Prognostic Significance of Magnetic Resonance Imaging Changes of the Sacroiliac Joints in Spondyloarthritis – A Followup Study

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ABSTRACT. ***Objective.*** To evaluate the prognostic significance of sacroiliac joint (SIJ) changes by magnetic resonance imaging (MRI) based on 2-7 years of followup of patients with axial spondyloarthritis (SpA).

Methods. Ninety-four patients (50 women, 44 men) with axial SpA obtained MRI of the SIJ from 1998-2004. They were examined at followup after 25-95 months (mean 51), including MRI and radiography of the SIJ and the spine. The Danish scoring method was used to quantify the activity and chronic SIJ changes by MRI. The activity score included subchondral edema and/or enhancement, while chronic changes encompassed erosions and subchondral fatty marrow deposition (FMD).

Results. The MR score values for chronic SIJ changes increased significantly during followup, and were most pronounced in HLA-B27-positive patients and patients fulfilling the modified New York criteria for ankylosing spondylitis (AS) at followup. SIJ activity scores ≥ 2, total chronic scores ≥ 1, erosion scores ≥ 1, and FMD scores ≥ 4 at baseline were significantly related to progression of chronic SIJ changes. Activity score values ≥ 3 at baseline had a sensitivity of 0.83, specificity of 0.75, and accuracy of 0.80 in relation to the presence of AS at followup. The similar values for total chronic SIJ scores ≥ 4 at baseline were 0.86, 0.75, and 0.82, respectively, and for erosion scores ≥ 2 they were 0.88, 0.75, and 0.83.

Conclusion. The occurrence of manifest SIJ activity by MRI or chronic changes at baseline was related to progression of chronic changes and the presence of AS at followup. (J Rheumatol First Release June 1 2010; doi:10.3899/jrheum.091155)

Key Indexing Terms:
SACROILIAC JOINTS SPONDYLOARTHRITIS ANKYLOSING SPONDYLITIS
MAGNETIC RESONANCE IMAGING PROGNOSIS

Diagnosis of spondyloarthritis (SpA) primarily involving the axial skeleton is often more challenging than diagnosing peripheral arthritides. Clinical findings in axial SpA are relatively nonspecific in the early stages of the disease, and biochemical findings are essentially limited to acute-phase reactants and HLA-B27, which alone have limited diagnostic value.

Radiographic SpA abnormalities occur late and detect only structural abnormalities in the form of erosion and joint space alteration[1]. This can cause a delay of 5-10 years between the first symptom and the diagnosis[2,3]. However, magnetic resonance imaging (MRI) has proven valuable in the evaluation of SpA. It can visualize features of active inflammation and thereby facilitate earlier diagnosis[4,5,6]. MRI can also be used for quantitative assessment of activity and chronic changes in the SIJ[6,7]. However, the prognostic significance of active inflammatory MRI changes in the sacroiliac joints (SIJ) is unclear and ought to be analyzed in prospective studies of patients not treated with disease-modifying anti-tumor necrosis factor-α (anti-TNF) agents. Only a few prospective studies describe the prognostic value of MRI of the SIJ in patients not treated with anti-TNF[4,5,8]. In early SpA, MRI was found to have a sensitivity of 95% and a specificity of 100% for detecting active sacroiliitis[4]. In somewhat later SpA, the prognostic value of chronic MRI changes had a positive predictive value of 60% for the development of radiographic sacroiliitis ≥ grade 2 after 3 years; the sensitivity was 85% and the specificity 47%[5]. Bennett, *et al* showed that the combination of severe active SIJ inflammation and HLA-B27 positivity predicted with 92% specificity those patients likely to develop ankylosing

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Supported by the Danish Rheumatism Association and the "A.P. Møller og Hustru Chastine Mc-Kinney Møllers Fond til Almene Formal".

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Accepted for publication March 18, 2010.

spondylitis (AS) at followup after 8 years[8]. However, only 13 patients developed AS according to the modified New York criteria[9] and 5 had received anti-TNF therapy.

The use of MRI to diagnose and monitor chronic changes has not been established, partly because of the lack of valid features and quantification methods[10]. Structural damage is therefore mainly assessed by radiography. However, the slow rate of radiographic progression requires at least 2 years of followup before measurable changes are detectable[1,11]. A more sensitive method for evaluating structural damage would therefore be advantageous. We have developed an MRI grading system for this purpose[7] that seems promising, but has to be evaluated for sensitivity to change in longitudinal studies.

Our primary purpose was to evaluate the prognostic significance of SIJ changes by MRI based on 2-7 years' followup of patients with SpA. We also analyzed the new Danish grading system for monitoring change of disease activity and chronicity.

MATERIALS AND METHODS

From 1998 to 2004, MRI of the SIJ was obtained in 132 patients fulfilling the European Spondylarthropathy Study Group (ESSG) criteria for axial SpA[12]. This SpA cohort comprised 41 patients with early SpA[6] in addition to patients with relatively early SpA confirmed by MRI on clinical request. All patients were invited to participate in a radiological and clinical followup study including MRI and radiography of the SIJ. Ninety-five patients agreed to participate, but 1 was excluded for being under 18 years old at the first examination. The main characteristics of the 94 patients included are shown in Table 1. At followup, 58 patients (33 men, 25 women) fulfilled the modified New York criteria for AS[9]; 6 of them had associated inflammatory bowel disease (IBD; Crohn's disease or ulcerative colitis), 12 had preceding urogenital or gastrointestinal infection (reactive AS), and 6 had concomitant psoriasis. Further, 11 patients without AS had psoriasis, 1 had IBD, and 6 had a preceding infection. Two patients with psoriasis and reactive arthritis, respectively, had concomitant peripheral arthritis. Only 2 patients were treated with an anti-TNF agent for a period during followup.

The 37 patients (20 men, 17 women) not reattending for a followup examination did not differ significantly from those included. Their mean/median age at the primary MRI was 30.6/31.0 years (range 20-43). Eight patients had psoriasis, 2 had IBD, and 19 of 35 patients tested had HLA-B27.

