Spinal inflammation lesions as detected by magnetic resonance imaging in patients with early ankylosing spondylitis are more often observed in posterior structures of the spine

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Abstract

Objective. To study the localization and extent of spinal inflammation in patients with AS in detail.

Methods. This cross-sectional study used standardized clinical tools and MRI, including T1 and T2 fat saturation sequences in both sagittal and axial planes. A simple method of analysis of MRI changes was performed using the principle of 'yes/no' to calculate the changes in vertebral body and posterior structures of spine, including costovertebral and costotransversal joints.

Results. Consecutive patients with AS (n=29), who fulfilled the modified NY criteria, were examined by MRI: 67% male, 93% HLA-B27-positive, median age 27.5 (18–49) years, median disease duration 7.5 (1.5–24) years. Inflammatory back pain (IBP), median duration 36 (1–240) months, with a mean intensity of 40 mm on a visual analogue scale (20–100) was present in 26 patients (89.7%), and the Bath AS Disease Activity Index (BASDAI) was >40 in 21 patients (72.4%). MRI evidence of spinal inflammation at any site was found in 27 patients (96.5%), whereas radiographic changes were only seen in 6.9% (p<0.05).

Patients with a short history of IBP (n=11) had significantly more lesions in posterior spinal structures than in vertebral bodies: 90.9 vs 27.2%, respectively (p<0.003). Isolated changes in posterior spinal structures were seen in eight of these patients (72.7%), whereas, in contrast, patients with a longer history of IBP (n=18) had significantly more inflammation in vertebral bodies: 88.9 vs 27.2%, respectively (p<0.01).

Conclusions. Inflammatory MRI lesions in early AS are seen more often in posterior structures of the spine. This may be relevant for the diagnosis of early AS and the early detection of inflammatory spinal involvement.

Key words: AS, MRI, Spine, Inflammatory lesions, Saggital and axial planes, Posterior spinal structures.

Introduction

AS is the most frequent inflammatory rheumatic disease that affects the spine, peripheral joints and entheses and also other organs such as the anterior uvea [1].

The disease starts relatively early in life at a mean age of 26 years and is only somewhat more frequent in male than in female patients, with inflammatory back pain (IBP) being a characteristic symptom [2]. The disease usually takes a chronic course that is characterized by new bone formation with syndesmophytes and ankylosis [1]. More than 30% of AS patients suffer from functional impairment and have a decreased quality of life [3].

As shown by MRI, many patients with AS have inflammatory changes in different structures of the axial skeleton [4, 5]; this is now increasingly used for diagnostic purposes [6].
Many anatomical structures, including the SI joints and the vertebral bodies, may become affected; but only the spinal column is assessed by the available scoring methods, MRI spinal lesions in Ankylosing Spondylitis [7] and Spondyloarthritis Research Consortium of Canada [8], whereas the zygapophyseal joints are not, even though they are believed to play a role in early disease stages [9, 10].

Treatment with TNF-α inhibitors was shown to reduce the spinal inflammation as detected by MRI, and this led to a change of technique and the available scoring systems [11–13]. The main objective of the present research was to study the localization of inflammation in spinal posterior and anterior structures in AS patients.

Patients and methods

In 29 consecutive patients (18 males and 11 females) with AS, according to the modified New York criteria [14], spinal MRIs were performed. All patients were recruited after obtaining approval from the local ethics committee (Ethics Committee for the Institute of Rheumatology RAMS). All study subjects provided informed consent.

Disease activity was assessed using the Bath AS Disease Activity Index (BASDAI) [15]. The degree of pain was measured by the visual analogue scale (VAS, 0–100 mm). In addition to the overall duration of the disease calculated from the very first signs of AS, the duration of IBP was estimated according to patients’ careful interviews (history). Furthermore, the duration of IBP was assessed separately for each area of the spine examined by MRI. All patients were divided into two groups: ‘short IBP history’ (duration is not >18 months) and ‘longer IBP history’ (duration is >2 years), according to the duration of IBP.

Standard radiographs in lateral projections (all areas of the spine) were performed in all patients not earlier than 6 months before the MRI. The X-ray images were evaluated by one radiologist and two rheumatologists.

