaluated the cases within the same period. In addition, each reader evaluated 20 cases from the ESPOIR cohort twice, with a 1-month washout period to evaluate intraobserver variability.

After a 6-month washout period and a new randomization of the cases, a new reading was performed by the same radiologists by using SAMIS. The intra- and interobserver reproducibility of both scores were calculated, and

Figure 3

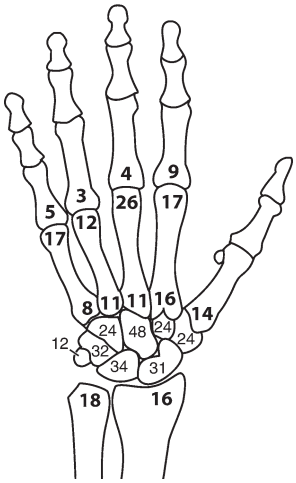

Figure 3: Number and distribution of erosions evaluated by one reader with RAMRIS.

correlations were tested. The average time necessary to analyze MR images by using RAMRIS and SAMIS was recorded.

Statistical Analysis

All corresponding measurements between RAMRIS and the simplified score were assessed by using the Spearman rank correlation coefficient. Left and right hand results in each patient and reading times between SAMIS and RAMRIS were compared by using the paired Wilcoxon test. Cohen κ coefficients of agreement between observers were determined for each feature (agreement on the basis of Fleiss classification: <0.40, poor; 0.40–0.59, moderate; 0.60–0.75, good; >0.75, excellent) (9). We used the *t* statistic to compare κ statistics. Data were processed and analyzed by using software (SAS for Windows, version 9.1.3; SAS Institute, Cary, NC). A *P* value less than .05 was considered to indicate a significant difference.

Results

RAMRIS Analysis

Four hundred sixteen erosions were detected in the 2668 bones studied. Carpal bones (excluding pisiform), the distal ulna, and the third metacarpal head showed the most erosions, whereas the other metacarpal heads, phalangeal bases, metacarpal bases, the pisiform, and radial bones were the least affected (Fig 3). The phalangeal bases were affected without any metacarpal head involvement in only 1.35% of the cases, and the metacarpal bases were affected without any wrist bone involvement in 3% of the cases. There was no significant difference between the global evaluation of the right and left hand for erosion ($P = .11$), edema ($P = .23$), and synovitis ($P = .26$).

Edema was found in 267 areas in the 2668 bones analyzed, and synovitis was found in 312 joints among the 812 joints analyzed. We found a close correlation between intercarpal and radiocarpal synovitis ($r = 0.91$; 95% confidence interval [CI]: 0.88, 0.93), whereas the correlation was lower when comparing radioulnar with radiocarpal or intercarpal synovitis (respectively, $r = 0.74$ [95% CI: 0.65, 0.82] and $r = 0.67$ [95% CI: 0.53, 0.78]). No close correlation was found between the different metacarpophalangeal joints with regard to the presence of synovitis ($r < 0.7$).

RAMRIS and SAMIS Comparative Analysis

For both trained radiologists, the examination time varied with the number of lesions present. It ranged from 5 to 20 minutes (13 minutes ± 3.90 [standard deviation]) when using RAMRIS and was reduced to 2 to 7 minutes (5 minutes ± 1.45) when the simplified score was applied ($P < .001$).

Correlation plots between RAMRIS and SAMIS for the three features in each patient for both observers are presented in Figure 4. The simplified score was closely correlated with RAMRIS for the whole series ($r = 0.91$ [95% CI: 0.84, 0.95], 0.79 [95% CI: 0.67, 0.87], and 0.94 [95% CI: 0.89, 0.96] for erosion, edema, and synovitis, respectively), as well as in group 1 ($r = 0.93$ [95% CI: 0.88, 0.97], 0.81 [95% CI: 0.65, 0.89], and 0.92 [95% CI: 0.86, 0.96]) and group 2 ($r = 0.83$ [95% CI: 0.60, 0.93], 0.73 [95% CI: 0.41, 0.89], and 0.94 [95% CI: 0.85, 0.98]).

Good or excellent intraobserver agreement was found for both readers for the three features when using RAMRIS (κ = 0.67 [95% CI: 0.60, 0.75], 0.81 [95% CI: 0.71, 0.92], 0.94 [95% CI: 0.90, 0.99] for erosion, synovitis, and edema, respectively). Intraobserver agreement proved to be excellent when using SAMIS (κ = 0.66 [95% CI: 0.60, 0.73], 0.91 [95% CI: 0.82, 1], 1.0 [95% CI: 1, 1] for erosion, synovitis, and edema, respectively).