The primary MRI of the SIJ was performed with a 1.5 T Siemens Vision scanner (Erlangen, Germany). Sequences were semicoronal T1-weighted spin echo (T1) and at least 1 semiaxial sequence visualizing inflammation, short tau inversion recovery (STIR), and/or a postcontrast T1 fat-saturated (T1FS) sequence.

The followup examinations were performed from 2005 to 2008 with a 1.5 T Siemens Magnetom Symphony scanner using a multiarray spine and a body array coil. The slice orientation for the SIJ examinations was standardized; semiaxial slices were parallel to the upper vertebral plate of S1 and semicoronal slices perpendicular to the semiaxial slices. Sequences were semicoronal T1 [TR/TE: 405/12 ms; time of acquisition (TA): 6.03 min], semicoronal T1FS (TR/TE: 660/12 ms; TA: 5.50 min), semiaxial STIR (TR/TE/TI: 4000/30/150; TA: 7.30 min), and semicoronal and semiaxial T1FS sequence after gadolinium contrast [0.2 ml/kg (0.1 mmol/kg) Magnevist or Omniscan; maximum 15 ml]. For all sequences the matrix was 512, the field of view 24 cm, and the slice thickness 4 mm.

The study complied with the Helsinki Declaration for medical research and was approved by the local ethics committee and the Danish Data Protection Agency. All participants were informed orally and in writing about the study and gave their written consent.

Evaluation of the MR images. MRI examinations were evaluated by a senior radiologist blinded to radiographic, clinical, and biochemical findings. The recently published Danish quantification method for SIJ changes in SpA was used (Table 2)[7]. The method has proven a reliable interobserver and intraobserver agreement with linear kappa values at patient level between 0.72 and 0.89 for signs of activity and 0.80-0.90 for chronic changes.

The SIJ was evaluated at 4 osseous locations: the sacral and iliac subchondral/subcortical bone at the cartilaginous and ligamentous part of the

Table 1. Characteristics of the 94 patients examined at followup.

Characteristics	All 94 Patients Number or Mean	Median	Range	Missing Values (No. Patients)	AS*, n = 58 Number or Mean	Psoriasis, n = 17 Number or Mean
Women/men	50/44				25/33	10/7
Age at baseline, yrs	32.84	33	15–49		33.4	36.9
Age at followup, yrs	36.6	37	18–51		37.03	44.5
Followup period, mo	51	48	25–95		48	46
Symptom duration at initial MRI, yrs	4	3	0–25		4	6
Symptom duration at followup, yrs	8	7	3–27		8	10
HLA-B27-positive/negative	55/36			3	40/17	7/9
Ankylosing spondylitis at followup*	58			4	58	6
CRP above normal (≥ 75 nmol/l)	9			8	7	1
BASDAI	3.2	2.8	0–9	14	2.9**	3.1
BASFI	2.1	1.4	0–9	14	1.9**	1.8
BASMI	0.4	0	0–6	6	0.5***	0.4

* Ankylosing spondylitis according to the modified New York criteria[9]. ** Based on data in 51 patients; *** based on data in 54 patients. MRI: magnetic resonance imaging; CRP: C-reactive protein; BASDAI: Bath Ankylosing Spondylitis Disease Activity Index; BASFI: BAS Functional Index; BASMI: BAS Metrology Index.

Table 2. The composition and ranges of SIJ scores. The extent of activity, fatty marrow deposition, and erosion was divided into 4 grades: (0) normal; (1) slight: < 25% of the joint area; (2) moderate: 25–< 50%; and (3) severe: ≥ 50%. Intensity and depth were score dichotomously with a value of 1 for pronounced increased signal intensity comparable to that of the spinal fluid at STIR or enhanced great vessels at T1FS postcontrast images and depth > 1 cm. Erosions were assessed only at the cartilaginous joint portion; the presence of partial or complete ankylosis added a score value of 1 or 2, respectively.

Activity Score	Each Joint Location	Joint Level	Patient Level
Edema or Enhancement			
Extent	0–3	0–12	0–24
Intensity	0–1	0–4	0–8
Depth	0–1	0–4	0–8
Total activity score	0–5	0–20	0–40
Chronic Score			
Fatty Marrow Deposition			
Extent	0–3	0–12	0–24
Depth	0–1	0–4	0–8
Bone Erosion	0–3	0–6	0–12
Additional ankylosis	0–2	0–2	0–4
Total chronic score	0–9	0–24	0–48

SIJ: sacroiliac joint; STIR: short tau inversion recovery; T1FS: T1 fat saturated.

joint, respectively. Each joint was analyzed for the occurrence of both activity and chronic changes (Table 2)[7]. Signs of SIJ disease activity included bone marrow edema and/or bone marrow enhancement detectable by STIR and T1FS postcontrast images, respectively. The findings were graded according to extent, depth, and intensity of the edema/enhancement, resulting in a total maximum activity score of 40 for a patient by STIR and T1FS postcontrast. The mean values of the grading by STIR and postcontrast T1FS were used if both were available, being the case for all followup examinations (Table 2)[7]. Chronic changes in the form of erosions and fatty marrow deposition (FMD) were primarily evaluated on T1 and T1FS images and graded according to the extent of osseous changes, resulting in a total maximum chronic score of 48 for a patient (Table 2)[7].

Radiographic data. Ninety patients agreed to radiography of the SIJ in connection with the MRI. All radiographs were evaluated and classified according to the modified New York criteria[9] on dedicated work stations with high-resolution screens by a radiologist blinded to MRI, clinical, and biochemical findings. An acceptable intraobserver variation has been demonstrated with a kappa value of 0.76[7].

Clinical data. Ninety-two participants were evaluated by an experienced rheumatologist in connection with the MRI followup examination, and 86 patients obtained biochemical examinations. The Bath Ankylosing Spondylitis Metrology Index (BASMI)[13] was obtained in 88 patients, and the Bath Ankylosing Spondylitis Disease Activity Index (BASDAI)[14] and the Bath Ankylosing Spondylitis Functional Index (BASFI)[15] in 80 patients (Table 1).

