Mod Rheumatol (2001) 11:56–60

ORIGINAL ARTICLE

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Comparative study of fat-suppressed Gd-enhanced MRI of hands in the early stage of rheumatoid arthritis (RA) and non-RA

Received: June 20, 2000 / Accepted: October 25, 2000

Abstract The object of this work was to evaluate the usefulness of fat-suppressed gadolinium (Gd)-enhanced magnetic resonance imaging (MRI) for the diagnosis of early-stage rheumatoid arthritis. Forty wrists of patients who had suffered from stiff or swollen hands for 1–12 months were examined prospectively by MRI. Rheumatoid arthritis (RA) was proven in 21 patients, and the other 19 patients were not classified as having RA. Hypertrophy of the synovial membrane and tendon sheaths were evaluated by fat-suppressed Gd-enhanced MRI, and bone erosions were also evaluated by T1-enhanced MRI. These results were compared between two groups. Seventeen of 19 patients (89.5%) in the non-RA group showed little or no synovial hypertrophy, while 17 of 21 patients (81%) in the RA group showed moderate to severe hypertrophy of the synovial membrane. Little or no tenosynovitis was found in 14 of 19 patients (73.7%) in the non-RA group, while 14 of 21 patients (66.7%) in the RA group had moderate to severe tenosynovitis. No bone erosion was found in the non-RA group, while a few bone erosions were found in 10 of 21 patients (47.6%) of the RA group. Fat-suppressed, Gd-enhanced MRI was useful in differentiating early-stage RA from non-RA when all patients had some symptoms in their hands.

Key words Hand · Magnetic resonance imaging (MRI) · Rheumatoid arthritis · Synovitis

Introduction

Pain and swelling of joints in the hands or finger stiffness is often observed in patients with rheumatoid arthritis (RA); however, these symptoms are also observed in collagen disease, osteoarthritis, nonspecific arthritis, or tenosynovitis. Therefore, it is sometimes difficult to diagnose the early stage of RA. Because these symptoms are caused by changes in soft tissues such as synovia or tendon sheaths, it is difficult to detect them by X-ray. Recently, gadolinium (Gd)-enhanced magnetic resonance imaging (MRI) has been used to examine the knees or the hands of patients with RA, and it was found that the synovial tissue in RA was enhanced due to the high vascularity of inflammed synovia.[1–4] However, there are some difficulties in distinguishing between bone marrow and enhanced synovia, because bone marrow, being abundant in fat, shows a high signal similar to that of enhanced synovia in T1-weighted MRI. Therefore, we used a fat-suppressed MRI technique to examine the synovia in hands of patients with RA. Using this method, the enhancement of the inflamed synovial membrane was easily detected.[5] In this study, we investigated whether fat-suppressed Gd-enhanced MRI was useful in the diagnosis of early-stage RA.

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Patients and methods

Patients

Forty patients (30 women, 10 men) who complained of pain or swelling of the hands were enrolled in the study. The disease duration was up to 1 year, and no patient received any treatment until the initial visit to our clinic. Patients were divided into two groups. Group 1 included 21 patients (15 women, 6 men, mean age 53 years) who fulfilled the American Rheumatism Association (ARA) criteria[6] for the diagnosis of RA. Group 2 included 19 patients (15 women, 4 men, mean age 53 years) who did not meet the diagnostic criteria for RA. The second group (non-RA group) comprised two patients with a Heberden nodule, one with erythema nodosum, one with Still's disease, one with Palindromic rheumatism, one with mixed connective tissue disease, one with tenosynovitis, and 12 with nonspecific arthritis.

Laboratory analysis

Laboratory evaluations included rheumatoid factor (RF; IgM-RF), erythrocyte sedimentation rate (ESR, by the Westergren method), and C-reactive protein (CRP, by nephelometry).

MRI protocol

Imaging was performed with a 1.5-Tesla unit (Signa, GE Medical Systems, Milwaukee, USA), using a circular surface coil 12.5 cm in diameter. The field of view was 12 or 14 cm, covering the area from the distal radioulnar joint to the metacarpophalangeal joints. The section thickness was 4 mm with a 2-mm gap, or 3 mm with a 1.5-mm gap. The imaging matrix was 256 × 192. Coronal and transaxial T1-weighted spin–echo MR images were obtained. With the pulse sequences, repetition time (TR)/echo time (TE) was 400–500/20 ms in T1-weighted images. For the fat-suppressed images, a presaturation pulse technique was employed. For contrast enhancement, 0.1 mmol/kg gadopentetate dimeglumine (Gd-DTPA) was used.

