Magnetic resonance imaging evaluation of shoulder joint in patients with early stage of ankylosing spondylitis: A case-control study

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**Abstract**

Purpose: The goal of this prospective study was to determine the prevalence of shoulder abnormalities on magnetic resonance imaging (MRI) in patients with ankylosing spondylitis (AS) who have normal shoulder X-ray examinations and no clinical shoulder abnormalities using a case-control study.

Materials and methods: Fifty-three patients with AS according to the SpondyloArthritis international Society (ASAS) criteria were enrolled in the study. Fifty-three patients with no AS served as control subjects. Shoulder MRI examinations of patients in the two groups were analyzed and results were compared.

Results: In the patient group, 26/53 patients (49.1%) demonstrated one or two of the defined pathological shoulder MRI findings, whereas 5/53 patients (9.4%) had similar findings in the control group. In the patient group, 11/53 patients (20.8%) had enthesal bone marrow edema, 19/53 patients (35.8%) had increased synovial fluid, 8/53 patients (15.1%) had tendinitis, and 2/53 patients (3.8%) had bursitis. There was statistically significant difference between the patient and control groups in terms of prevalence of enthesal bone marrow edema, increase in synovial fluid, and tendinitis.

Conclusion: Shoulder involvement is often overlooked in AS. Knowledge of the early-stage findings of the shoulder involvement due to AS is important to establish an early diagnosis and select treatment options.

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Ankylosing spondylitis (AS) is a chronic inflammatory disease [1,2]. Peripheral limb involvement is a predictive factor for progression of the disease and functional loss [3]. Shoulder involvement during AS is observed more frequently than for other peripheral joints [3]. Shoulder involvement is observed in 15% of patients with AS at initial presentation but may reach 35% during disease course [4–7]. Etiologies of shoulder involvement include enthesitis, bursitis and synovitis. Scarce studies have investigated the causes of shoulder pain in AS patients. Early diagnosis of shoulder involvement is crucial since effective treatment options are available when diagnosed at an early stage [8]. Imaging plays an important role in detecting disease activity in early AS stage [9]. Magnetic resonance imaging (MRI) is the preferred imaging technique for displaying early inflammation [10].

The goal of this study was to prospectively determine the prevalence of shoulder abnormalities as observed on MRI in patients with AS who have normal shoulder X-ray examination and no clinical shoulder abnormalities using a case-control study.

Materials and methods

This prospective study has approved by the Ethics Committee of our hospital. Written informed consents were obtained from all patients. In this study, 53 consecutive patients with AS were assigned to the patient group. They were 25 men and 28 women with a mean age of 34.08 years ± 5.29 (SD) (range: 24–50). AS was diagnosed according to the criteria of the SpondyloArthritis International Society (ASAS). The subjects with chronic inflammatory bowel disease, reactive arthritis, previous shoulder surgery, osteoarthritis, psoriasis, brucellosis, salmonellosis, findings of involvement due to AS encountered by the previous MRI examination and shoulder pain beside the patients who were receiving previously or currently proceeding anti-TNF treatment and local or systemic steroid treatment were excluded from the study. A control group was built, including consecutive patients without findings of impingement, bursitis, tendonitis and trauma history who were matched for age and sex. It was confirmed via physical examination and laboratory tests that control subjects had no AS.

The control group included 53 patients (24 men, 29 women) with a mean age of 35.56 years ± 6.20 (SD) (range: 25–52). Beside exclusion criteria determined for the patient group, the patients with seronegative spondyloarthropathy in their medical history were also excluded from the control group. AP shoulder X-ray examinations of the patient and control groups were evaluated. The patients found to have findings of AS, degeneration and trauma, calcific tendinitis or focal tumoral bony lesions were excluded from the study. Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) was assessed using the Bath Ankylosing Spondylitis Functional Index (BASFI). Patients were surveyed with respect to axial or peripheral involvement by questioning whether a previous or currently proceeding swelling in the peripheral joints. In the patient group, nondominant shoulder was evaluated taking into consideration that possibility of pathology depending on excessive use of the dominant shoulder regardless of AS may increase. MRI investigations of the patients who made up the patient and control groups were evaluated via consensus opinion by two radiologists with an experience of 7- and 12-years without knowledge of patient information.

