Inflammatory and Structural Evaluation in Spondyloarthritis: Magnetic Resonance Imaging Analysis of Axial and Peripheral Involvement

VIRGINIE HOENEN-CLAVERT, ANNE CHRISTINE RAT, DAMIEN LOEUILLE, ISABELLE BETTEMBOURG-BRAULT, CHRISTINE MICHEL-BATOT, ALAIN BLUM, JACQUES POUREL, and ISABELLE CHARY-VALCKENAERE

ABSTRACT. ***Objective.*** To determine the magnetic resonance imaging (MRI) criteria of most value in the assessment of patients with spondyloarthropathy (SpA) with axial or peripheral involvement.

Methods. Fat suppressed (FS)-T2 and pre- and postinjection FS-T1 images were obtained in the most symptomatic region (axial or peripheral) of patients requiring tumor necrosis factor-α blockers. Thirty-eight MRI (21 axial and 17 peripheral) were blindly scored at synovial (S) and entheseal (E) sites by 2 experienced observers screening for 7 inflammatory and 7 structural predefined criteria, which were evaluated for frequency (N) and intra- and interobserver reproducibility.

Results. In peripheral regions, synovitis (S; N = 69.4%), ligament inflammation (E; N = 39.7%), bone marrow edema (S; N = 22.1%; E; N = 15%), and tenosynovitis (S; N = 21%) were recorded with good to excellent intraobserver reproducibility [intraclass correlation coefficient (ICC) 0.49–0.93] and moderate to good interobserver reproducibility (ICC 0.49–0.66). With regard to structural criteria, erosions (S; N = 17.1%) and enthesophytes (E; N = 13.9%) exhibited good to excellent intraobserver (ICC 0.71–0.85) and moderate interobserver reproducibility (ICC 0.54–0.49); the reproducibility of fat inflation (N = 1.4%) was good (ICC 0.76–0.78). In axial regions, no inflammatory criteria achieved good interobserver reproducibility. However, fat inflation (S; N = 86%), chondral lesions (S; N = 85.8%), enthesophytes (E; N = 76.7%), fusion (S; N = 41.2%), and erosions (S; N = 25.1%) showed excellent intraobserver reproducibility (ICC 0.81–0.98), and moderate to excellent interobserver reproducibility (ICC 0.50–0.96).

Conclusion. In terms of intra- and interobserver reproducibility, MRI is a reliable tool with which to assess synovitis, bone edema, ligament inflammation, tenosynovitis, erosion, enthesophytes, and fat inflation in patients with peripheral involvement. In those with axial involvement, inflammatory criteria lack interobserver reproducibility, but chondral lesions, erosion, fat inflation, fusion, and enthesophytes are relevant. (First Release Mar 1 2007; J Rheumatol 2007;34:762–8)

Key Indexing Terms:
SPONDYLOARTHROPATHY
INFLAMMATORY CRITERIA
MAGNETIC RESONANCE IMAGING
STRUCTURAL CRITERIA

Spondyloarthritis (SpA) comprises a heterogeneous group of rheumatological diseases including ankylosing spondylitis (AS) and psoriatic arthritis (PsA). The prevalences of AS and PsA in Caucasian populations have recently been estimated at 0.1–0.4%[1,2] and 0.1–0.2%[3,4], respectively. SpA affects axial and/or peripheral joints and is characterized by enthesitis (inflammation of tendon, ligament, and/or joint capsule attachments) that progresses secondarily to new bone formation and ankylosis over time. Recently, the concept of the "enthesis organ" has been invoked to encompass other peripheral lesions observed in SpA, such as arthritis (synovitis), dactylitis, and tenosynovitis[5].

SpA commonly takes 5 to 7 years to diagnose on the basis of structural damage to the spine and sacroiliac joints (SIJ) on plain radiography. However, newer techniques, such as magnetic resonance imaging (MRI) of axial and peripheral sites and ultrasound imaging of peripheral sites[6-8], can be expected to reduce the delay in diagnosis by revealing acute changes before the emergence of structural lesions.

MRI of axial joints (spine and sacroiliac) clearly reveals inflammation and chronic damage, depicts acute disease, and

From the Department of Rheumatology, Hôpitaux de Brabois; Clinical Epidemiology Centre, INSERM, Hôpital Central, Centre Hospitalo-Universitaire de Nancy; Unité Mixte de Recherches 7561 CNRS – Université Nancy I "Physiopathologie et Pharmacologie Articulaires"; and Department of Radiology, Hôpital Central, Centre Hospitalo-Universitaire de Nancy, Nancy, France.

V. Hoenen-Clavert, MD; I. Bettembourg-Brault, MD; C. Michel-Batot, MD, Department of Rheumatology, Hôpitaux de Brabois; A.C. Rat, MD, Department of Rheumatology, Hôpitaux de Brabois and Clinical Epidemiology Centre, INSERM; D. Loeuille, MD, PhD; J. Pourel, MD; I. Chary-Valckenaere, MD, PhD, Department of Rheumatology, Hôpitaux de Brabois and Unité Mixte de Recherches 7561 CNRS–Université Nancy I "Physiopathologie et Pharmacologie Articulaires"; A. Blum, MD, PhD, Unité Mixte de Recherches 7561 CNRS–Université Nancy I "Physiopathologie et Pharmacologie Articulaires" and Department of Radiology, Hôpital Central, Centre Hospitalo-Universitaire de Nancy.