MRI scoring

To make semiquantitative estimations of synovial hypertrophy, we used the MRI scoring system described by Østergaard et al.[7] Synovial hypertrophy was scored as follows: 0, no visible enhancement; 1, linear enhancement (width <2 mm); 2, band-like enhancement (width ≧2 mm, but <4 mm); 3, diffuse enhancement (width ≧4 mm). Examples are shown in Fig. 1. An MRI score (0–42) was calculated by adding the scores from 14 regions. The 14 regions were as follows: distal radioulnar joint, ulnar radiocarpal joint, radial radiocarpal joint, intercarpal joint, 1st to 5th carpometacarpal joints, and 1st to 5th metacarpophalangeal joints.

Tenosynovitis was also scored by the enhanced tendon sheath in the axial and coronal slices: 0, no visible enhancement; 1, width <2 mm; 2, width ≧2 mm, but <4 mm; 3, width ≧4 mm. Examples are shown in Fig. 2. An MRI score (0–15) was calculated by adding the scores from five regions, i.e., the 1st to 5th flexor tendons.

Bone erosions were identified by T1-weighted images. Each of the eight carpal bones and the bases of the five metacarpal bones were assessed for erosions. The number

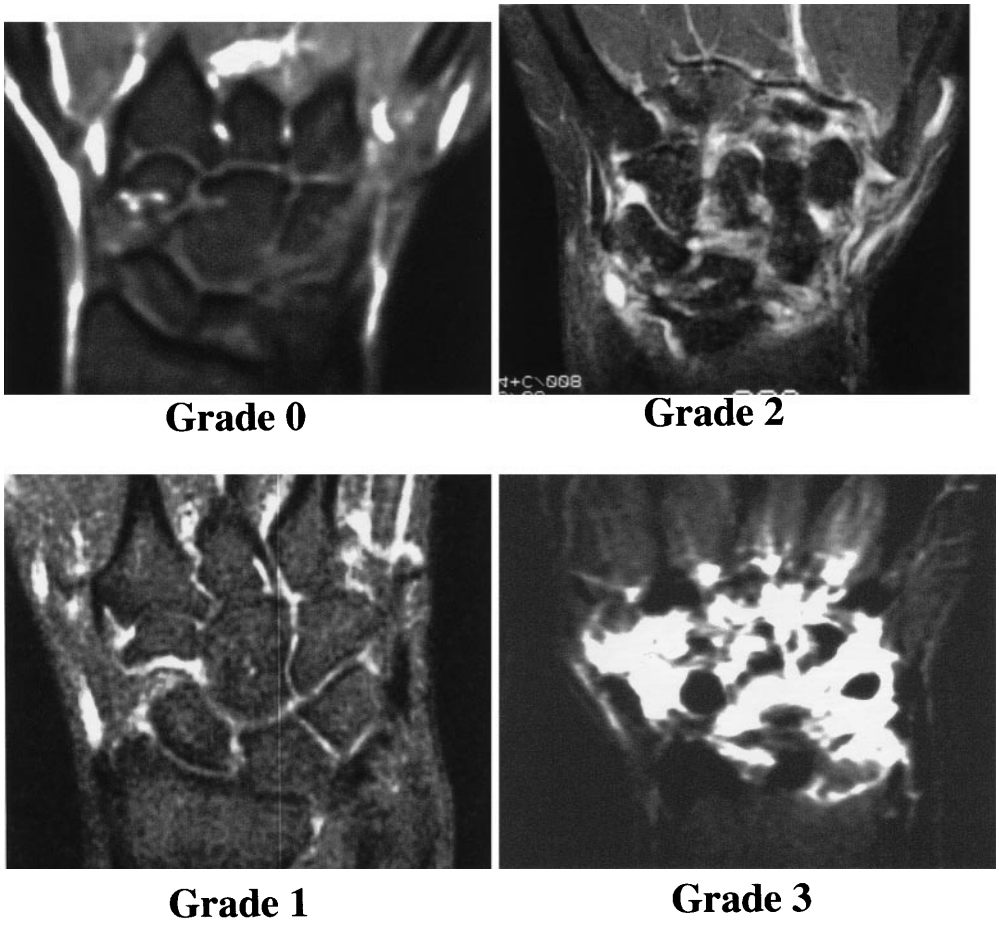

Fig. 1. Grading of synovial membrane hypertrophy of intercarpal joints. T1-weighted spin–echo contrast-enhanced MRI with fat suppression. Grade 0, no visible enhancement; grade 1, slight enhancement (<2 mm); grade 2, moderate enhancement (width ≧2 mm, but <4 mm); grade 3, severe enhancement (width ≧4 mm)