MRI protocol

All the subjects in the patient and control groups were applied the same protocol. MRI examination was performed using a 1.5-T MRI system (Siemens Magnetom Avanto, Erlangen, Germany). A dedicated shoulder coil was used for all patients, transverse and coronal T1-weighted short tau inversion recovery (STIR), sagittal and coronal T1-weighted turbo spin echo (TSE) and sagittal T2-weighted TSE images were obtained. The parameters of the sequences used in the study were as follows: repetition time (TR): 4330 ms; echo time (TE): 37 ms; slice thickness: 5 mm; field of view (FOV): 200 × 200 mm and echo train length (ETL): 8 for transverse T1-weighted STIR; TR: 4330 ms; TE: 37 ms; slice thickness: 4 mm, FOV: 210 × 210 mm, ETL: 8 for coronal T1-weighted STIR imaging; TR: 704 ms, TE: 11 ms, slice thickness: 4 mm, FOV: 190 × 190 mm, ETL: 3 for sagittal T1-weighted TSE imaging; TR: 508 ms, TE: 11 ms, slice thickness: 4 mm, FOV: 160 × 160 mm, ETL: 2 for coronal T1-weighted TSE imaging; TR: 4100 ms, TE: 81 ms, slice thickness: 4 mm, FOV: 190 × 190 mm, ETL: 16 for sagittal T2-weighted TSE imaging.

MR image analysis

On T2-weighted sequences, presence of high-signal intensity exceeding 3 mm in the subacromial-subdeltoid bursae and glenohumeral joint space was considered as synovial fluid [11]. Regarding bone marrow, low signal intensity on T1-weighted sequences and high-signal intensity on T2-weighted and STIR sequences were considered as bone marrow edema [12]. The edema encountered in the subcortical fields of the tendon, ligament and muscular adhesion localizations were considered as entheseal bone marrow edema [13]. High-signal intensities on T1- and T2-weighted sequences besides tendon thickening were reported as tendinitis [14]. In the bursal field, hyperintense field with lower intensity monitored in the joint space by T2-weighted sequence was evaluated bursal inflammation [13].

Statistical analysis

Data analysis was performed using the software IBM Statistical Package for Social Sciences (IBM SPSS; Armonk, NY, USA, IBM Corp.) for Windows (version 20.0). Continuous variables were presented as mean (standard deviation, SD) or median (min – max) for abnormal distributions and categorical variables were presented as frequencies (%). Comparisons between the distributions of demographical characteristics of the patients were evaluated using Student’s t-test or Mann-Whitney U test for continuous variables. Chi-square test or Fisher’s exact test were applied for categorical variables. Then, subgroups were created by the patients with peripheral and axial involvement and these subgroups were compared using Chi-square test based on categorical variables. Statistically significance was considered for P < 0.05 in all tests.
Results

No statistically significant difference with respect to mean age was found between AS patients and control subjects. Disease duration was 3.57 ± 2.54 (SD) years (range: 0–10) in the AS group. In the AS group, BASDAI and BASFI scores were 4.59 ± 2.32 (SD) and 3.47 ± 2.58 (SD), respectively. Table 1 presents the clinical and demographic characteristics of the patients.

In the AS group, 2/53 patients (49.1%) had findings of radiological involvement such as synovial fluid, enthesal bone marrow edema, tendinitis or bursitis whereas one or two of these identified pathologies were present in 5 (9.4%) patients of the control group. This difference between AS patients and control subjects was significant (P < 0.001). In the patient group, enthesal bone marrow edema, increased synovial fluid, tendinitis and bursitis were found in 11/53 (20.8%), 19/53 (35.8%), 8/53 (15.1%) and 2/53 (3.8%) patients, respectively. Significant differences were found between AS patients and control subjects with respect to enthesal bone marrow edema (P = 0.001), increased synovial fluid (P < 0.001) and tendinitis (P = 0.046). No significant differences were found between the two groups with respect to bursitis. MRI findings in both groups are reported in Table 2.