Address reprint requests to Prof. I. Chary-Valckenaere, Department of Rheumatology, Hôpitaux de Brabois, Rue du Morvan, 54511 Vandoeuvre Cedex, France. E-mail: i.valckenaere@chu-nancy.fr

Accepted for publication December 22, 2006.

has been used to evaluate structural progression and to follow response to treatment in large cohorts of patients[9-11]. MRI inflammatory patterns at peripheral sites have been studied using not only conventional approaches but also sophisticated dynamic imaging techniques. However, the series were small, and intra- and/or interobserver reproducibility was moderate to low[12-14]. Two recent studies have outlined the potential of MRI in assessing the prevalence of asymptomatic or symptomatic peripheral lesions among patients with AS[15,16].

In clinical practice, MRI is increasingly used to evaluate SpA involvement as a guide to treatment, and for patient followup. Examinations for those purposes usually focus on the most symptomatic region — whether axial or peripheral. Validated scores are available for axial involvement in SpA, but most were designed for clinical studies and AS specifically and are not used in clinical practice. Indeed, not all lesions are taken into account and the scoring system for the whole spine is less relevant for patients with other forms of SpA.

In studying the various axial and peripheral criteria, the aim here was to be as comprehensive as possible and to take into account all the structures involved. Both regions (axial and peripheral) were addressed in the same way in order to determine which MRI criteria are the most relevant to clinical practice.

Our objective was to analyze 14 inflammatory and structural MRI criteria in the most symptomatic region in patients with active SpA. Aspects considered are: (1) frequency and reproducibility; (2) region (axial or peripheral); and (3) synovial or entheseal involvement.

MATERIALS AND METHODS

Patients. Seventeen patients (13 men and 4 women) fulfilling European Spondylarthropathy Study Group criteria for SpA[17] were prospectively included in the study between June 2003 and May 2004. As patients were hospitalized in a rheumatology department for initiation of tumor necrosis factor-α (TNF-α) blocker therapy according to ASsessments in Ankylosing Spondylitis (ASAS) Working Group recommendations[18], they were all considered to have active disease.

Assessment. Demographic data and other characteristics were recorded at baseline (Table 1). Disease activity, function, and pain were assessed using the Bath Ankylosing Spondylitis Disease Activity Index (BASDAI), the Bath Ankylosing Spondylitis Functional Index (BASFI)[19,20], and a visual analog scale (VAS) for patient global assessment. Specialists performed clinical examinations prior to MRI, determining the target region based on the dominant complaint. Standard blood tests were conducted, including serum C-reactive protein and erythrocyte sedimentation rate. The presence of HLA-B27 was determined in each case.

MRI data acquisition. MRI was performed using a 1.5 Tesla General Electric scanner (GE Medical Systems, Milwaukee, WI, USA) at baseline (M0), 6 months (M6), and 12 months (M12). Two patients declined to participate, and 7 MRI were not performed for patient-related reasons.

A total of 38 MRI examinations were conducted at axial (n = 21) and peripheral (n = 17) target regions.

Axial regions concerned were SIJ (n = 8), cervical spine (n = 9), dorsal spine (n = 2), and lumbar spine (n = 2). Investigations included multiplanar imaging in at least the axial and coronal planes, spin-echo (SE) T1-weighted imaging, fast SE T2-weighted imaging with fat saturation (FS), and pre- and post-contrast SE T1-weighted imaging with FS. The intravenous contrast agent used was Gadolinium-DTPA (0.05 mole per kg; Guerbet, Aulnay, France). All MRI examinations were performed routinely, but attention was paid to keeping imaging variables (field of view, slice thickness, matrix size) consistent in followup studies.

Table 1. Demographic and clinical characteristics of patients at baseline.

Characteristic	
Sex ratio (male/female)	2.7
Diagnosis, %	
AS	66.6
PsA	26.6
Undifferentiated SpA	6.8
HLA-B27, %	100
Pattern of SpA, %	
Axial	41.2
Peripheral	41.2
Mixed	17.6
Age, yrs, mean (SD)	41.9 (16.2)
Disease duration, yrs, mean (SD)	9.5 (5.8)
BASDAI score (0–10), mean (SD)	6.2 (1.2)
BASFI score (0–100), mean (SD)	56.3 (19.1)
Global VAS score (0–100), mean (SD)	69.1 (22.2)
CRP, mg/l, mean (SD)	44.5 (44.8)
ESR, mm/h, mean (SD)	44.6 (32.5)

SpA: spondyloarthropathy; AS: ankylosing spondylitis; PsA: psoriatic arthritis; BASDAI: Bath AS Disease Activity Index; BASFI: Bath AS Functional Index; VAS: visual analog scale; CRP: C-reactive protein; ESR: erythrocyte sedimentation rate.