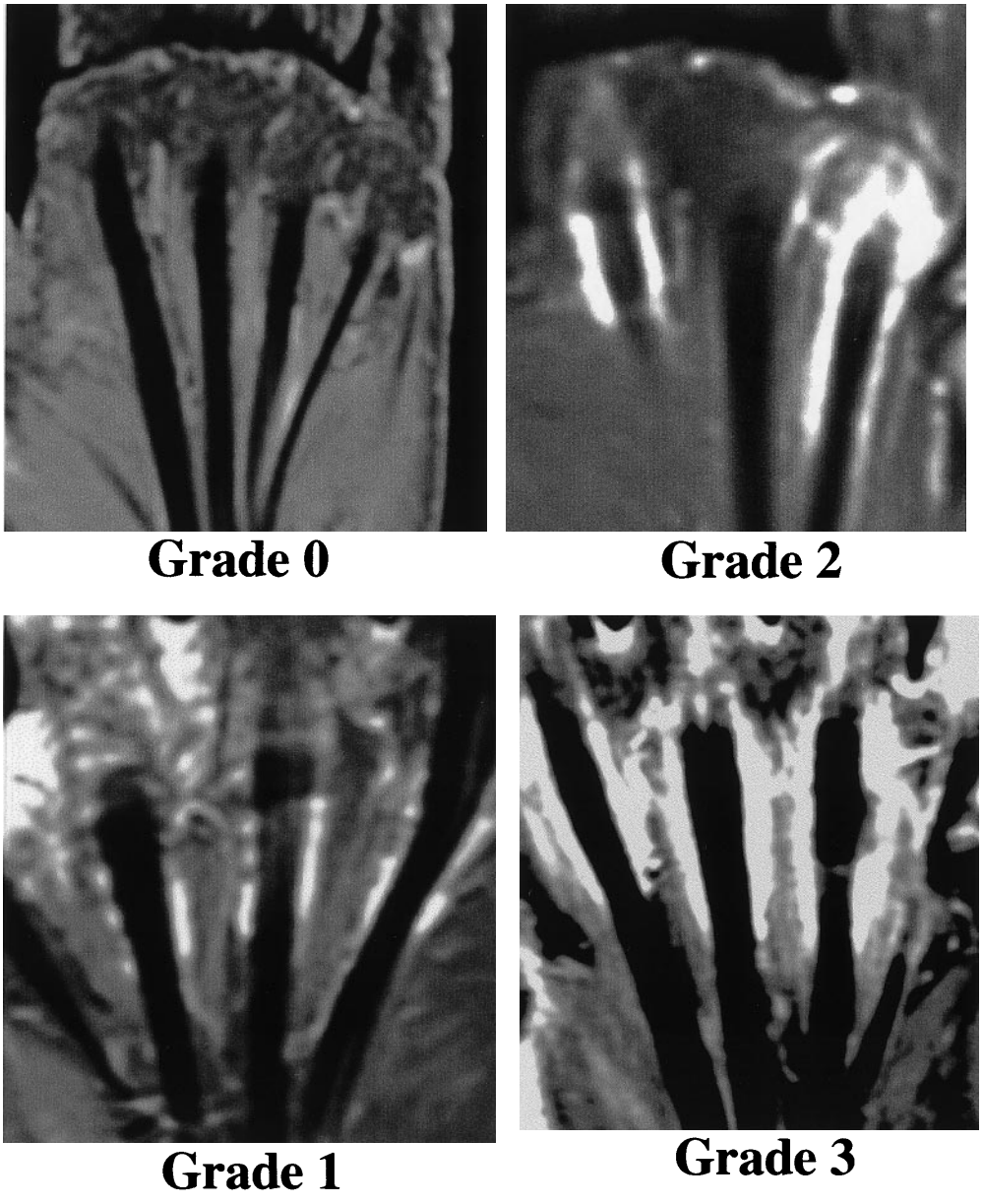

Fig. 2. Grading of enhancement of the tendon sheath. T1-weighted spin–echo postcontrast magnetic resonance imaging (MRI) with fat suppression. Widths of tendons were measured. Grade 0, no visible enhancement; grade 1, slight enhancement (<2 mm); grade 2, moderate enhancement (width ≧2 mm, but <4 mm); grade 3, severe enhancement (width ≧4 mm)

