Ultrasonography as a useful modality for documenting sacroiliitis in radiographically negative inflammatory back pain: a comparative evaluation with MRI

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Abstract

Objectives. The aims of this study were to identify and characterize features of sacroiliitis in patients with non-radiographic inflammatory low back pain by ultrasonography (USG) and to correlate the findings with that of MRI.

Methods. MRI and USG of SI joints were performed on 29 patients who fulfilled the definition of inflammatory low back pain according to the Assessment of SpondyloArthritis International Society 2009 criteria for axial SpA but were X-ray negative for sacroiliitis. Increased vascularity, low resistive index (RI) and hyperechogenicity of the joint space were considered USG features of sacroiliitis. The findings were compared with those of 32 controls. USG features of sacroiliitis were compared with MRI by κ statistics.

Results. Receiver operating characteristic analysis revealed cut-off values for flow signals and RI of 3 and 0.605, respectively. There was a significant difference in the number of flow signals, RI and echogenicity of the SI joint between MRI-proven cases and controls. The Cohen’s κ for flow signals, RI and hyperechogenicity when compared with MRI were 0.816 (95% CI 0.676, 0.937) and 0.821 (95% CI 0.662, 0.965) and 0.403 (95% CI 0.108, 0.695). Taking both flow signals and RI parameters as criteria for determining sacroiliitis, comparison with MRI returned a κ of 0.816 (95% CI 0.601, 0.963).

Conclusion. Three or more flow signals and a RI ≤0.605 can be applied as USG criteria for sacroiliitis. USG can be a cost-effective and non-inferior modality compared with MRI in documenting sacroiliitis in early SpA.

Key words: non-radiographic spondyloarthropathy, sacroiliitis, ultrasonography, MRI.

Introduction

Inflammatory back pain (IBP) is the earliest and most common symptom of axial SpA (axSpA) [1]. The prevalence of IBP in a UK primary care population is 1.7–3.4% [1], whereas in the USA the prevalence is ~5–6% [2]. SpA is a group of diseases comprising AS, reactive arthritis, PsA, IBD-related arthritis and uSpA [3]. The estimated prevalence of AS in Europe is 0.3–0.5% and of SpA is 1–2% [4], whereas the prevalence of SpA in the USA is ~1.4% [5]. The prevalence of SpA in India, according to a study by Malaviya et al. [8] in a rural population, is between 0.1% and 0.2%.

AS, with its typical young age of onset, is associated with a tremendous burden and loss of function during the most productive years of a person’s life [7]. An average delay of 8.5–11.4 years occurs between onset of symptoms and time of diagnosis [8]. Early diagnosis and treatment of SpA can improve clinical outcome [9], but the opportunities for early diagnosis are challenged by the lack of accurate clinical signs or specific laboratory test
In an Indian study it was found that of all people with low back pain, only 1–2% were found to have SpA [6]. Radiological evidence of sacroilitis becomes evident after at least 9 years (s.d. 6) [11]. ESR and CRP were also found to have limited value in assessing disease activity [12]. The axial type of SpA is further subdivided into the early non-radiographic type (nr-axSpA) and the radiographic type, which is equivalent to the diagnosis of AS (according to the modified New York criteria) [13, 14]. In a study performed in Berlin, Germany, with 522 patients who had chronic back pain for >3 months and were <45 years of age at the start of symptoms, a definite diagnosis of axSpA was made in 43.7% of patients. Of them, nr-axSpA represented the majority of patients (67.3%) if the duration of back pain was ≤1 year at the time of referral. As the duration of symptoms increases, the proportion of AS increases in comparison with nr-axSpA [15]. MRI can demonstrate early inflammatory changes of the SI joint and thus provide an early diagnosis of SpA [16, 17]. However, it has limited availability and is time consuming, costly and difficult to apply in clinical practice, especially in developing countries [16–18]. An alternative easy-to-apply, feasible and effective screening modality needs to be found for early detection of sacroilitis. The purpose of our study was to determine whether USG is a reliable alternative to MRI for detecting sacroilitis in nr-axSpA. The aims and objectives of this study were to (i) to detect inflammatory changes of the SI joint on USG in non-radiographic inflammatory low back pain; (ii) to characterize USG findings of sacroilitis and (iii) to compare the USG findings of sacroilitis with those of MRI.