With regard to peripheral regions, MRI examinations were performed at the wrist (n = 9), shoulder (n = 2), knee (n = 2), and ankle (n = 4). With the exception of the wrist, for which a 3-inch superficial coil was used, joints were explored with a transmit-receive knee coil to achieve uniform receptivity throughout the joint. The joint was placed in a neutrally rotated position and the same MRI modalities were used as described above for axial joints. Total acquisition times for axial and peripheral MRI examination were similar, at approximately 25 min.

MRI evaluation. MRI data were scored independently by 2 experienced readers (ICV and VHC) blinded to the patients' clinical characteristics and names, and to the timing of scans. Predefined MRI criteria were studied at axial and peripheral synovial and entheseal sites. Features of interest at entheseal sites were either inflammatory [ligament inflammation, bone marrow edema (BME), tendinitis, bursitis] or structural (chondral lesions, bone defects, sclerosis, fat inflation, enthesophytes, and fusion) and have been previously studied in SIJ[21]. Criteria at synovial sites reflected those usually assessed in rheumatoid arthritis (RA), and were both inflammatory (synovitis, effusion, tenosynovitis, and BME) and structural (chondral lesions, erosions, bone defects). They were in accord with criteria reported in observational studies of peripheral MRI in patients with SpA[15,16,22,23].

All diarthrodial joints were considered to be synovial sites. The number of sites assessed for each synovial criterion depended on the region. For example, 2 were assessed for synovitis at the shoulder (glenohumeral and acromioclavicular joints), while 22 zygapophyseal joints were analyzed in the dorsal spine. All sites with ligament, tendon, and/or capsule attachments were considered to be entheseal. The number of sites assessed for each entheseal criterion varied from 2 at the humeral head (greater tubercle of humerus, intertubercular groove) to 22 at the dorsal spine (anterior and posterior ligament attachments of 11 spinal segments as defined by Braun, *et al*[9].

Assessment of inflammation. The 7 inflammatory criteria were (1) synovitis, (2) effusion, (3) tenosynovitis, (4) ligament inflammation, (5) BME, (6) tendinitis, and (7) bursitis. All criteria were graded on a 2-point scale according to their presence or absence at the site concerned.

Definitions were as follows: (1) synovitis — thickening of the enhanced

synovium (≥ 2 mm) on FS T1-weighted sequence post-Gd-DTPA images; (2) effusion — intraarticular fluid in high signal (≥ 2 mm) on FS T2-weighted sequences and low signal on T1-weighted sequences; (3) tenosynovitis — thickening of the tendon sheath enhanced on FS T1-weighted post-Gd-DTPA images and/or effusion in the tendon sheath in high signal on FS T2-weighted sequences and low signal in T1-weighted sequences; (4) ligament inflammation — high signal within the ligaments or capsule attachments on FS T2-weighted and/or FS T1-weighted post-Gd-DTPA images (instead of the normal pattern of low signal intensity); (5) BME — intermediate to high signal of the trabecular bone FS T2-weighted and/or FS T1-weighted post-Gd-DTPA images; (6) tendinitis — high signal within the tendon on FS T2-weighted and/or FS T1-weighted post-Gd-DTPA images (instead of the normal pattern of low signal intensity); and (7) bursitis — bright signal of bursa on FS T2-weighted images and/or enhancement of the synovium surrounding the bursa on FS T1-weighted sequence post-Gd-DTPA images. Criteria were required to appear on 2 consecutive images, with the exception of ligament inflammation and tendinitis, which had to be observed in at least 2 different planes.

Assessment of disease chronicity. The 7 criteria used to determine chronicity were (1) chondral lesions, (2) erosions, (3) bone defects, (4) sclerosis or hyperostosis, (5) fat inflation, (6) enthesophytes, and (7) fusion. Each was graded on a 2-point scale depending on its presence or absence.

Definitions were as follows: (1) chondral lesions — thinning of the cartilage or exposure of the subchondral bone on FS T2-weighted images; (2) erosions — irregularities or discontinuities of the subchondral or cortical bone in at least 2 different planes, whatever the sequence studied; (3) bone defects — lesions of the trabecular bone with low signal intensity on SE T1-weighted sequences and high signal on FS T2-weighted images with clearly delineated margins and no disruption of the cortical bone; (4) sclerosis or hyperostosis — new bone formation with hypointense signal of the cancellous bone adjacent to the subchondral bone or to ligament, tendon, or capsule attachments on 2 consecutive images using SE T1-weighted sequences or/and FS T2-weighted images; (5) fat inflation — fatty deposits in the trabecular bone in high signal on SE T1-weighted sequences and in low signal on FS sequences, on 2 consecutive images; (6) enthesophyte — substitution of tendon or ligament insertion by new bone formation with hypointense signal on both SE T1-weighted sequences and FS T2-weighted images; and (7) fusion — bony bridging replacing the joint space.