The interreader single-measure κ of RAMRIS and the simplified score is presented in Table 3. The κ values were higher for scoring synovitis than for the two other features. Interreader κ values were moderate to good when using RAMRIS (median baseline, κ = 0.61 [95% CI: 0.57, 0.66] for erosion, 0.74 [95% CI: 0.69, 0.79] for synovitis, and 0.58 [95% CI: 0.52, 0.64] for edema). κ Values were good to excellent when the simplified score was applied (κ = 0.59 [95% CI: 0.50, 0.68] for erosion, 0.81 [95% CI: 0.74, 0.88] for synovitis, and 0.81 [95% CI: 0.71, 0.91] for edema), with a significant difference for edema ($P = .26$, .32, and .0026, respectively).

Discussion

A reproducible scoring scheme is useful in evaluating disease progression and in making therapeutic decisions and treatment evaluations, regardless of the modality. RAMRIS is widely approved as a reference standard in rheumatoid arthritis trials (10,11), although barely applied in usual clinical practice, because of its time commitment. MR imaging is now not only used in protocols and trials but also in routine practice for arthritis diagnosis and outcome (12). A simplified scoring method with acceptable interpretation time that correlated with the RAMRIS method would be of great help in everyday practice.

Sufficient reproducibility is a prerequisite for any scoring method. This study confirmed others in showing that the OMERACT RAMRIS had acceptable intra- and interreader reliability (5,13,14) when performed by trained readers. Our proposed, simplified score had good to excellent intra- and interreader reliability. This high degree of agreement may be explained by both the reduced scale and the two readers' previous experience in reading MR images