Data analyses. The data were analyzed using Analyze-IT software and STATA. Nonparametric t-tests were used to compare mean values; Pearson's chi-squared and Fisher's exact tests to compare proportions; Spearman's method to analyze correlations, and the paired Wilcoxon test to compare baseline and followup data.

RESULTS

MRI findings. At baseline, MRI abnormalities of the SIJ occurred in 87 (93%) of the 94 patients; 82 (87%) had signs of activity and 80 (85%) had chronic changes (Figure 1). Coexistence of activity and chronic changes occurred in 75 patients while 7 had only activity and 5 only chronic changes.

At followup, 91 patients (96%) had SIJ abnormalities by MRI; 86 (91%) had signs of activity and 86 had chronic changes (Figure 2). Four patients with normal MRI findings at baseline developed signs of activity (n = 2), chronic changes (n = 1), and both activity and chronic changes (n = 1). Three patients had no SIJ MRI abnormalities at baseline and followup.

The mean and median activity and chronic MRI scores are shown in Table 3. The mean total activity score increased from baseline to followup, but not significantly. The activity score increased in 48 patients (51%) with a mean value of 6.2 (range 0.5-21) and decreased in 28 patients (30%) with a mean value of 5.9 (range 0.5-15.5), while 18 patients had unchanged activity scores ranging from 0 to 14 with a mean of 2.7.

The mean total chronic score, erosion, and FMD scores increased significantly from baseline to followup (Wilcoxon tests; $p < 0.0001$; Table 3). The chronic score increased in 70 patients (74%), decreased in 6 patients, and was unchanged in 18 patients (19%), including the 3 patients with normal SIJ (Table 4).

The total activity score values at baseline were significantly correlated to the total chronic score values at followup ($\rho = 0.63$, $p < 0.0001$). A significant correlation also occurred for activity corresponding to the 2 joint portions separately with $\rho = 0.59$ ($p < 0.0001$) for the cartilaginous and $\rho = 0.53$ ($p < 0.0001$) for the ligamentous joint portion, respectively.

Total SIJ activity score values ≥ 2 at baseline were significantly related to progression of chronic SIJ changes ($p = 0.02$). Activity changes in the ligamentous part of the SIJ seemed more strongly related to progression than activity in the cartilaginous part. Thus, the occurrence of activity scores ≥ 1 in the ligamentous part was to a greater extent related to progression of chronic changes ($p = 0.02$) than scores ≥ 1 in the cartilaginous part ($p = 0.04$).

There was a significant relation between total chronic score values ≥ 1 ($p < 0.01$), erosion scores ≥ 1 ($p = 0.01$), and FMD scores ≥ 4 ($p < 0.01$) at baseline and progression of total chronic SIJ scores during followup.

Sixty-four of the patients (78%) with signs of activity at baseline developed or had progression of chronic changes at followup, including 4 of the 7 patients with only activity changes at baseline. Regression of disease activity in 28 patients was accompanied by progression of chronic changes in 20, while all 5 patients with only chronic changes at baseline progressed in erosion score.

Relation of MRI findings to radiographic changes. Fifty-eight of the 90 patients obtaining radiography at followup fulfilled the modified New York criteria for AS[9].

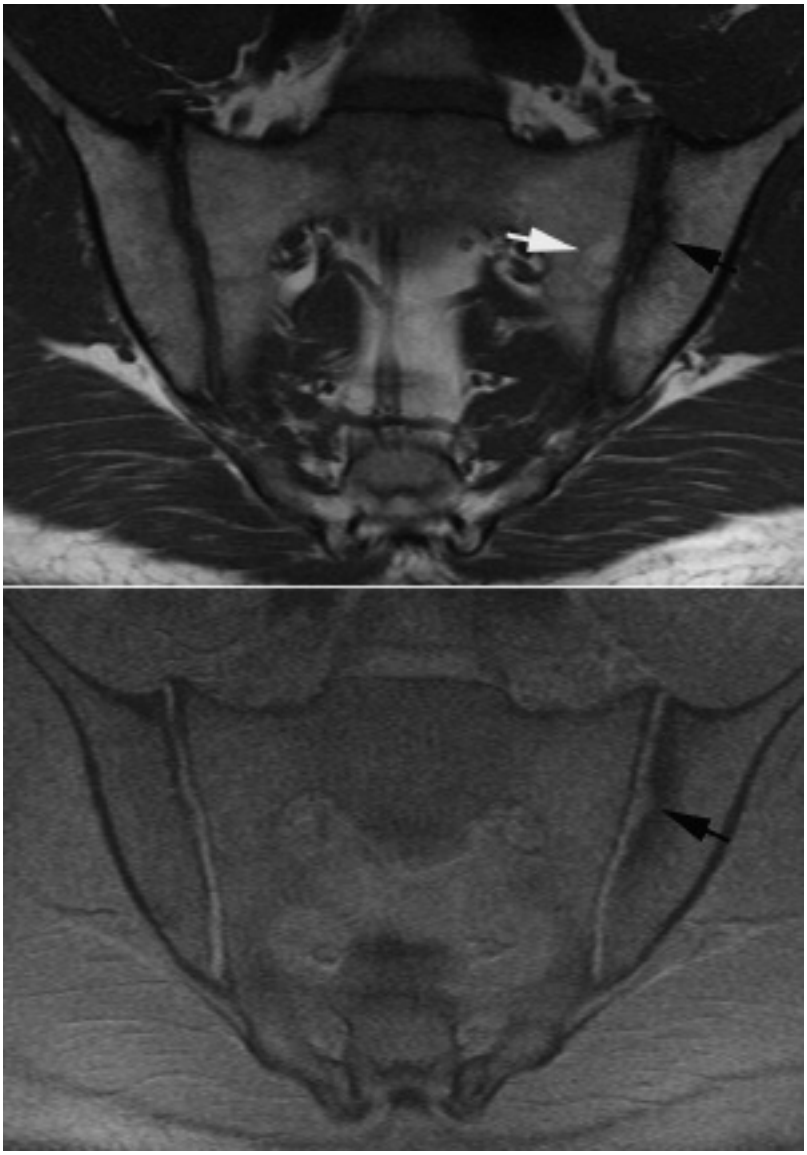

Figure 1. Primary magnetic resonance imaging, semicoronal T1 (upper image) and T1 fat-saturated images showing slight chronic changes in the form of left-sided erosion (black arrow) of the iliac joint facet and slight subchondral fatty marrow deposition in the sacrum (white arrow). There were no signs of disease activity at this time.