Statistical analysis. Descriptive statistics (percentages) were used to characterize the frequency (N) of the different criteria. Frequencies of inflammatory and structural criteria were recorded as the mean findings of the 2 readers. Intra- and interobserver test-retest reliabilities were calculated by site, using analysis of variance to provide intraclass correlation coefficients (ICC). A 2-way mixed effects model was used. With regard to test-retest reliability, values of 0.5–0.6, $0.6 < ICC \leq 0.8$ and > 0.8 were considered to reflect moderate, good, and excellent reproducibility, respectively. Frequencies were compared with a Fisher exact test. Statistical analysis was performed using SAS® version 8.0 software (SAS Institute, Cary, NC, USA).

RESULTS

MRI inflammatory criteria (Table 2). Inflammatory features were more common peripherally than axially (25.1% vs 16.6%; $p < 0.0001$) with a very similar number of sites (881 peripheral and 879 axial).

Peripheral MRI features. Of the 881 peripheral sites scored, 469 were synovial and 412 entheseal. The frequencies (N) of inflammatory criteria were 28.4% and 21.4%, respectively ($p = 0.002$).

At synovial sites, synovitis was the most frequent inflammatory criterion (N = 69.4%), followed by effusion (N = 25%), BME (N = 22.1%), and tenosynovitis (N = 21%) (Figures 1 and 2). Intra- and interobserver reproducibilities were excellent and moderate for BME and synovitis, respectively; and good and moderate for tenosynovitis, respectively. At entheseal sites, bursitis was most common (N = 46.9%), followed by ligament inflammation (Figure 1). Only ligament inflammation (N = 39.7%) and BME (N = 15%) achieved good intraobserver reproducibility and moderate to good interobserver reproducibility.

Synovitis, BME, tenosynovitis, and ligament inflammation appeared to be the most reliable MRI criteria with which to evaluate synovial and entheseal inflammation in the peripheral region, and frequencies were reasonable.

Axial MRI features. Of 879 axial sites scored, 679 were synovial and 200 entheseal. The frequencies of inflammatory criteria at each site were 11.4% and 34.2%, respectively.

At entheseal sites, ligament inflammation (N = 34.0%) and BME (N = 34.2%) were the most frequent criteria. At synovial sites, they were synovitis (N = 14.1%) and BME (N = 14.0%) (Figure 3).

Good intra- and interobserver reliabilities were not achieved for axial inflammatory lesions in this series.

MRI structural criteria (Table 3). Structural criteria were more frequent at axial (n = 2479) than peripheral (n = 1440) sites (51.8% vs 14.2%, respectively; $p < 0.0001$).

Peripheral MRI features. Of 1440 peripheral sites scored, 840 were synovial and 600 entheseal. The frequencies of structural criteria at each were 15.1% and 12.9%, respectively. At synovial sites, chondral lesions were most frequent (N = 72.1%). Intra- and interobserver reproducibilities were good and moderate, respectively, for erosions (N = 17.1%); both were good for fat inflation (N = 1.4%). At entheseal sites, sclerosis was the most frequent criterion (N = 25.1%). Intra- and interobserver reproducibilities were excellent for fat inflation (N = 8.3%) and excellent and moderate, respectively, for enthesophytes (N = 13.9%) (Figure 2).

Data for erosions (S), enthesophytes (E), and fat inflation (S and E) showed relevant intra- and interobserver reliabilities when evaluating structural lesions at peripheral regions, but fat inflation was rare.

Axial MRI features. Of 2479 axial sites scored, 1499 were synovial and 980 entheseal. Structural criteria were observed with very similar frequencies at synovial (51.3%) and entheseal (52.6%) sites.

At synovial sites, intra- and interobserver reproducibilities were excellent to moderate for chondral lesions and fat inflation, both of which occurred with the highest frequency (N = 86%), as well as for erosions (N = 25.1%) and fusion (N = 41.2%). At entheseal sites, sclerosis was the most frequent criterion (N = 97.7%). Only enthesophytes achieved excellent and moderate intra- and interobserver reproducibility (N = 76.7%).

In the present series, chondral lesions (S), erosions (S), fat inflation (S), fusion (S), and enthesophytes (E) were the only reliable MRI criteria, in terms of intra- and interobserver reproducibility.

Table 2. Frequency and reproducibility of inflammatory criteria.

Inflammatory Criterion	Peripheral				Axial			
	No. Sites	%†	ICC, intra	ICC, inter	No. Sites	%†	ICC, intra	ICC, inter
Synovial (S)								
Synovitis	62	69.4	0.90*	0.58*	212	14.1	0.53*	0.03
BME	181	22.1	0.93*	0.49*	254	14.0	0.76*	0.23
Effusion	62	25.0	0.28	0.96	213	5.6	0.75*	0.39*
Tenosynovitis	164	21.0	0.69*	0.49	0	—		
Total (S)	469	28.4			679	11.4		
Entheseal (E)								
Ligament inflammation	58	39.7	0.66*	0.60*	50	34.0	0.48*	0.11
Bursitis	16	46.9	0.96*	0.29	0	—		
Tendinitis	171	19.0	-0.09	0.63*	0	—		
BME	167	15.0	0.59*	0.66*	150	34.2	0.79*	-0.03
Total (E)	412	21.4			200	34.2		
Total (E+S)	881	25.1**			879	16.6**		

* $p < 0.05$ (ICC); ** $p = 0.0001$ (Fisher exact test); † frequency of site presenting at least one abnormality among the totality of sites assessed. ICC: intraclass correlation coefficient; BME: bone marrow edema.