Figure 4

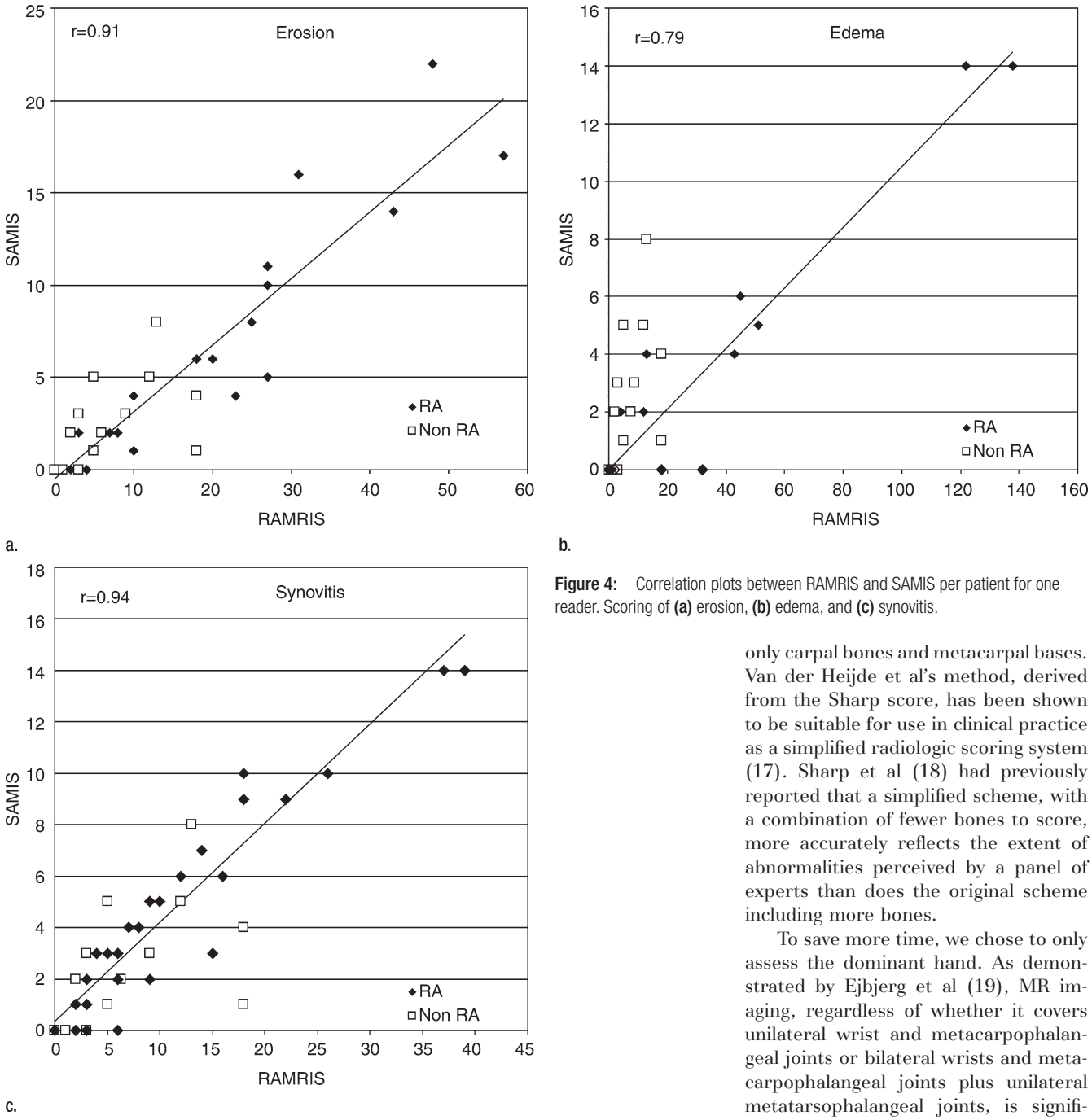

Figure 4: Correlation plots between RAMRIS and SAMIS per patient for one reader. Scoring of **(a)** erosion, **(b)** edema, and **(c)** synovitis.

of the hands and wrists, as already mentioned by Bird et al for radiographs (15). Furthermore, radiologists were initially trained by using the OMERACT atlas of images of rheumatoid arthritis joints (16). This might have further enhanced standardized assessment of rheumatoid arthritis joints and reproducible scoring of MR imaging lesions.

Our scoring system allows a reduction in the number of bones to be analyzed from 23 to 15. In accordance with van der Heijde et al's method, we decided to simplify RAMRIS by evaluating only carpal bones and metacarpal bases. Van der Heijde et al's method, derived from the Sharp score, has been shown to be suitable for use in clinical practice as a simplified radiologic scoring system (17). Sharp et al (18) had previously reported that a simplified scheme, with a combination of fewer bones to score, more accurately reflects the extent of abnormalities perceived by a panel of experts than does the original scheme including more bones.

To save more time, we chose to only assess the dominant hand. As demonstrated by Ejbjerg et al (19), MR imaging, regardless of whether it covers unilateral wrist and metacarpophalangeal joints or bilateral wrists and metacarpophalangeal joints plus unilateral metatarsophalangeal joints, is significantly superior to radiography of the hands, wrists, and forefeet with respect to the detection of progressive joint destruction in rheumatoid arthritis.

Although this score proved to be closely correlated with RAMIS and more reproducible, our study had limitations. The degree of agreement in the results

Table 3

Interobserver Agreement for Scoring of Individual Area When Using RAMRIS and SAMIS

	RAMRIS		SAMIS		
Feature	No. of Areas	Interreader κ	No. of Areas	Interreader κ	*P* Value*
Erosion	1748	0.61 (0.57, 0.66)	532	0.59 (0.50, 0.68)	NS
Synovitis	532	0.74 (0.69, 0.79)	228	0.81 (0.74, 0.88)	NS
Edema	1748	0.58 (0.52, 0.64)	532	0.81 (0.71, 0.91)	.0026

Note.—Data in parentheses are 95% CIs.

* NS = no significant difference.

may be explained by the two readers' previous experience in reading MR images of the hands and wrists. As a scoring system needs to be reliable, the score needs to be tested by using readers with different levels of experience. Even if MR imaging is most useful for clinicians in early rheumatoid arthritis, or when radiographic results remain normal, the score should be further tested in more patients with advanced disease. Nevertheless, a few high-grade lesions were included in our series. SAMIS will also have to be evaluated in early unclassified arthritis to assess its possible interest as a rheumatoid arthritis predictor, thus allowing early treatment and preventing further structural damage. In the future, SAMIS sensitivity to change should be evaluated and compared with that of RAMRIS. This was a preliminary report, and further longitudinal studies aiming at evaluating follow-up and least discernable changes when using SAMIS are mandatory, because the follow-up of these patients is more important than the initial score.

Although SAMIS must be further validated in more patients and in longitudinal studies, our results indicated that damage to joints in patients with rheumatoid arthritis could be reliably evaluated with this simplified MR imaging scoring method. SAMIS is closely correlated with and as reproducible as RAMRIS, while being less time-consuming.

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