Shoulder involvement was encountered in 14 (66.7%) patients with peripheral involvement and 12 (37.5%) patients with axial involvement (P = 0.036). Enthesal bone marrow edema was present in 8 (38.1%) patients with peripheral involvement and in 3 (9.4%) patients with axial involvement (P = 0.015) (Fig. 1). The presence of increased synovial fluid was more frequent in patients with peripheral AS (52.4%) than in patients with axial AS (25%) (P = 0.041). Tendinitis was found in the 4 (19%) and 4 (12.5%) patients with peripheral and axial AS, respectively (Fig. 2). Bursitis was detected in 1 (4.8%) and 3 (3.1%) patients with peripheral and axial AS, respectively. No statistically significant difference was found with respect to tendinitis and bursitis between the two forms of the disease. Of the 8 patients with tendinitis; involvement of supraspinatus tendon and biceps tendon was determined in the 6 (75%) and 2 (25%) patients, respectively. Among the 11 patients with enthesal bone marrow edema; involvement of acromioclavicular joint, head of the humerus and acromion was encountered in 6 (54.5%), 3 (27.2%) and 2 (18.2%) patients, respectively. Of the 2 patients with bursitis, involvement of subdeltoid and subacromial bursa was present in 1 patient each.

Discussion

Shoulder is the most commonly involved joint in patients with AS. Prevalence of shoulder involvement in patients with AS has been investigated in some studies. Lambert et al. have found an incidence of shoulder involvement of 24.7% via a clinical evaluation in their study [13]. The incidence of shoulder involvement in patients with AS ranges between 7 and 33% [6,15]. In these studies, shoulder involvement has been detected via clinical evaluation and findings of advance imaging techniques generally have not been used. Differently from these studies, we have evaluated shoulder involvement according to MRI findings. We found a higher incidence of shoulder involvement than other studies did. It may be assumed that a number of patients with no clinical sign have MRI abnormalities due to shoulder inflammation. Unnoticed shoulder involvement that is commonly considered not disabling may have contributed to this situation [6].

Etiology of shoulder pain in patients with AS has been investigated in a small number of studies. In previous studies, MRI findings of AS have been identified as bone marrow edema, subacromial bursitis and rotator cuff tendinitis in the acromion, greater tubercle and acromioclavicular joint, respectively [9,13,16]. The primary finding of AS is enthesitis defined as the inflammation of entheses, the sites where ligament, tendon and joint capsule insert to bone [16]. Weber et al. compared 10 suspicious and 10 confirmed patients

Table 1 Clinical and demographic features of 53 patients with ankylosing spondylitis.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mean ± SD</th>
<th>Median</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>34.08 ± 5.29</td>
<td>33</td>
<td>24–50</td>
</tr>
<tr>
<td>Disease duration (years)</td>
<td>3.57 ± 2.54</td>
<td>3</td>
<td>0–10</td>
</tr>
<tr>
<td>BASDAI</td>
<td>4.59 ± 2.32</td>
<td>4.87</td>
<td>0–9</td>
</tr>
<tr>
<td>BASFI</td>
<td>3.47 ± 2.58</td>
<td>3</td>
<td>0–9.8</td>
</tr>
</tbody>
</table>

Data are presented as mean ± SD/median value (interquartile range); SD, Standard deviation; BASDAI: The bath ankylosing spondylitis disease activity index; BASFI: The bath ankylosing spondylitis function index.