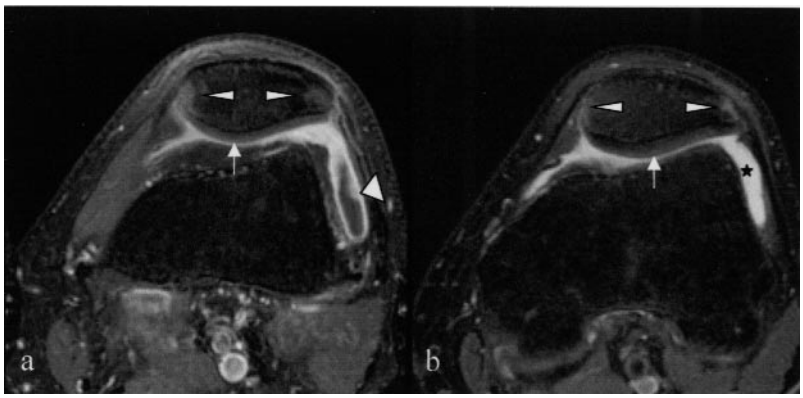

Figure 1. MRI axial examination of the left knee in a 25-year-old patient with ankylosing spondylitis. Synovitis (◁), bone marrow edema (BME) in the entheseal site (◅), and effusion (★) are visible on axial FS T1-weighted post-contrast image (a) and FS T2-weighted image (b). No patellar cartilage lesions were observed (↑).

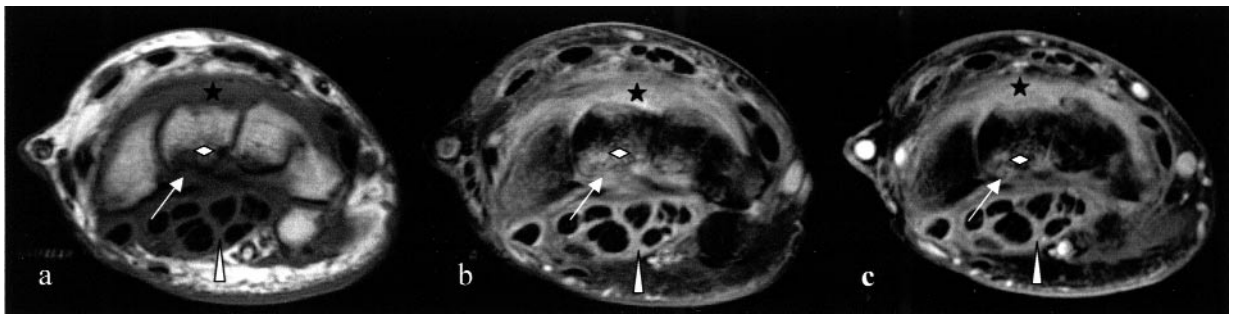

Figure 2. Axial MRI examination of the left wrist in a 39-year-old patient with psoriatic arthritis. Synovitis (★), bone marrow edema in the synovial site (◇), and tenosynovitis (△) are visible on axial SE T1-weighted (a), FS T1-weighted post-contrast (b), and FS T2-weighted images (c). Erosion localized in the synovial site of the capitatum (↑).

DISCUSSION

Our main objective was to assess the reliability of inflammatory and structural criteria observed using routine MRI examination of the most symptomatic region in patients with active SpA. To date, acute and chronic criteria have been investigated only in MRI examinations of the spine — as assessed by Ankylosing Spondylitis Spine MRI scores and the Spondyloarthritis Research Consortium of Canada MRI index

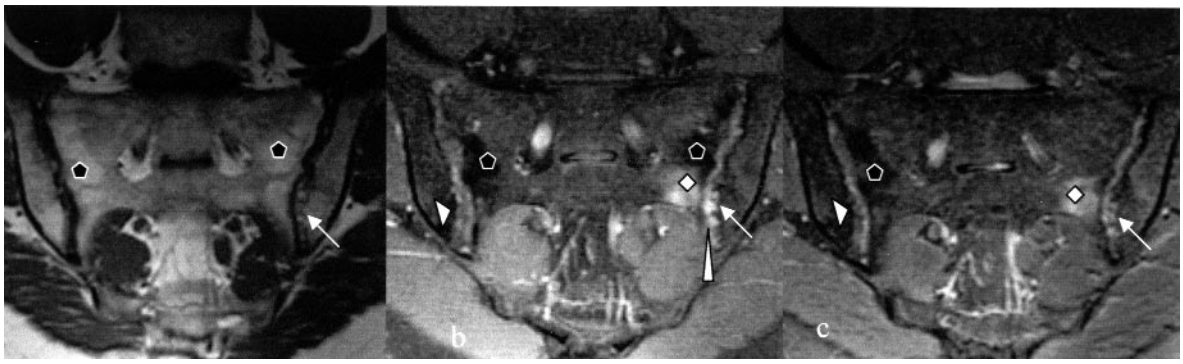

Figure 3. Coronal MRI examination of the sacroiliac joint in a 43-year-old patient with AS. Fat inflation (⬟) is visible on SE T1, FS T1-weighted post-contrast (b) and FS T2-weighted images (c), on both sacral and iliac sides (a). Cartilage lesions (⩒) and erosions (⍓) were scored on FS T1-weighted post-contrast (b) and FS T2-weighted images (c). Concerning inflammatory criteria, bone marrow edema is present on the sacral side of the synovial site (◇) on T1-weighted postinjection and T2-weighted images. Synovitis (△) is localized in the inferior part of the left sacroiliac joint on FS T1-weighted postcontrast images (b).