The MRIs were performed in the Department of Radiology of Research Centre of Neurology RAMS using Magnetom Symphony, Siemens (Germany) with a magnetic field strength of 1.5 T. Patients lying on their backs were examined with no prior preparation. Cervical, thoracic and lumbosacral regions of the spine were examined with no prior preparation. Cervical, thoracic and lumbosacral regions of the spine were examined separately according to a standard protocol. The choice of the spine area to be examined was based on the localization of pain; three patients with no pain at present on the localization of pain in past (thoracic spine in two cases and thoracic and lumbar spines in one case). Images received using the regimens T2, T2 fat saturation (T2-FS) and T1 in the sagittal plane were evaluated in all patients. For better visualization of arches, vertebral processes, facet joints and, in some cases, atlanto-odontoid joint, tomography in the axial plane was performed. MRIs in this plane were either focused on a definite target (in cases where inflammatory changes had been revealed in the sagittal plane) or aimed at spine segments corresponding to the localization of pain experienced by patients, usually six or seven segments (when there were no findings in the sagittal plane). MRIs in the axial plane were performed in 23 cases in the thoracic spine, in 7 cases in the cervical spine and in 11 in the lumbar spine. The number of MRIs performed in the sagittal plane was 12–15. The section thickness in the sagittal and the axial planes was 4 and 3 mm, respectively. All MRI images were examined by two readers (A.V.L. and A.G.B.; one of them, A.V.L., was blinded to the clinical data) independently. In questionable cases, decisions were made after discussion. Only inflammatory changes, defined as lesions with an increased signal intensity on T2-FS-weighed images, were analysed.

Simple analysis of MRI changes was performed using the principle of ‘yes/no’ to calculate changes separately in vertebral body and posterior structures of the spine. Posterior structures of the spine included oedema of subchondral bone of costovertebral and costotransversal joints, rib heads, isolated oedema of vertebral arches, isolated oedema of transverse and spinous processes of vertebra, oedema of interspinous and other vertebral ligaments, effusion in atlanto-odontoid and facet joints.

We analysed the association between the localization of pain and inflammatory MRI changes and the relationship between the changes detected in different anatomical structures (vertebral body or posterior structures of the spine) and the duration of IBP in different areas. All tomograms (sagittal and axial) were conventionally considered as one image of the respective spinal area.

Results

The patients’ characteristics are summarized in Table 1; six patients had a disease onset in childhood and seven patients had early AS <3 years. At the time of MRI, 21 patients had high activity of disease (BASDAI ≥40),

### Table 1 Characteristics of AS patients (n = 29)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Median (25–75% interquartile range) [extremes]</th>
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<tbody>
<tr>
<td>Age, years</td>
<td>27.5 (23–32) [18–49]</td>
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<tr>
<td>Duration of disease, years</td>
<td>7.5 (3.8–14) [1.5–24]</td>
</tr>
<tr>
<td>Duration of IBP located on the spine, months</td>
<td>36 (12–63) [1–240]</td>
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<tr>
<td>X-ray stage of sacroiliac changes, n</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>13</td>
</tr>
<tr>
<td>III–IV</td>
<td>16</td>
</tr>
<tr>
<td>HLA-B27+, n (%)</td>
<td>28 (96)</td>
</tr>
<tr>
<td>BASDAI (0–100)</td>
<td>40 (30–55) [10–77]</td>
</tr>
<tr>
<td>ESR, mm/h</td>
<td>19 (12–35) [3–54]</td>
</tr>
<tr>
<td>Severity of IBP (VAS, 0–100 mm)</td>
<td>40 (30–50) [0–100]</td>
</tr>
<tr>
<td>IBP localization (n = 26), n (%)</td>
<td></td>
</tr>
<tr>
<td>Cervical spine</td>
<td>3 (10.3)</td>
</tr>
<tr>
<td>Thoracic spine</td>
<td>14 (48.2)</td>
</tr>
<tr>
<td>Lumbar spine</td>
<td>4 (13.7)</td>
</tr>
<tr>
<td>Cervical and thoracic spine</td>
<td>2 (6.9)</td>
</tr>
<tr>
<td>Thoracic and lumbar spine</td>
<td>2 (6.9)</td>
</tr>
<tr>
<td>Whole spine</td>
<td>1 (3.4)</td>
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</tbody>
</table>
6 patients had peripheral arthritis and 26 patients had IBP in different areas of the spine. The degree of IBP measured by VAS (0–100 mm) exceeded 20 mm in 26 patients. Night pain was reported by 22 patients (75.8%). A total of 21 patients had pain only in one area of the spine, whereas the other five had pain in two or three areas of the spine. Almost half of the patients (n = 14) experienced pain in the thoracic spine, although they had previously reported pain in other areas of the spine as well. Only three patients denied having spinal pain at the time when the MRI was performed. This was possibly explained by an increase in the dosage of the NSAIDs taken.

Spinal radiographs showed structural changes in the spine in two (6.9%) patients with AS duration >10 years (spondylitis anterior, syndesmophytes in thoracic spine and ankylosis of facet joints in cervical spine).