Fifty-seven of the 58 patients had chronic MRI changes at baseline and 55 had activity changes. The chronic score values increased significantly from baseline to followup in these 58 patients with AS. Mean values and ranges were 12.8 (0-36) at baseline and 21.8 (1-48) at followup ($p < 0.0001$). However, the difference regarding activity scores was not significant, with mean values (ranges) 8.6 (0-27.5) and 9.9 (0-26.5) at baseline and followup, respectively.

The sensitivity, specificity, and accuracy for different levels of total SIJ activity score, total chronic score, and erosion and FMD scores at baseline in relation to the presence of AS according to the modified New York criteria at followup are shown in Table 5. This table can be used to select the most appropriate cutoff values for the MRI scores, taking the sensitivity, specificity, and accuracy into account.

Relation of MRI findings to HLA-B27 and psoriasis. Patients with HLA-B27 had a significantly higher mean chronic score at baseline than patients who were HLA-B27 negative ($p = 0.0008$), and the significant rise in chronic score was highest for patients who were HLA-B27 positive (Table 6). Regression of chronic changes was only observed in 1 patient who was HLA-B27 positive, compared with 5 of the patients who were HLA-B27 negative (Table 4). The activity score increased slightly in both groups, but not significantly. The administration of anti-TNF in 2 patients who were HLA-B27 positive had a slight but not significant

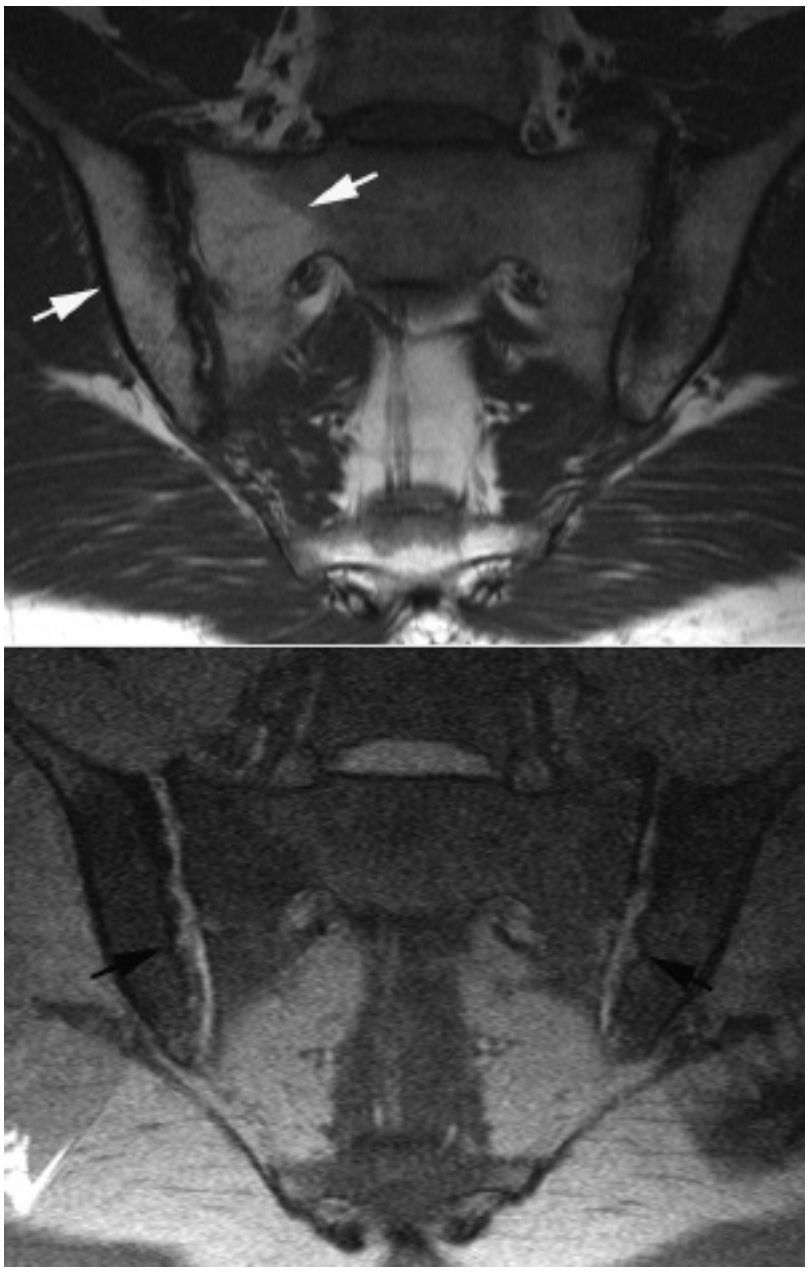

Figure 2. Followup magnetic resonance imaging, 5 years later: semicoronal T1 (upper image) and T1 fat-saturated images showing pronounced chronic changes in the form of bilateral erosion (black arrows) and fatty marrow deposition (white arrows).

Table 3. Score values at baseline and followup for all 94 patients, mean and median values, and ranges.