— and SIJ[9,11,21]. To our knowledge, there are no published data concerning the reproducibility of structural and inflammatory criteria at peripheral sites in SpA.

Peripheral MRI features. Two recent studies described lesions with high frequencies on foot[16] and shoulder[15] MRI in patients with SpA, regardless of whether the joints concerned were symptomatic or asymptomatic. However, these descriptive analyses were performed on consensus readings, and did not explore reliability of inflammatory or structural MRI criteria.

To date, MRI assessments in the peripheral region have looked at small numbers of patients enrolled in clinical trials using 2 different approaches. In the first, a semiquantitative scale is applied to changes in bone and soft tissue lesions before and after therapy. For example, Marzo-Ortega, *et al* looked at 3 knees, 2 hips, and one hand (proximal interphalangeal and metacarpophalangeal joints) in patients with SpA requiring anti-TNF-α[24]. At 24 weeks, improvement in enthesitis, osteitis, and synovitis had occurred at most of the sites considered. Patients who flared most rapidly after stopping etanercept had MRI evidence of persistent enthesitis or osteitis.

The second approach is quantitative and based on dynamic MRI sequences (analysis of the rate and/or the maximal uptake of enhancement). Maksymowych, *et al* and Antoni, *et al* reported decreases in these enhancement variables at a small number of peripheral joints following pharmacological therapy[25,26]. However, such sophisticated MRI procedures require dynamic sequences (usually used in RA to discriminate acute from chronic synovitis) and have yet to be validated for longitudinal followup in RA and SpA[27,28]. Moreover, they depend on good reproducibility of MRI acquisitions and require that the cursor be placed in the same region of interest[29].

It has recently been shown that ultrasound can easily depict both acute and chronic abnormalities at peripheral sites[6-8]. However, it is important to be aware of the technical limits of ultrasound: it does not allow synovitis to be explored in different parts of a joint, and cannot detect bone edema.

Our study uses routine MRI examination at a large number of sites to determine, for the first time, which criteria are reliable means of assessing peripheral involvement in patients with severe SpA. It highlights (in terms of intra- and interobserver reproducibilities and frequency) inflammatory criteria that can be helpful when scoring such involvement.

Inflammatory synovial criteria, particularly synovitis, were more common than inflammatory entheseal criteria (ligament inflammation and BME). Thus, as demonstrated histologically, synovitis could play a crucial role in the evaluation and followup of patients with peripheral involvement[30]. Synovitis, ligament inflammation, tenosynovitis, and BME are of value thanks to their reproducibility and their high frequency in this series.

Ligament inflammation, a classic MRI pattern in SpA, occurred with a high frequency (N = 39.7%), and good intra- and interobserver reproducibility (ICC 0.66 and 0.60, respectively). BME of synovial sites and tenosynovitis was also frequent and exhibited good intraobserver reproducibility.

Erosions (S) and enthesophytes (E) remain the principal structural criteria of interest in the peripheral region. Fat inflation occurred with a low frequency in our study, but this criterion should not be disregarded, considering the number of our examinations. Chondral lesions lack specificity because they are also observed in osteoarthritic joints and joints with trauma history. The high frequency of structural criteria here may be explained by the mean disease duration of 7 years and the mean age of 38.57 years among patients with peripheral involvement.

Axial MRI features. Results at the spine and SIJ have not been analyzed separately, and the low reliability of spinal data probably affects the results of the whole axial analysis, as we have shown elsewhere that some inflammatory criteria (such as BME and synovitis) are reliable in SIJ[21]. With the aim of assessing the reliability of peripheral and axial criteria in the most symptomatic region, axial localization was assessed

Table 3. Frequency and reproducibility of structural criteria.