of bones with erosions was calculated as the MR score (total 13).

Statistical analysis

The Mann–Whitney test was used to analyze differences between the groups of patients.

Results

Patient characteristics

Rheumatoid factor was negative in 95% of the patients in group 2 (non-RA group), and in 38% in group 1 (RA group). CRP in the RA group was significantly higher (median 0.67, range 0.25–11.75 mg/dl) than in the non-RA group (median 0.19, range 0.04–1.6 mg/dl) ($P < 0.001$). ESR was also significantly higher in the RA group (median 47, range 10–120 mm/h) than in the non-RA group (median 9, range 3–67 mm/h) ($P < 0.0001$).

MRI scores in the two groups

The MRI score of the synovial membrane of joints, tendon sheaths, erosions, and the total score of these in RA and non-RA groups are shown in Table 1. All scores were significantly higher in the RA group. The distribution of these MRI scores in each group are shown in Fig. 3.

MR score of synovial hypertrophy

Seventeen of 19 patients (89.5%) in the non-RA group showed slight or no enhancement of the periarticular syn-

Table 1. MRI score in the rheumatoid arthritis (RA) and non-RA groups

	MRI score	RA (n = 21)	Non-RA (n = 19)	P
Synovial membrane	Range	0–34	0–10	<0.0001
	Median	11	0	
Tendon sheath	Range	0–11	0–8	<0.01
	Median	3	0	
Erosion	Range	0–4	0	<0.001
	Median	0	0	
Total	Range	0–48	0–11	<0.0001
	Median	14	0	