	Baseline, mean/median (range)	Followup, mean/median (range)	p
Total active score	6.4/4 (0–27.5)	7.9/4.5 (0–26.5)	0.059
Edema	6.7/4 (0–28)	8.2/5 (0–28)	0.054
Enhancement	6.2/4 (0–27)	7.6/4 (0–27)	0.069
Total chronic score	9.3/7.5 (0–36)	16.0/12 (0–48)	< 0.0001
Erosions	4.5/4 (0–14)	6.3/6 (0–14)	< 0.0001
Fatty marrow deposition	4.8/2 (0–25)	9.4/6 (0–32)	< 0.0001

influence on this result. The SIJ activity score decreased in both patients with score values of 3 and 9, respectively, and in 1 of them the chronic score decreased, by a value of 1.

The chronic score values increased significantly from baseline to followup in the 17 patients with psoriasis. Mean values and ranges were 3.8 (0-12) and 11.1 (0-33), respectively ($p < 0.01$). The difference regarding activity scores was not significant: mean values and ranges were 4.7 (0-17) and 5.7 (0-26.5) at baseline and followup, respectively. There were, however, some differences related to the fulfillment of the modified New York criteria for AS[9]. The 6

Table 4. Change of total chronic score in progression, regression, and stable values in HLA-B27-positive or negative patients. Three patients had unknown HLA-B27 status. Two of them progressed with score values of 5 and 15, and 1 had an unchanged score.

Change of Chronic Score	HLA-B27-positive	HLA-B27-negative
Progression		
No. of patients (%)	47 (84)	21 (58)
Mean change (range)	10.19 (1–31)	7 (1–25)
Regression		
No. of patients (%)	1 (2)	5 (14)
Mean change (range)	1 (9)	2.8 (1.7)
Stable chronic score		
No. of patients	8	9

Table 5. MRI score values in the 90 patients obtaining radiography at followup, 86 of whom had radiographic signs of sacroiliitis; sensitivity, specificity, and accuracy of MRI abnormalities at baseline in relation to the presence of ankylosing spondylitis according to the modified New York criteria[9] in 58 patients at followup.

	No. Patients	Sensitivity	Specificity	Accuracy
Total activity score				
0	12	0.05	0.72	0.29
≥ 1	78	0.95	0.28	0.71
≥ 2	67	0.88	0.50	0.74
≥ 3	56	0.83	0.75	0.80
≥ 4	52	0.78	0.78	0.78
Total chronic score				
0	13	0.02	0.63	0.23
≥ 1	77	0.98	0.38	0.77
≥ 2	64	0.90	0.63	0.80
≥ 3	60	0.86	0.69	0.80
≥ 4	58	0.86	0.75	0.82
Erosion score				
0	15	0.02	0.56	0.21
≥ 1	75	0.98	0.44	0.79
≥ 2	59	0.88	0.75	0.83
≥ 3	54	0.81	0.78	0.80
≥ 4	43	0.72	0.97	0.81
Fatty marrow deposition score				
0	31	0.17	0.34	0.23
≥ 1	59	0.83	0.66	0.77
≥ 2	53	0.78	0.75	0.77
≥ 3	41	0.60	0.81	0.68
≥ 4	37	0.57	0.88	0.68

patients with psoriasis fulfilling the criteria at followup had a mean activity score value (range) at baseline of 6.1 (0-24) compared with 4.0 (0-34) in the 11 non-AS patients with psoriasis, and the difference was more pronounced at followup: 8.3 (1-12) and 4.3 (0-29), respectively. The erosion score values were also highest in the patients with psoriatic AS. Their mean erosion score was 3.7 (range 1-8) at baseline compared with 2.0 (range 0-7) in the patients without AS, and the difference was more pronounced at followup: 5.7 (1-9) and 2.7 (0-10), respectively.

Relation of MRI findings to other clinical and biochemical findings. No significant relations were observed between the SIJ scores obtained by MRI and BASDAI, BASFI, BASMI, and C-reactive protein, including analysis of patients with BASDAI > 4 and ≤ 4. However, patients with progression of chronic changes were older (mean age 51.3 years) and had longer disease duration (10.9 years) at followup compared with patients showing unchanged or reduced chronic score values (mean age 37.2, mean disease duration 8.6 years).

DISCUSSION

Our study described the course of SIJ abnormalities by MRI in patients with SpA not treated with anti-TNF, with the exception of 2 patients. This is in contrast to a variety of anti-TNF interventional studies[16,17]. The patients initially had axial SpA at different stages, but most of them had relatively early and mild disease (Table 1) and did not fulfill the Assessment of SpondyloArthritis International Society (ASAS) recommendations for anti-TNF therapy[18]. Further, the proportion of women (53%) and of patients who were HLA-B27 positive (60%) differs from SpA studies using the modified New York criteria at study inclusion[16]. This may partly be explained by the inclusion of 17 patients with sacroiliitis associated with psoriasis and 7 with IBD. Ten (59%) of the patients with psoriasis were women and HLA-B27 occurred in only 7 of 16 tested patients with psoriasis (Table 1).

The cohort was inhomogeneous and 3 of the patients never did develop SIJ abnormalities by MRI, but fulfilled the ESSG criteria[12] and also the new ASAS classification criteria for axial SpA[19] because of the occurrence of psoriasis, IBD, and/or HLA-B27, in addition to inflammatory back

Table 6. Score values at baseline and followup in 55 HLA-B27-positive and 36 negative patients, with mean values and ranges.

	HLA-B27-Positive			HLA-B27-Negative		
	Baseline Mean (range)	Followup Mean (range)	p	Baseline Mean (range)	Followup Mean (range)	p
Total active score	7.7 (0–27.5)	9.1 (0–26.5)	0.19	4.7 (0–23)	6.0 (0–25)	0.26
Edema	8.0 (0–28)	9.4 (0–28)	0.20	4.8 (0–23)	6.2 (0–25)	0.24
Enhancement	7.4 (0–27)	8.8 (0–27)	0.19	4.5 (0–23)	5.8 (0–25)	0.29
Total chronic score	11.8 (0–36)	20.3 (0–36)	< 0.0001	6.0 (0–28)	9.8 (0–44)	< 0.001
Erosions	5.7 (0–14)	8 (0–14)	< 0.0001	2.8 (0–12)	4.0 (0–13)	< 0.005
Fatty marrow deposition	6.0 (0–25)	11.9 (0–32)	< 0.0001	3.1 (0–17)	5.7 (0–30)	< 0.001

pain. The mean/median symptom duration was 4/3 years at baseline, so it is possible that some of the patients fulfilled the modified New York criteria at baseline, when radiography was not always obtained. The finding of a chronic score range up to 36 supports this, but most of the patients had relatively mild disease reflected by mean/median chronic score values of 9.3/7.5 at baseline.