Patients and methods

Twenty-nine patients fulfilling the definition of inflammatory low back pain according to the Assessment of SpondyloArthritis International Society (ASAS) 2009 criteria for the classification of axSpA [19] and who were negative for any features of sacroilitis on X-ray were included in the study. The study was conducted between May 2013 and October 2013. Patients were classified as having nr-axSpA if radiographic changes in the SI joints of at least grade II bilaterally or grade III or IV unilaterally were lacking [13]. The study was approved by the Research Oversight Committee (Institutional Ethics Committee) of the Institute of Post Graduate Medical Education and Research and informed consent according to the Declaration of Helsinki was obtained. All the patients underwent MRI and sonographic evaluation of the SI joint simultaneously. The MRI and USG were carried out by two separate radiologists, each of whom was blinded to the other’s report and to the patient’s clinical profile.

They were also assessed for the presence of other features of the ASAS 2009 classification criteria for axSpA. Laboratory parameters studied were HLA-B27, ESR and CRP.

Thirty-two age- and sex-matched volunteers without any IBP served as our control group and underwent USG and MRI of their SI joints. MRI of bilateral SI joints was performed in all the patients with a Signa HDxt 3T (GE Healthcare, Waukesha, WI, USA) using the following sequences: T2, T2 fat saturated, short tau inversion recovery (STIR) and T1 fat saturated after gadolinium. MRI of the SI joints was performed with a field strength of 3 T using a lumbar coil. The image matrix and section thickness were 512 pixels and 4 mm, respectively. SI joints were imaged along an oblique coronal plane oriented along the long axis of the sacrum. Active inflammatory lesion in the SI joint was defined as the presence of subchondral bone marrow oedema and/or osteitis. The presence of more than one lesion in a single slice or a single lesion in at least two slices was considered to be sacroilitis [20].

Sonography of bilateral SI joints was performed with a MyLab 25 Gold (Esaote, Genova, Italy). A linear transducer of 7.5 MHz was used for imaging the SI joints. The pulse repetition frequency was 0.7–1 kHz with a Doppler angle ≤60°. With the patient lying prone, the transducer was first oriented transversely to identify the spinous process of the fifth lumbar spine and moved caudally to the sacral hiatus where the sacral cornu were identified. It was then moved laterally to identify the lateral edge of the sacrum. Maintaining the transverse orientation of the transducer, the lateral sacral margin was followed in a cephalad direction to identify the ilium. The hypoechocic cleft between the lateral sacral margin and ilium represented the SI joint, which was then scanned in a cranio-caudal direction in both the transverse and oblique sagittal plane. The procedure was repeated on the other side as well. For each subject we recorded three parameters: echogenicity of the joint space in B-mode USG and the number of flow signals and resistive index (RI) in colour Doppler ultrasound (CDUS). In CDUS, the area with the highest number of flow signals was selected in each SI joint and the number of flow signals in that area was counted. The RI of any visible flow signal was measured by spectral wave analysis. The joint space is considered to be hypervascular when its echogenicity is greater as compared with the normal joint space. Hypervascularity, low-resistance flow and hyperechogenicity of the joint space were considered to be USG features of sacroilitis.

Statistical analysis

MRI was used as the comparator for USG in the diagnosis of sacroilitis. The USG parameters—number of flow signals, RI and hyperechogenicity of the SI joint—were compared between subjects with MRI-proven sacroilitis and controls using the Mann–Whitney U test. To assess the diagnostic efficiency of flow signals and RI parameters, a receiver operating characteristic (ROC) curve analysis was done with MRI-proven sacroilitis as the end point. Cut-off values of the individual parameters were estimated with their sensitivities and specificities. Subsequently these cut-off values were used for defining USG positivity for sacroilitis and the extent of agreement with the MRI diagnosis was assessed using Cohen’s k statistics.
The 95% CI values are presented where relevant and \( P < 0.05 \) was considered statistically significant. SPSS version 21 (IBM, Armonk, NY, USA) was used for statistical analysis.