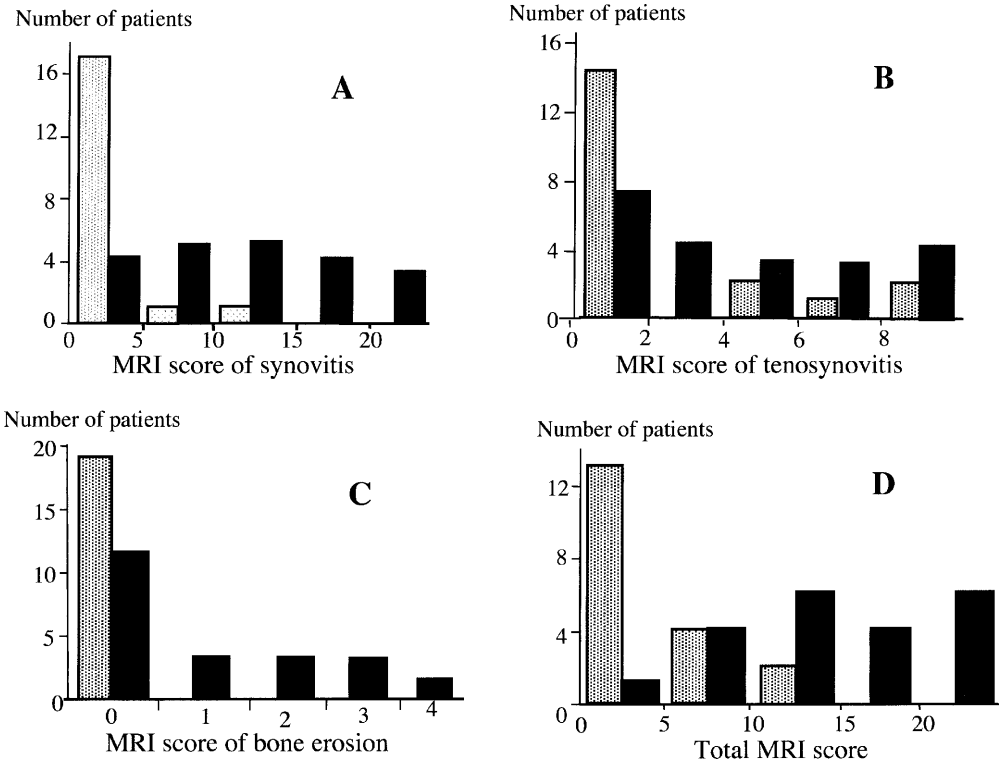

Fig. 3. Comparison of MRI score of **A** synovitis, **B** tenosynovitis, **C** bone erosion, and **D** total score between the RA and non-RA groups. *Shaded blocks*, non-RA group (n = 19); *solid blocks*, RA group (n = 21)

ovial membrane, while a moderate to high MR score (8–21) was obtained in 17 of 21 patients (81%) in the RA group. Furthermore, high MR scores (>15) were obtained exclusively in the RA group (Fig. 3A).

MRI score of tenosynovitis

Enhancement of the tendon sheath was seen to be slight in 14 of 19 patients (73.7%) in the non-RA group, while 14 of 21 patients (66.7%) in the RA group showed moderate to severe tenosynovitis. However, 5 of 19 patients (26.3%) in the non-RA group also showed moderate to severe tenosynovitis (Fig. 3B).

MRI score of bone erosion

Bone erosions were detected in 10 of 21 patients in the RA group, while no erosions were detected in the non-RA group (Fig. 3C).

Total MRI score

The total MRI scores of the synovial membrane, tendon sheath, and bone erosions are shown in Fig. 3. Thirteen of 19 patients in the non-RA group showed a very low score (total <5), while only 1 of 21 patients (4.8%) in the RA group did so. In contrast, 10 of 21 patients (47.6%) in the RA group showed a high score (total >15), while no patients in the non-RA group did so (Fig. 3D).

Discussion

The usefulness of fat-suppressed Gd-enhanced MRI to detect synovitis has been reported recently.[5,8,9] This has made it possible to distinguish proliferative synovia from joint fluids and bone marrow. However, it is sometimes difficult

to differentiate RA from other nonspecific synovitis. Therefore, we have studied prospectively whether there were some differences in the MRI findings when both groups had similar symptoms in their hands, such as pain, swelling, or finger stiffness. Using T1-weighted Gd-enhanced MRI with fat suppression, inflamed synovia and tendon sheaths could easily be detected. These phenomena were entirely nonspecific, and only reflected hypervascularity and abnormal vascular permeability.[10] Therefore, various inflammatory diseases does not seem possible. Recently, a few studies have attempted to quantify the synovial volume by means of image-processing software.[11,12] In this study, we used semiquantitative synovial membrane hypertrophy scoring methods, which are more easily obtained and have been shown to be acceptable in clinical studies.[12] Using these methods, varying degrees of synovitis and tenosynovitis were found in RA and non-RA groups. We found that the greatest extent and severity of synovitis was observed only in the RA group, whereas, little or no enhancement of synovia was observed in the non-RA group but never in the RA group. However, in the case of a moderate degree of synovitis, it seemed difficult to distinguish these two groups by MR alone, suggesting the limitation of this method. Diseases which showed an inflamed tendon sheath by MRI in the non-RA group included Still's disease (1), palindromic rheumatism (1), nonspecific tenosynovitis (1), and nonspecific arthritis (2). Since these patients all showed stiffness of the fingers, their problem may be more than just tenosynovitis of the flexor tendons. However, they had no symptoms in other joints, and the causes of their disease are still uncertain.

Because there have been few reports comparing MRI findings in a RA group to those in a control group with/without symptoms in their hands,[13,14] our results should be valuable.

As well as synovitis, bone erosions were also detected in T1-weighted MRI, while they were not clear in plain X-rays. It was also shown that enhanced erosions were significantly more frequent in RA than in other chronic inflammatory diseases.[1] Since it seemed difficult to detect synovia in erosion complicated by hypertrophic synovia of the intercarpal bone, we evaluated bone erosions by T1-weighted MRI without enhancement. The findings that bone erosions were only detected in the RA group might be useful in distinguishing RA from other diseases.