Despite the inhomogeneity, conclusions can be drawn about the disease course not modified by anti-TNF in patients presenting with inflammatory back pain and clinically suspected and/or imaging-confirmed sacroiliitis.

The presence of SIJ changes by MRI, in addition to HLA-B27, were found to imply a high risk for disease progression and were thus important prognostic factors. Most patients without HLA-B27 also had progressive disease, but to a lesser extent. Progression of chronic SIJ changes was observed in 74% of the patients, implying that MRI for monitoring chronic changes with the Danish scoring method[7] is more sensitive than radiography. Chronic SIJ changes have in other studies been difficult to assess by MRI[20] and there is no universally accepted MRI scoring system for chronic SIJ changes in SpA[10].

Using radiography, SIJ progression was observed in only 9% of the patients after 4 years[21]. This minimal change has implied that evaluation of radiographic progression in AS usually is based on lumbar and cervical spine examinations instead of SIJ radiography. For comparison, radiographic progression in the lumbar and cervical spine occurred in approximately 40% of the patients after 4 years[21].

Our study showed that the occurrence of MRI activity signs at the SIJ with score values ≥ 2 at baseline was significantly related to progression of chronic SIJ changes by MRI. Activity changes in the ligamentous joint portion seemed more important (related to progression) than changes in the cartilaginous portion. Evaluation between the 2 anatomically different joint portions has only been performed in 1 followup study, including 34 patients followed for a 1-year period[22]. The results were comparable to ours, although limited because of the small number of participants. Also, a possible regression of chronic changes was observed[22], consistent with the regression detected in 6 of our patients. The regression observed could be caused by intraobserver variation or true regression, e.g., in patients with reactive arthritis.

Although significant relations reflect that activity changes often were succeeded by chronic changes, that was not always the case. Eighteen patients with signs of activity at baseline did not progress in chronic score, and progression of chronic changes was not observed in 8 patients with regression of disease activity. The occurrence of chronic SIJ changes may be more predictive for progressive structural damage. Thus, all 5 patients with only chronic changes at baseline progressed in erosion score.

The MRI evaluation method has been compared with radiography of the SIJ and found to be valid for detecting chronic changes[7]. The relations found are therefore comparable with those obtained by radiography if the higher sensitivity of MRI is taken into account. The specificity of the SpA-related MRI changes compared with degenerative changes could not be determined in our study. However, in the cross-sectional study by Brandt, *et al*[2] encompassing 58 patients with axial SpA and 68 with mechanical low back pain, active MRI changes in the SIJ had both a high sensitivity (87.9%) and specificity (98.5%). By comparison, the sensitivity for active spinal lesions was low (40.9%).

The sensitivity, specificity, and accuracy of the SpA-related SIJ changes by MRI at baseline in relation to the presence of AS according to the modified New York criteria at followup could be determined. Activity score values ≥ 3 at baseline had a sensitivity of 0.83, specificity 0.75, and accuracy 0.80. The similar values for total chronic SIJ scores ≥ 4 at baseline were 0.86, 0.75, and 0.82, respectively, and for erosion scores ≥ 2 were 0.88, 0.75, and 0.83, respectively. FMD scores ≥ 1 had a high sensitivity but relatively low specificity (Table 5).

Three previous reports addressed the predictive value of MRI of the SIJ for diagnosing sacroiliitis[4,5,8]. In the study by Blum, *et al*[4], 44 patients with clinically diagnosed sacroiliitis had a baseline MRI with contrast enhancement that was compared with the findings in 20 controls. Sixteen of 17 patients without radiographic changes at baseline had signs of activity by MRI, which in 11 was succeeded by radiographic sacroiliitis after 1.5-2.5 years. In the study by Oostveen, *et al*[5], 25 patients who were HLA-B27 positive with inflammatory back pain and minor changes by radiography (≤ grade 2 unilateral sacroiliitis) had baseline MRI using T1, T2, and T2FS sequences. Chronic MRI changes were graded according to the grading of radiographic changes, and the positive predictive value of chronic MRI changes ≥ grade 2 for the development of radiographic sacroiliitis ≥ grade 2 after 3 years was 60%. Marrow edema was a less common finding and its diagnostic value was not stated. The duration of symptoms was much longer (mean 4 years) than in the Blum study[4,5]. These results are not directly comparable with ours as they did not analyze the ligamentous joint portions, although axial slices were performed. In the study by Bennett, *et al*[8] encompassing 40 patients followed for 8 years, the combination of severe active SIJ inflammation and HLA-B27 positivity was found to be an excellent predictor of future AS. This is in accordance with our findings. Further, in two 1-year followup studies, the combination of SIJ changes by MRI and HLA-B27 was also found associated with disease progression[22,23]. The disease progression related to HLA-B27 can be explained by the close association between this genetic marker and AS. Further, that progression of reactive arthritis to a chronic disease occurs especially in patients who were HLA-B27 positive[24].

The present scoring method used to evaluate SIJ activity changes has the advantage of being usable with either STIR and/or postcontrast images (Figure 3). In a blinded analysis it was shown that active bone marrow abnormalities in patients with SpA were detected nearly equally well with STIR and postcontrast T1FS sequences, with STIR being most sensitive to visualize active abnormalities in the periphery of chronic changes[25]. The costly gadolinium enhancement showed the only advantage over STIR in detecting small localized subchondral lesions.