**Results**

Of the 29 patients with inflammatory low back pain, 21 were males and 8 females. The mean age was 29.83 years (s.d. 6.07). The mean duration of clinical disease at the time of detection was 2.997 years (s.d. 2.17). Peripheral arthritis was present in 17 patients (58.62%), enthesitis in 8 patients (27.6 %) and a history of uveitis and dactylitis in 1 patient each (3.448%). A positive family history was found in 3 patients (10.34%). HLA-B27 was positive in 18 patients (62.1 %) among the sample population. The ESR was elevated in 18 individuals (62.069%). Among the control population, 26 (81.3%) were males and 6 (18.7%) were females. The mean age of the control population was 29.75 years (s.d. 6.68).

Twenty patients (68.97%) had MRI-proven sacroiliitis and nine patients (31.04%) did not have any MRI evidence of SI joint involvement. Osteitis/bone marrow oedema was present in all 20 MRI-positive cases. Synovitis was present in 12 patients and capsulitis and enthesitis were found in 5 patients each. Asymmetric sacroiliitis was found in nine patients. There was a significant difference in the number of flow signals (\( P < 0.0001 \)), RI values (\( P < 0.0001 \)) and echogenicity (\( P = 0.001 \)) of the SI joint between MRI-proven cases and controls.

**Fig. 1** Receiver operating characteristic (ROC) curve for flow signals on colour Doppler US in the detection of MRI-proven sacroiliitis

The estimated area under the curve (AUC) is 0.921 (95% CI 0.835, 1.0; \( P < 0.0001 \)).

**Fig. 2** Receiver operating characteristic (ROC) curve for resistive indices on colour Doppler US in the detection of MRI-proven sacroiliitis

The estimated area under the curve (AUC) is 0.866 (95% CI 0.738, 0.994; \( P < 0.0001 \)).

Considering MRI-proven sacroiliitis as the diagnostic standard, a ROC analysis of the maximum number of flow signals in the cases and controls revealed a cut-off value of 3 for optimum sensitivity and specificity of detecting active sacroiliitis (sensitivity 90% and specificity 92.7%) (Fig. 1). With 3 as the cut-off, CDUS diagnosis based on flow signals when compared with MRI diagnosis returned a Cohen’s \( \kappa \) of 0.816 (95% CI 0.676, 0.937).

A ROC analysis was also done of the RIs of the flow signals in cases and controls, considering MRI-proven sacroiliitis as the diagnostic standard. The cut-off RI value with the optimum sensitivity and specificity was 0.605 (sensitivity 94.7%, specificity 86.4%) (Fig. 2). With 0.605 as the cut-off, a CDUS diagnosis based on RI when compared with an MRI diagnosis yielded a Cohen’s \( \kappa \) of 0.821 (95% CI 0.662, 0.965).

Considering both flow signals (>3) and RI (<0.605) positivity as CDUS criteria for sacroiliitis, an interrater agreement analysis with MRI yielded a Cohen’s \( \kappa \) of 0.816 (95% CI 0.601, 0.963). Twenty-one (72.41%) of the 29 cases fulfilled the CDUS criteria of sacroiliitis. The sensitivity and specificity of this USG parameter were 90% and 92.7%, respectively. Nineteen (59.38%) of the 32 controls without any history of low back pain had some flow signal in their SI joint, though not more than three. None of the controls had a low RI.

Only 10 (34.48%) of the 29 cases had hyperechogenicity of the SI joint space. The sensitivity and specificity of hyperechogenicity of the SI joint on B-mode USG in detecting MRI-proven sacroiliitis were 40% and 95%,
respectively. On performing an interrater agreement analysis between echogenicity of the SI joint with MRI positivity, we found a Cohen’s $\kappa$ of 0.403 (95% CI 0.108, 0.695). There was no case who was CDUS negative for sacroiliitis based on flow signal or RI values but had hyperechogenicity of the SI joint. Therefore this parameter did not provide any additional information in diagnosing sacroiliitis.