Table 2 MRI features of 53 patients with AS and 53 control subjects.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Patient</th>
<th>Control</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Radiological shoulder involvement</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>27</td>
<td>50.9</td>
<td>48</td>
</tr>
<tr>
<td>Yes</td>
<td>26</td>
<td>49.1</td>
<td>5</td>
</tr>
<tr>
<td>Enthesitis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>42</td>
<td>79.2</td>
<td>53</td>
</tr>
<tr>
<td>Yes</td>
<td>11</td>
<td>20.8</td>
<td>0</td>
</tr>
<tr>
<td>Synovial Fluid</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>No</td>
<td>34</td>
<td>64.2</td>
<td>51</td>
</tr>
<tr>
<td>Yes</td>
<td>19</td>
<td>35.8</td>
<td>2</td>
</tr>
<tr>
<td>Tendinitis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>45</td>
<td>84.9</td>
<td>51</td>
</tr>
<tr>
<td>Yes</td>
<td>8</td>
<td>15.1</td>
<td>2</td>
</tr>
<tr>
<td>Bursitis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>51</td>
<td>96.2</td>
<td>52</td>
</tr>
<tr>
<td>Yes</td>
<td>2</td>
<td>3.8</td>
<td>1</td>
</tr>
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</table>
with AS and found findings of shoulder involvement in the group of patients with confirmed AS. In the group of patients with confirmed AS, bone marrow edema in the acromioclavicular joint and inflammatory changes in subacromial bursa were encountered in 3 and 1 patients, respectively [9]. Lambert et al. have studied MRI examinations of 15 randomly selected patients with AS. They found that acromioclavicular joint involvement is more frequent. However, edema of enthesal bone marrow in the acromion and greater tubercle were the most specific MRI findings of AS [13]. Consistent with these studies, a significant difference with respect to enthesal bone marrow edema was observed in our study. In our study, bone marrow edema in the acromioclavicular joint was higher and an enthesal bone marrow edema was detected in the adhesion localizations of the deltoid and supraspinatus tendon (Fig. 3). Differently from these investigations, in our study, a significant difference was found between AS patients and control subjects with respect to increased synovial fluid in the glenohumeral joint. In the study of Soker et al., MRI findings of 46 hip joints in 23 patients without hip pain and any finding of plain radiography have been analyzed and increased synovial fluid was observed in 23 hip joints [14]. Huang et al. have investigated MRI findings of 116 hip joints of 58 patients and have encountered increased synovial fluid in 73 hip joints and synovial involvement in the bilateral hip joints in 23 of the 27 patients who received intravenous administration of gadolinium chelate [17]. These researchers found that increased synovial fluid and synovial enhancement are the...
most common MRI findings in hip joints of patients with AS [17]. Even though, the use of contrast agent for the diagnosis of synovitis is important.

The plain radiography findings of shoulder involvement in patients with AS have been identified as joint space narrowing beside bone proliferations in acromioclavicular joint, glenohumeral joint and adhesion sites of rotator cuff [3,4]. However, these findings are the late findings, which occur after ankylosis develops in the joint. Early diagnosis of involvement due to AS is important with respect to alter therapy [8]. It has been stated in a study conducted by Will et al. that 23% of the patients with limited shoulder motions had normal AP shouldergraphy [6]. Plain radiography and computed tomography are successful in demonstrating chronic bony changes while ultrasonography and MRI may also detect the early findings such as enthesitis and entheseal bone marrow edema. Ultrasonography is helpful for the diagnosis of enthesitis by revealing edema and neovascularization at the entheseal points with the advantage of wide availability, higher patient comfort and low cost [18]. However, since sound waves can not penetrate bone cortex, it can not show entheseal bone marrow edema like MRI. Bony changes of the shoulder can be depicted with the SILENZ sequence, so that this sequence should be evaluated for patients with AS [19]. In STIR sequence, inflammatory foci may be detected as hyperintense fields. Hermann et al. have expressed in their study that STIR sequence provides similar information than T1-weighted sequence obtained administering chemical substance in diagnosis of inflammation in patients with suspected of AS [20]. We have also used STIR sequence obtained in the coronal and sagittal planes in detecting entheseal bone marrow edema (Fig. 4).

Specialized musculoskeletal high field MRI may aid in the diagnosis of involvement of the shoulder in AS. With the use of dedicated MR equipment, involvement of the shoulder joint could be depicted at an early stage of AS [21].

One limitation of our study is that we did not administrate contrast agent for MRI. Demonstration of diffuse sinovial enhancement may facilitate the differentiation between synovitis and free fluid. Intravenous administration of gadolinium chelate has been shown to improve the diagnosis of synovitis in previous studies [10]. Evaluation of the nondominant shoulder in the patient group and greater number of the patients when compared with the other studies are the factors that make our study more powerful.

Conclusion

In conclusion, prevalence of shoulder involvement in AS patients is quite high on MRI. Early diagnosis of shoulder involvement is crucial since effective treatment options are available in the early stage of AS. Knowledge of the early-stage findings of the shoulder involvement due to AS is important with respect to establish an early diagnosis and determine the best treatment options. Although MRI findings were not specific for AS, these findings may be helpful to indicate shoulder involvement in the patients with known AS.

Disclosure of interest

The authors declare that they have no competing interest.

References