To our knowledge only 2 methods for detailed scoring of chronic SIJ changes have been published[6,7,10]. They both include assessment at 4 osseous positions, the iliac and sacral side of the cartilaginous and ligamentous portion of the joint. The first method proposed included sclerosis and erosion in addition to joint space width[6]. MRI was found superior to radiography in the staging of sacroiliitis, but the interobserver agreement was moderate to poor. The agreement involving sclerosis and joint space alteration by MRI was especially poor. Although the method was able to detect disease progression[22], it was not optimal. The detection of sclerosis by MRI may be difficult because of varying appearance[6]. Regions displaying significantly increased density by computed tomography compatible with the definition of sclerosis do not always appear with low signal intensity at all MRI sequences. They can contain areas with increased signal intensity at STIR and/or contrast enhancement as signs of inflammatory activity. Moreover, they can display regions with increased signal intensity at T1 as a sign of fat deposition in the bone marrow. Detection of joint space alteration by MRI may also be difficult[6]. The SIJ in AS can initially show pseudo-widening followed by gradual narrowing until there is definite ankylosis, so an apparently normal joint width may be abnormal[6]. The importance of

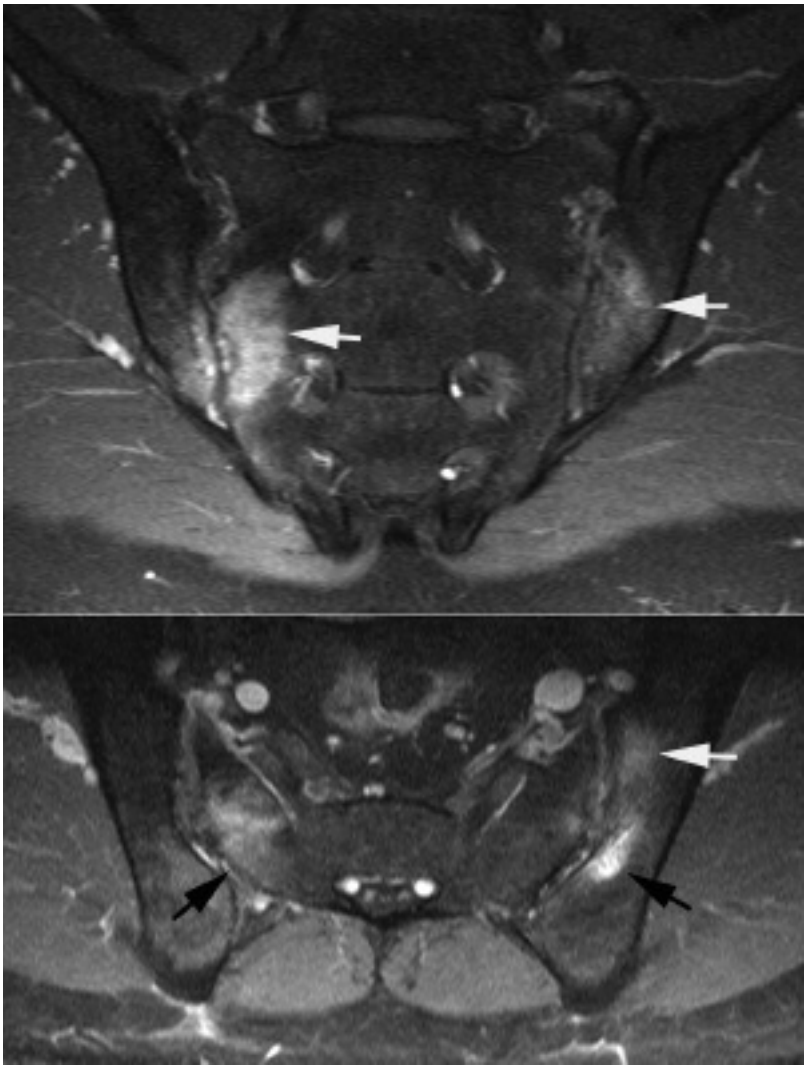

Figure 3. Semicoronal (upper image) and semiaxial T1 fat-saturated postcontrast images showing pronounced activity both in the cartilaginous (white arrows) and the ligamentous part of the joint (black arrows).

FMD as a sign of chronic changes was subsequently reported to be correlated to higher radiographic scores[26]. Based on extended knowledge and experience, the Danish researchers therefore elaborated a more valid SIJ scoring method with a justifiable exclusion of sclerosis and joint space alteration as well as inclusion of FMD[7]. The modified method included only erosion and fat deposition in the subchondral bone marrow as measures for chronic changes[7]. The interobserver and intraobserver agreement of this method was good and it was therefore used in our study. Based on our analysis, the method seems to be sensitive to change, but needs to be evaluated in cohorts of patients treated with anti-TNF agents, especially regarding chronic changes.

The occurrence of manifest activity or chronic SIJ changes by MRI in patients with relatively early stages of axial SpA implied a significant risk for progressive structural changes in the SIJ consistent with AS, especially in patients who were HLA-B27 positive. The presence of disease activity in the ligamentous portion of the SIJ seems more predictive for disease progression than changes in the cartilaginous joint portion.