Structural Criterion	Peripheral				Axial			
	No. Sites	%†	ICC, intra	ICC, inter	No. Sites	%†	ICC, intra	ICC, inter
Synovial (S)								
Chondral lesions	55	72.1	0.64*	0.23	208	85.8	0.97*	0.57*
Erosion	181	17.1	0.71*	0.54*	253	25.1	0.81*	0.53*
Bone defect	181	8.6	0.15	–0.01	253	5.7	–0.04	0.21
Sclerosis	181	19.3	0.23	0.42*	251	77.7	0.86*	–0.14
Enthesophytes	38	7.9	0.09	0.02	248	66.0	0.75*	–0.02
Fat inflation	176	1.4	0.78*	0.76*	82	86.0	0.92*	0.96*
Fusion	28	0.0	—	—	204	41.2	0.92*	0.67*
Total (S)	840	15.1			1499	51.3		
Entheseal (E)								
Sclerosis	169	25.1	0.21	0.58*	64	97.7	0.51	0.14
Erosion	169	12.7	0.25	0.49*	247	41.5	0.77*	0.37*
Fat inflation	24	8.3	1.00	0.96*	163	76.7	0.79*	0.29
Enthesophytes	75	13.9	0.85*	0.49*	236	76.7	0.98*	0.50*
Bone defect	163	0.6	–0.06	–0.04	64	7.0		0.00
Fusion	0	—	—		206	19.2	0.54*	0.29
Total (E)	600	12.9			980	52.6		
Total (E+S)	1440	14.2**			2479	51.8**		

* $p < 0.05$ [intraclass correlation coefficient (ICC)], ** $p < 0.0001$ (Fisher's exact test), † frequency of site presenting at least one abnormality among the totality of sites assessed.

using the same descriptive pattern as for peripheral localization. This approach allows for the assessment of zygapophyseal joints that frequently exhibit enthesitic and synovial processes in SpA[31]. The evaluation of vertebral and zygapophyseal lesions failed due to low intra- and interobserver reproducibility as a result of the high number of sites assessed, the large field of view, and an inadequate plane of view to examine spine structures[10,12,32]. If inflammatory involvement of zygapophyseal joints is frequently observed in our study, we also showed that the sagittal plane is inadequate to examine these joints. An ideal SpA spine evaluation requires sagittal and axial planes, which would be too time-consuming in clinical practice.

Thus, structural and inflammatory data easily obtained with conventional MRI are of use in assessing inflammation of the most symptomatic region among patients with SpA. Our findings suggest that MRI assessment of inflammation in the peripheral region should be of value thanks to validated criteria — as has been shown axially[9,11]. Moreover, validated inflammatory criteria may help the clinician identify patients with active forms of peripheral SpA, and poor responders requiring more aggressive treatment. However, further studies are necessary to confirm the validity and sensitivity to change of the inflammatory and structural criteria described.

Synovitis, ligament inflammation, tenosynovitis, BME, erosions (S), enthesophytes (E), and fat inflation are of most value in assessing acute and chronic lesions in the peripheral region among patients with active disease. In the context of axial involvement, inflammatory criteria lack interobserver reproducibility while chondral lesions (S), erosions (S), fat inflation, fusion (S), and enthesophytes (E) are relevant. Concerning SpA patients with peripheral involvement, for whom axial MRI scores are not well validated and useful, the entheseal and synovial criteria described could allow for assessment of the degree of inflammation and response to treatment.

REFERENCES

1. Braun J, Bollow M, Remlinger G, et al. Prevalence of spondylarthropathies in HLA-B27 positive and negative blood donors. Arthritis Rheum 1998;41:58-67.
2. Gran JT, Husby G, Hordvik M. Prevalence of ankylosing spondylitis in males and females in a young middle-aged population of Tromso, northern Norway. Ann Rheum Dis 1985;44:359-67.
3. Wright V, Roberts MC, Hill AG. Dermatological manifestations in psoriatic arthritis: a follow-up study. Acta Derm Venereol 1979;59:235-40.
4. Saraux A, Guillemin F, Guggenbuhl P, et al. Prevalence of spondyloarthropathy in France. Ann Rheum Dis 2005;64:1431-5.
5. McGonagle D, Marzo-Ortega H, Benjamin M, Emery P. Report on the Second International Enthesitis Workshop. Arthritis Rheum 2003;48:896-905.
6. D'Agostino MA, Said-Nahal R, Hacquard-Bouder C, Brasseur JL, Dougados M, Breban M. Assessment of peripheral enthesitis in the spondylarthropathies by ultrasonography combined with power Doppler: a cross-sectional study. Arthritis Rheum 2003;48:523-33.
7. Balint PV, Kane D, Wilson H, McInnes IB, Sturrock RD. Ultrasonography of entheseal insertions in the lower limb in spondyloarthropathy. Ann Rheum Dis 2002;61:905-10.
8. Milosavljevic J, Lindqvist U, Elvin A. Ultrasound and power Doppler evaluation of the hand and wrist in patients with psoriatic arthritis. Acta Radiol 2005;46:374-85.
9. Braun J, Baraliakos X, Golder W, et al. Magnetic resonance imaging examinations of the spine in patients with ankylosing