Discussion

Synovial inflammation and bone marrow oedema are the earliest pathological changes in SpA [21]. The salient features of SI inflammation are neovascularization, inflammatory infiltrate and IA fluid collection [22, 23]. The flow signals may be interpreted as a sign of hyperaemia due to neovascularization [24]. The RI is a numerical value of the amount of diastolic flow and is directly proportional to the peripheral vascular resistance [24]. Low RI values mean low-resistance flow, indicating inflammation [25, 26]. IA fluid accumulation within the SI joint is responsible for the hyperechogenicity in B-mode USG.

In our study, CDUS findings of sacroiliitis, defined as flow signals $\geq 3$ and an RI $\leq 0.605$ were in good agreement with MRI-proven sacroiliitis, with a $\kappa$ of 0.816 and 0.821, respectively. Hyperechogenicity of the joint space yielded poor agreement with MRI ($\kappa = 0.4$) but was the most specific parameter (95%). The most sensitive parameter of the three was low RI value (94.7%). We propose that an increased number of flow signals ($\geq 3$) and a decreased RI ($\leq 0.605$) should together be considered as the USG criteria for sacroiliitis.

Few previous studies have shown that increased vascularity and lower RI values in CDUS are indicative of active AS [27-29]. Unlu et al. [30] demonstrated a significant change in the RI of joint vascularity in response to anti-TNF therapy. Klauser et al. [31] evaluated the usefulness of CDUS in inflammatory low back pain by assessing the vascularity of the joint. In detecting MRI-proven sacroiliitis, they showed that unenhanced CDUS had a sensitivity of 17% and a specificity of 96%, whereas contrast-enhanced CDUS demonstrated a sensitivity of 94% and a specificity of 86%. Thus they proposed that detection of increased vascularity in SI joints was significantly increased by microbubble contrast administration. In our study, however, unenhanced CDUS had a sensitivity of 90% and a specificity of 92.7%. The sensitivity was low in the Klauser et al. [31] study, possibly because they considered only those flow signals that were present within the SI joint, whereas we included all the vessels that were inside as well as around the SI joint, because the blood vessels that penetrate the subchondral bone plate on both the iliac and sacral auricular facet and come into close contact with the overlying articular cartilage are most likely to contribute to inflammatory diseases in the SI joint [32]. However, they considered three or more flow signals as abnormal, which was similar to our study, though they did not take the RI into account. Our study thus had the advantage of avoiding the cost and hazards of microbubble contrast administration.

In a study by Arslan et al. [27], apart from sacroiliitis, increased vascularity around the SI joint was also found in patients with early OA and healthy volunteers, but their RI values were significantly higher than those of patients with sacroiliitis [27]. Our criteria of considering both an increased number of flow signals ($\geq 3$) and decreased RIs ($\leq 0.605$) together as USG criteria for sacroiliitis will help to minimize these false positives.

The salient features of our study are that we included only the non-radiographic cases of IBP to detect early SpA and that we compared USG with MRI to document sacroiliitis. To the best of our knowledge, there are no studies to date that have looked at Doppler US vis-à-vis MRI findings in X-ray-negative patients with IBP.

The limitation of the study design is the small sample size. The drawbacks of USG of the SI joint were that it was slightly difficult to do in obese subjects and counting of flow signals was, at times, subjective.

In conclusion, USG can be a cost-effective and non-inferior modality compared with MRI in documenting sacroiliitis in early nr-axSpA.

Rheumatology key messages

- Three or more flow signals and a resistive index $\leq 0.605$ can be applied as ultrasonography criteria for sacroiliitis.
- Low resistive index is the most sensitive parameter; joint space hyperechogenicity is most specific for sacroiliitis.
- Ultrasonography can be a non-inferior modality compared with MRI in documenting sacroiliitis in early SpA.

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