To make an early diagnosis of RA is important for drug therapy and management of the disease. However, it takes at least 6 weeks from the onset for diagnosis according to the criteria of the ACR, and in addition, some cases do not always fulfill the criteria. Some reports have shown the usefulness of MRI for early diagnosis of RA.[9,15] In this study we also confirmed, that in combination with laboratory data and clinical symptoms, fat-suppressed Gd-enhanced MRI is a useful strategy for distinguishing RA from non-RA disease in the early stage.

References

1. Tonolli-Serabian I, Poet JL, Dufour M, Carasset S, Mattei JP, Roux H. Magnetic resonance imaging of the wrist in rheumatoid arthritis: comparison with other inflammatory joint disease and control subjects. Clin Rheumatol 1996;15:137–42.
2. Yanagawa A, Takano K, Nishioka K, Shimada J, Mizushima Y, Ashida H. Clinical staging and gadolinium–DTPA enhanced images of the wrist in rheumatoid arthritis. J Rheumatol 1993;20: 781–4.
3. Adam G, Dammer M, Bohndorf K, Christoph R, Fenker F, Gunther RW. Rheumatoid arthritis of the knee: value of gadopentetate dimeglumine-enhanced MR imaging. Am J Roentgenol 1991;156:125–9.
4. Bjorkengren AG, Geborek P, Rydholm U, Holtas S, Petterson H. MR imaging of the knee in acute rheumatoid arthritis: synovial uptake of gadolinium–DOTA. Am J Roentgenol 1990;155:329–32.
5. Nakahara N, Uetani M, Hayashi K, Kawahara Y, Matsumoto T, Oda J. Gadolinium-enhanced MR imaging of the wrist in rheumatoid arthritis: value of fat suppression pulse sequences. Skeletal Radiol 1996;25:639–47.
6. Arnett FC, Edworthy SM, Bloch DA, McShane DJ, Fries JF, Cooper NS, et al. The American Rheumatism Association 1987 revised criteria for the classification of rheumatoid arthritis. Arthritis Rheum 1988;31:315–24.
7. Østergaard M, Gideon P, Sorensen K, Hansen M, Stoltenberg M, Henriksen O, et al. Scoring of synovial membrane hypertrophy and bone erosions by MR imaging in clinically active and inactive rheumatoid arthritis of the wrist. Scand J Rheumatol 1995;24:212–18.
8. McQueen FM, Stewart N, Crabbe J, Robinson E, Yeoman S, Tan PL, et al. Magnetic resonance imaging of the wrist in early rheumatoid arthritis reveals a high prevalence of erosions at four months after symptom onset. Ann Rheum Dis 1998;57:350–6.
9. Sugimoto H, Takeda A, Masuyama J, Furuse M. Early-stage rheumatoid arthritis: diagnostic accuracy of MR imaging. Radiology 1996;198:185–92.
10. König H, Sieper J, Wolf KJ. Rheumatoid arthritis: evaluation of hypervascular and fibrous pannus with dynamic MR imaging enhanced with Gd–DTPA. Radiology 1990;176:473–7.
11. Huh YM, Suh JS, Jeong EK, Lee SK, Lee JS, Choi BW, et al. Role of the inflamed synovial volume of the wrist in defining remission of rheumatoid arthritis with gadolinium-enhanced 3D-SPGR MR imaging. J Magn Reson Imaging 1999;10:202–8.
12. Østergaard M, Hansen M, Stoltenberg M, Lorenzen I. Quantitative assessment of the synovial membrane in the rheumatoid wrist: an easily obtained MRI score reflects the synovial volume. Br J Rheumatol 1996;35:965–71.
13. Klarlund M, Østergaard M, Gideon P, Sorensen K, Jensen KE, Lorenzen I. Wrist and finger joint MR imaging in rheumatoid arthritis. Acta Radiol 1999;40:400–9.
14. Jevtic V, Watt I, Rozman B, Kos-Golja M, Demsar F, Jarh O. Distinctive radiological features of small hand joints in rheumatoid arthritis and seronegative spondyloarthritis demonstrated by contrast-enhanced (Gd–DTPA) magnetic resonance imaging. Skeletal Radiol 1995;24:351–5.
15. Backhaus M, Kamradt T, Sandrock D, Loreck D, Fritz J, Wolf KJ, et al. Arthritis of the finger joints: a comprehensive approach comparing conventional radiography, scintigraphy, ultrasound, and contrast-enhanced magnetic resonance imaging. Arthritis Rheum 1999;42:1232–45.