spondylitis, before and after successful therapy with infliximab: evaluation of a new scoring system. Arthritis Rheum 2003;48:1126-36.
10. Rudwaleit M, Baraliakos X, Listing J, Brandt J, Sieper J, Braun J. Magnetic resonance imaging of the spine and the sacroiliac joints in ankylosing spondylitis and undifferentiated spondyloarthritis during treatment with etanercept. Ann Rheum Dis 2005;64:1305-10.
11. Maksymowych WP, Inman RD, Salonen D, et al. Spondyloarthritis Research Consortium of Canada magnetic resonance imaging index for assessment of spinal inflammation in ankylosing spondylitis. Arthritis Rheum 2005;53:502-9.
12. Marzo-Ortega H, McGonagle D, Jarret S, et al. Infliximab in combination with methotrexate in active ankylosing spondylitis: a clinical and imaging study. Ann Rheum Dis 2005;64:1568-75.
13. Maksymowych WP, Lambert R, Jhangri GS, et al. Clinical and radiological amelioration of refractory peripheral spondyloarthritis by pulse intravenous pamidronate therapy. J Rheumatol 2001;28:144-55.
14. Cimmino MA, Parodi M, Innocenti S, et al. Dynamic magnetic resonance of the wrist in psoriatic arthritis reveals imaging patterns similar to those of rheumatoid arthritis. Arthritis Res Ther 2005;7:725-31.
15. Lambert RG, Dhillon SS, Jhangri GS, et al. High prevalence of symptomatic enthesopathy of the shoulder in ankylosing spondylitis: deltoid origin involvement constitutes a hallmark of disease. Arthritis Rheum 2004;51:681-90.
16. Erdem CZ, Sarikaya S, Erdem LO, Ozdolap S, Gundogdu S. MR imaging features of foot involvement in ankylosing spondylitis. Eur J Radiol 2005;53:110-9.
17. Dougados M, van der Linden S, Juhlin R, et al. The European Spondylarthropathy Study Group preliminary criteria for the classification of spondylarthropathy. Arthritis Rheum 1991;34:1218-27.
18. Braun J, Pham T, Sieper J, et al. International ASAS consensus statement for the use of anti-tumour necrosis factor agents in patients with ankylosing spondylitis. Ann Rheum Dis 2003;62:817-24.
19. Garrett S, Jenkinson T, Kennedy LG, Whitelock H, Gaisford P, Calin A. A new approach to defining disease status in ankylosing spondylitis: the Bath Ankylosing Spondylitis Disease Activity Index. J Rheumatol 1994;21:2286-91.
20. Calin A, Garrett S, Whitelock H, et al. A new approach to defining functional ability in ankylosing spondylitis: the development of the Bath Ankylosing Spondylitis Functional Index. J Rheumatol 1994;21:2281-5.
21. Bigot JL, Loeuille D, Chary-Valckenaere I, Pourel J, Cao MM, Blum A. Determination of the best MRI criteria for diagnosis of sacroiliitis. J Radiol 1999;80:1649-57.
22. Ostergaard M, Gideon P, Sorensen K, 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;24:212-8.
23. Lassere M, McQueen F, Ostergaard M, et al. OMERACT Rheumatoid Arthritis Magnetic Resonance Imaging Studies. Exercise 3: an international multicenter reliability study using the RA-MRI Score. J Rheumatol 2003;30:1366-75.
24. Marzo-Ortega H, McGonagle D, O'Connor P, Emery P. Efficacy of etanercept in the treatment of the entheseal pathology in resistant spondylarthropathy: a clinical and magnetic resonance imaging study. Arthritis Rheum 2001;44:2112-7.
25. Maksymowych WP, Jhangri GS, Lambert RG, et al. Infliximab in ankylosing spondylitis: a prospective observational inception cohort analysis of efficacy and safety. J Rheumatol 2002;29:959-65.
26. Antoni C, Dechant C, Hanns-Martin Lorenz PD, et al. Open-label study of infliximab treatment for psoriatic arthritis: clinical and magnetic resonance imaging measurements of reduction of inflammation. Arthritis Rheum 2002;47:506-12.
27. Ostergaard M, Stoltenberg M, Lovgreen-Nielsen P, Volck B, Sonne-Holm S, Lorenzen I. Quantification of synovitis by MRI: correlation between dynamic and static gadolinium-enhanced magnetic resonance imaging and microscopic and macroscopic signs of synovial inflammation. Magn Reson Imaging 1998;16:743-54.
28. Cimmino MA, Innocenti S, Livrone F, Magnaguagno F, Silvestri E, Garlaschi G. Dynamic gadolinium-enhanced magnetic resonance imaging of the wrist in patients with rheumatoid arthritis can discriminate active from inactive disease. Arthritis Rheum 2003;48:1207-13.
29. McQueen FM, Crabbe J, Stewart N. Dynamic gadolinium-enhanced magnetic resonance imaging of the wrist in patients with rheumatoid arthritis: comment on the article by Cimmino et al. Arthritis Rheum 2004;50:674-5.
30. Baeten D, Demetter P, Cuvelier C, et al. Comparative study of the synovial histology in rheumatoid arthritis, spondyloarthropathy, and osteoarthritis: influence of disease duration and activity. Ann Rheum Dis 2000;59:945-53.
31. Vlam K, Mielants H, Veys EM. Involvement of zygapopyseal joint in ankylosing spondylitis: relation to the bridging syndesmophyte. J Rheumatol 1999;26:1738-45.
32. Braun J, Bollow M, Sieper J. Radiologic diagnosis and pathology of the spondylarthropathies. Rheum Dis Clin North Am 1998;24:697-735.