Overall, 41 MRIs were performed in 29 AS patients: 23 thoracic, 11 lumbar and 7 cervical spine cases. Spinal inflammation was detected in 27 patients (96.5%). Changes in posterior structures of the spine were detected in the majority of patients on sagittal MRIs. MRIs in the axial plane were only used for confirmation or analysis of details. However, 26.2% of all inflammatory MRI changes were only detected in the axial plane.

In three patients with early AS, inflammatory changes were revealed only in axial MRIs: in the facet joints of the lumbar spine, in costovertebral and costotransversal joints and also in transverse and spinous processes.

Changes were usually seen in the edges of the vertebral bodies, reflecting anterior and posterior spondylitis in rib heads (Fig. 1), in transverse and spinous processes (Figs 2 and 3), and arches. In some cases, arthritis of the atlanto-odontoid joint (Fig. 4), facet joints (Fig. 5), costovertebral and costotransversal joints (Figs 1, 3, 5 and 6), isolated oedema of arches, transversal and spinous processes, interspinous and supraspinous ligaments (Fig. 2) were observed.

In the vast majority of patients who complained of IBP in any part of the spine (VAS >20), it was found that the localization of inflammatory MRI changes corresponded exactly to the subjective localization of the pain: in 26 of 29 patients (90%).

Thus, the localization of MRI changes and IBP did not match in only three patients. In one female patient with severe neck pain (VAS 52 mm), who had ankylosed facet joints of the cervical spine as shown by the corresponding radiograph, the MRI revealed herniation of the intervertebral disc at the level of C6–C7 as a potential cause of pain. In another female patient with long-standing thoracic and lumbar IBP, inflammatory changes were only detected in the thoracic but not in the lumbar spine. One male patient had extensive inflammatory MRI changes in the thoracic spine but had no pain. This HLA-B27 negative patient had a symptom duration of 10 years and currently not very active disease (BASDAI = 23, and normal levels of CRP and ESR).

The relationship between the changes in the vertebral bodies and in the posterior structures of the spine with the duration of IBP in the corresponding areas is summarized in Table 2. The median of duration in the ‘short IBP history’ group (n = 11) was 4 (range 1–18) months and in the longer IBP history group (n = 18) 54 (range 24–180) months. In the patients with a ‘short IBP history’, inflammatory changes were detected significantly more often in the posterior structures of the spine than in the vertebral bodies: in 90.9 vs 27.2% of the images, respectively (P = 0.003). Isolated changes in the posterior structures were observed in the MRIs (72.7%) of 8 of 11 patients. Inflammatory MRI changes in the vertebral bodies were observed significantly more frequently in patients with

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Fig. 1 Twenty-eight-year-old female had pain in the thoracic spine during the night for 7 months, 12 years duration of AS. (A) Sagittal T2-FS images in the thoracic spine: no zones of inflammation. (B) Axial T2-FS image. Th5: arthritis right costovertebral joint with concomitant osteitis of the adjacent rib and vertebral portions (arrows).
Discussion

Our study confirms the significance of revealing spinal inflammation by MRI in early AS before X-ray structural change appearances. The vertebral column was found to be affected in the majority of AS patients using MRI (97%). Only isolated patients had X-ray changes (6.9%) at the same time.

The results of this study suggest the commencement of spinal inflammation in patients with early AS, being most likely situated in the posterior structures and later spreads to vertebral bodies and anterior elements.

The high prevalence of spinal inflammation suggests that active patients were included in this study—this may in part be due to the referral system in our area. In comparison, MRI-proven spinal inflammation was found in 70–100% [5, 7, 12, 13, 16] of patients in other studies with patients who had a longer disease duration.

Inflammatory oedematous spinal lesions were found in different anatomical structures in this study. The locations described in this study correspond to other reports [17–19] that have suggested a major affect of not only bone tissue in AS (osteitis), but also of ligaments and tendons attached to bone (enthesitis) and the synovial parts of joints (arthritis).

The majority of inflammatory changes were seen in the thoracic spine confirming previous results [5]. Inflammation in the lower thoracic spine was observed not only in patients with longer IBP history but also in those with a short IBP history (<18 months).

This is the first study showing that changes of posterior spinal structures are frequently observed in early AS. This is consistent with earlier radiographic studies in more advanced cases [9, 10]. Furthermore, we show for the first time that in patients with relatively early spondylitis (IBP <18 months), the frequency of inflammatory changes in posterior spinal structures was significantly higher (about 4-fold) than in the vertebral bodies, suggesting that this localization is the most likely site where spinal inflammation in AS starts. Of course, in the axial skeleton, the SI joints are still the region where the inflammation starts in the majority of patients [20, 21]. Whether the examination of posterior spinal structures should be
**Fig. 4** Twenty-four-year-old female, duration of AS 2 years, with cervical IBP for 3 months. T2-FS image of the cervical spine (A: sagittal and B: axial plane). Effusion in cavity of atlanto-odontoid joint (arrows).