REFERENCES

1. Baraliakos X, Listing J, Brandt J, Haibel H, Rudwaleit M, Sieper J, et al. Radiographic progression in patients with ankylosing spondylitis after 4 yrs of treatment with the anti-TNF-alpha antibody infliximab. Rheumatology 2007;46:1450-3.
2. Brandt HC, Spiller I, Song IH, Vahldiek JL, Rudwaleit M, Sieper J. Performance of referral recommendations in patients with chronic back pain and suspected axial spondyloarthritis. Ann Rheum Dis 2007;66:1479-84.
3. Feldtkeller E, Khan MA, van der Heijde D, van der Linden S, Braun J. Age at disease onset and diagnosis delay in HLA-B27 negative vs. positive patients with ankylosing spondylitis. Rheumatol Int 2003;23:61-6.
4. Blum U, Buitrago-Tellez C, Mundinger A, Krause T, Laubenberger J, Vaith P, et al. Magnetic resonance imaging (MRI) for detection of active sacroiliitis - a prospective study comparing conventional radiography, scintigraphy, and contrast enhanced MRI. J Rheumatol 1996;23:2107-15.
5. Oostveen J, Prevo R, den Boer J, van de Laar M. Early detection of sacroiliitis on magnetic resonance imaging and subsequent development of sacroiliitis on plain radiography. A prospective, longitudinal study. J Rheumatol 1999;26:1953-8.
6. Puhakka KB, Jurik AG, Egund N, Schiottz-Christensen B, Stengaard-Pedersen K, van Overeem Hansen G, et al. Imaging of sacroiliitis in early seronegative spondylarthropathy. Assessment of abnormalities by MR in comparison with radiography and CT. Acta Radiol 2003;44:218-29.
7. Madsen KB, Jurik AG. MRI grading system for active and chronic spondyloarthritis changes in the sacroiliac joint. Arthritis Care Res 2010;62:11-8.
8. Bennett AN, McGonagle D, O'Connor P, Hensor EM, Sivera F, Coates LC, et al. Severity of baseline magnetic resonance imaging-evident sacroiliitis and HLA-B27 status in early inflammatory back pain predict radiographically evident ankylosing spondylitis at eight years. Arthritis Rheum 2008;58:3413-8.
9. van der Linden S, Valkenburg HA, Cats A. Evaluation of diagnostic criteria for ankylosing spondylitis. A proposal for modification of the New York criteria. Arthritis Rheum 1984;27:361-8.
10. van der Heijde DM, Landewé RB, Hermann KG, Jurik AG, Maksymowych WP, Rudwaleit M, et al. Application of the OMERACT filter to scoring methods for magnetic resonance imaging of the sacroiliac joints and the spine. Recommendations for a research agenda at OMERACT 7. J Rheumatol 2005; 32:2042-7.
11. van der Heijde D, Landewé R, Einstein S, Ory P, Vosse D, Ni L, et al. Radiographic progression of ankylosing spondylitis after up to two years of treatment with etanercept. Arthritis Rheum 2008;58:1324-31.
12. Dougados M, van der Linden S, Juhlin R, Huitfeldt B, Amor B, Calin A, et al. The European Spondylarthropathy Study Group preliminary criteria for the classification of spondylarthropathy. Arthritis Rheum 1991;34:1218-27.
13. Madsen OR, Hansen LB, Rytter A, Suetta C, Egsmose C. The Bath metrology index as assessed by a trained and an untrained rater in patients with spondylarthropathy: a study of intra- and inter-rater agreements. Clin Rheumatol 2009;28:35-40.
14. 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.
15. Calin A, Garrett S, Whitelock H, Kennedy LG, O'Hea J, Mallorie P, 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.
16. Lambert RG, Salonen D, Rahman P, Inman RD, Wong RL, Einstein SG, et al. Adalimumab significantly reduces both spinal and sacroiliac joint inflammation in patients with ankylosing spondylitis: a multicenter, randomized, double-blind, placebo-controlled study. Arthritis Rheum 2007;56:4005-14.
17. Maksymowych WP, Inman RD, Salonen D, Dhillon SS, Williams M, Stone M, et al. Spondyloarthritis research Consortium of Canada magnetic resonance imaging index for assessment of sacroiliac joint inflammation in ankylosing spondylitis. Arthritis Rheum 2005;53:703-9.
18. Zochling J, van der Heijde D, Burgos-Vargas R, Collantes E, Davis JC Jr, Dijkmans B, et al. ASAS/EULAR recommendations for the management of ankylosing spondylitis. Ann Rheum Dis 2006;65:442-52.
19. Rudwaleit M, van der Heijde D, Landewé R, Listing J, Akkoc N, Brandt J, et al. The development of Assessment of Spondyloarthritis international Society (ASAS) classification criteria for axial spondyloarthritis (part II): validation and final selection. Ann Rheum Dis 2009;68:777-83.
20. Heuft-Dorenbosch L, Landewé R, Weijers R, Wanders A, Houben H, van der Linden S, et al. Combining information obtained from magnetic resonance imaging and conventional radiographs to detect sacroiliitis in patients with recent onset inflammatory back pain. Ann Rheum Dis 2006;65:804-8.
21. Wanders AJ, Landewé RB, Spoorenberg A, Dougados M, van der Linden S, Mielants H, et al. What is the most appropriate radiologic scoring method for ankylosing spondylitis? A comparison of the available methods based on the Outcome Measures in Rheumatology Clinical Trials filter. Arthritis Rheum 2004; 50:2622-32.
22. Puhakka KB, Jurik AG, Schiøttz-Christensen B, Hansen GV, Egund N, Christiansen JV, et al. MRI abnormalities of sacroiliac joints in early spondylarthropathy: a 1-year follow-up study. Scand J Rheumatol 2004;33:332-8.
23. Marzo-Ortega H, McGonagle D, O'Connor P, Hensor EM, Bennett AN, Green MJ, et al. Baseline and 1-year magnetic resonance imaging of the sacroiliac joint and lumbar spine in very early inflammatory back pain. Relationship between symptoms, HLA-B27 and disease extent and persistence. Ann Rheum Dis 2009;68:1466-9.

24. Leirisalo-Repo M, Helenius P, Hannu T, Lehtinen A, Kreula J, Taavitsainen M, et al. Long-term prognosis of reactive salmonella arthritis. Ann Rheum Dis 1997;56:516-20.
25. Madsen KB, Egund N, Jurik AG. Grading of inflammatory disease activity in the sacroiliac joints with magnetic resonance imaging: comparison between short-tau inversion recovery and gadolinium contrast-enhanced sequences. J Rheumatol 2010;37:393-400.
26. Bredella MA, Steinbach LS, Morgan S, Ward M, Davis JC. MRI of the sacroiliac joints in patients with moderate to severe ankylosing spondylitis. Am J Roentgenol 2006;187:1420-6.