**Fig. 5** Thirty-year-old female, duration of AS 4 years, with intense thoracic IBP for 10 months. Axial T2-FS image, Th5: arthritis of the left costovertebral joint with concomitant osteitis of the adjacent rib and vertebral portions (arrows).

**Fig. 6** Twenty-four-year-old man, duration of AS 5 years. Axial T2-FS images Th XII. Inflammation lesions in both costotransversal joints with concomitant osteitis of the adjacent rib and transversal processes (arrows).

**Table 2** Analysis of inflammatory MRI changes in different anatomical structures and their relationship with IBP duration

<table>
<thead>
<tr>
<th>Inflammatory changes</th>
<th>Short IBP history ( (n = 11) )</th>
<th>Long IBP history ( (n = 18) )</th>
<th>( P )-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>In vertebral bodies</td>
<td>3 (27.2)</td>
<td>16 (88.9)</td>
<td>0.01</td>
</tr>
<tr>
<td>In posterior structures of spine</td>
<td>10 (90.9)</td>
<td>12 (66.7)</td>
<td>0.10</td>
</tr>
<tr>
<td>Only in vertebral bodies</td>
<td>1 (9.1)</td>
<td>5 (27.8)</td>
<td>0.17</td>
</tr>
<tr>
<td>Only in posterior structures of spine</td>
<td>8 (72.7)</td>
<td>1 (5.6)</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

The values are given as \( n \) (%). *Fisher’s exact test.
more systematically performed in order to improve the early diagnosis of AS and early axial SpA remains to be shown.

Furthermore, our data suggest that more attention should be paid to include both sagittal and axial planes in MRI studies and analyses. Indeed, in some cases, bone marrow oedema, especially between vertebral bodies and ribs, was only detected on transverse sections (in 1/4 patients). In the majority of previous MRI studies in AS, only images in the sagittal plane and mainly the vertebral bodies were studied [11–13]. This can also be recognized when looking at the proposed quantitative assessment of changes and the scoring systems developed [7, 8]. However, some data on inflammation in posterior spinal structures of AS patients have been published in abstract form [22]. In this Canadian study, MRI changes (sagittal plane) in posterior spinal structures were observed in 87.5% of the patients with active AS, and predominantly, as in our study, in the thoracic spine. These authors also reported that if the MRI scanning area did not cover the pedicles of the vertebral arches, up to 37% of the inflammatory changes in the thoracic spine and up to 18% of the changes in the lumbar spine would possibly be omitted when only sagittal sections were analysed [23].

Our systematic analysis of axial sections enabled us to interpret the changes observed in the thoracic spine in the sagittal plane, as bone marrow oedema in the vertebral arch of the vertebral bodies is indicative of posterior spondylitis. These changes may well originate from an expansion of the inflammation of costovertebral joints to the vertebral bodies. However, whether the initial lesion is rather an enthesitis or an osteitis or a synovitis cannot be concluded from these data.

A strong association of clinical findings with the localization of inflammation in the spine was observed in this study, showing consistent data in 90% of patients. Although the correlation between the localization of IBP and MRI has not been very impressive in other studies [24], we think that the localization of pain should guide the clinician in planning the MRI. This is probably also meaningful when other aspects such as organization, feasibility and costs are considered.

However, one study [25] has recently provided some insight into this matter by correlating the histological changes in facet joints of patients with long-standing AS that had been resected during surgery for severe spinal deformity and compared with MRI changes of these joints performed before surgery. Although an association between interstitial oedema in the tissue specimen and MRI findings was observed, the data also suggested a limited sensitivity of MRI to detect oedema, as no MRI changes were observed when <30% of a pre-specified area was affected [25].

In one female patient, inflammation of atlanto-odontoid joint, which is rarely reported in relatively early stages of AS, was observed. However, in late stages of AS, atlanto-axial inflammation may occur more frequently [26].

In conclusion, the present study confirms the ability of MRI to detect inflammatory changes at different locations of the spine in AS patients. Our data confirm that inflammation may occur in different anatomical structures of the spine: in the body of the spine, in facet, vertebrocostal and costotransverseal joints, processes and in supraspinous ligaments. Changes in posterior structures are more frequent in AS patients with a short IBP history. Additional MRIs in the axial plane may increase the diagnostic yield. The localization of pain, as indicated by the patient, should guide the decision as to where the MRI should be focused.

**Rheumatology key messages**

- Inflammatory MRI lesions in early AS are seen more often in posterior structures of the spine.
- MRIs in the axial plane may increase the diagnostic yield.

**Disclosure statement:** The authors have declared no conflicts of interest.

**References**


