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Commentary

Commentary on: reporting in axial spondyloarthritis: proposal for an MRI reporting system

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Introduction

Spondyloarthritis (SpA) is an umbrella terminology used to describe a group of closely related diseases with a predisposition for inflammatory arthritis of the axial skeleton (spine and sacroiliac joints [SIJs]), as well as peripheral joints. This group includes ankylosing spondylitis (AS), psoriatic arthritis, reactive arthritis, juvenile SpA, arthritis associated with inflammatory bowel disease (enteropathic arthritis), and undifferentiated SpA. AS occurs in about 0.5% of the Caucasian population, whereas the prevalence of SpA as a group is about 1.5–2%.[1] These diseases show familial clustering and are associated with HLA-B27 to varying degrees. They also share common clinical features, but the presentation can be quite heterogeneous, including inflammatory back pain (IBP), peripheral inflammatory arthritis, peri-articular manifestations such as enthesitis and dactylitis ("sausage" digits), and extra-articular manifestations such as psoriasis, uveitis, and inflammatory bowel disease.

SpA can also be broadly divided into axial SpA and peripheral SpA. Patients with axial SpA predominantly have inflammation of the spine, SIJ, or both. In contrast, patients with peripheral SpA predominantly have peripheral arthritis, enthesitis, and dactylitis.[2] Of note, there is no single diagnostic feature for the SpA group as a whole, or for any of the disease subsets. Diagnosis in the clinical setting is therefore dependent on the assessment of symptoms and signs, laboratory investigations, and imaging such as radiographs and magnetic resonance imaging (MRI). MRI is increasingly being utilised, with the final diagnosis often hinging upon MRI findings. This proposal paper reviews the role of MRI in the diagnosis of SpA and presents a new MRI reporting system for assessment of axial SpA in the clinical setting.

Clinical challenges in diagnosing axial SpA

Clinically, back pain is often the first feature that raises suspicion for axial SpA, especially in younger patients, but can be insidious in onset, mild, and non-specific. This is confounded by the fact that back pain is extremely common in the general population with a point-prevalence of 25%,[3] and lifetime prevalence of 84%.[4] The Assessment of Spondyloarthritis International Society (ASAS) classification criteria for IBP attempt to differentiate IBP from non-specific back pain. According to the ASAS criteria, IBP is

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typically insidious in onset, improves with exercise, is not alleviated by rest, and is associated with pain at night.[5] Although IBP is present in 70–80% of patients with axial SpA, it also occurs in 20–25% of patients with mechanical back pain.[6] Additionally, the presence of IBP only increases the probability of axial SpA from 5% to 14–16%.[6] IBP therefore has limited diagnostic utility for axial SpA.

Although HLA-B27 is clinically useful, it does present challenges as an entry-point to the clinical arm of the ASAS criteria. In AS, 75–95% of patients are HLA-B27 positive, whereas in axial SpA associated with psoriasis and colitis, the prevalence is much lower (42–75%).[7] Therefore, the absence of HLA-B27 cannot be used to exclude SpA, and can lead to delayed or missed diagnosis. On the other hand, given that HLA-B27 occurs in 6–10% of the background population,[6] and that non-specific back pain is extremely common, the majority of patients with positive HLA-B27 and back pain do not have SpA. In fact, AS accounts for no more than 5% of all patients presenting with chronic back pain.[8] HLA-B27 therefore has limited diagnostic utility.

Of note, there are currently no established diagnostic criteria, although multiple classification criteria have been developed for axial SpA. Classification criteria are based on assessment of a group of patients with a known disease to identify similar characteristics to create a homogeneous group with high specificity, but often low sensitivity for the disease. Classification criteria are predominantly used in clinical trials and cannot be simply translated into diagnostic criteria due to inherent low sensitivity. Diagnostic criteria, on the other hand, allow for identification of a disease within members of the general population. Diagnostic criteria have a high sensitivity but often lower specificity and are used for diagnosis of the individual patient. The current reference standard for diagnosis of axial SpA is the expert opinion of a rheumatologist based on the clinical, laboratory, and imaging findings. The lack of an objective reference standard hampers clinical diagnosis and clinical studies.

Imaging challenges in diagnosing axial SpA

AS is characterised by a prolonged course before development of structural changes that may become evident radiographically. Prospective studies have shown that only 10–15% of patients develop radiographic sacroiliitis (i.e. structural changes) after 2 years, about 40% after 5 years, and about 60% after 10 years.[9] Radiographs are unable to assess the early inflammatory components of axial SpA due to limited sensitivity and lack of reliable diagnostic assessment and therefore have limited utility in early disease.

Radiographic interpretation is negatively impacted by the oblique nature of the joints, and by the overlap between early degenerative changes and early sacroiliitis. This has been shown to be particularly problematic in women and in older age groups. A comparative study between radiographs and computed tomography (CT), the reference standard imaging for structural changes at the SIJs, demonstrated poor sensitivity for radiographs in the detection of erosions (42%) and joint space changes (41%), with only fair inter-reader agreement.[10] This has confirmed similar findings in earlier studies.[10,11]

CT, although excellent at demonstrating structural changes at the SIJ, is not routinely used as first line imaging for the detection of sacroiliitis due to the inherent radiation exposure and inability to detect earlier inflammatory components of the disease.[10]

MRI is the imaging reference standard for assessment of active disease allowing for earlier imaging identification of disease. MRI of the SIJ, with or without limited imaging of the entire spine, is being increasingly utilised for the clinical diagnosis of axial SpA. MRI sequences typically include a fat-sensitive T1-weighted spin-echo (T1SE) and a T2-weighted sequence sensitive for free water (such as short tau inversion recovery [STIR] or T2 fat-suppressed). There are five MRI features of active sacroiliitis: osteitis/bone marrow oedema (BMO), oedema and/or enhancement related to an erosion, enthesitis, capsulitis, and synovitis/joint space enhancement. BMO is considered to be the most important and indispensable feature indicating active sacroiliitis in SpA.[12]

The 2009 ASAS classification criteria for axial SpA represented the first time MRI was included in classification criteria for SpA. Given that these ASAS criteria are often adapted in clinical practice, and the wealth of published research utilising these criteria, there is a risk that the imaging criteria will be incorrectly incorporated into the MRI interpretation in clinical practice. In a recent update for the imaging arm, the ASAS MRI Working Group definition of a positive MRI stated that inflammation must be "located in a typical anatomical area (subchondral bone)" and the MRI appearance must be "highly suggestive of SpA".[12] This definition remains controversial. A prior joint ASAS-OMERACT expert consensus statement suggested that two bone marrow lesions on the same SIJ section, or one lesion seen on at least two consecutive sections are indicative of SpA.[13] The high specificity of the imaging arm (97%)[14] can erroneously lead radiologists and rheumatologists to believe that these findings are diagnostic in clinical practice; however, BMO meeting the ASAS-OMERACT criteria was seen in 23% of patients with mechanical back pain and in 7% of healthy volunteers in one study.[15] BMO is visualised in up to 30% of mechanical back pain and healthy controls.[16–18] In a recent study comparing MRI evidence of BMO in healthy subjects to those with known mechanical stress across the SIJs, patients with known axial SpA and patients with chronic back pain, 23% of the healthy volunteers had MRI evidence of BMO that met the ASAS definition for lesions highly suggestive for axial SpA.[17], The presence of BMO fulfilling the ASAS definition was as high as 35% and 41% in recreational runners and elite hockey players, respectively.[18]

It is worthwhile emphasising that classification criteria are applied after a patient has been diagnosed. Increasingly, the ASAS criteria for a positive MRI are being applied for diagnostic purposes so that testing of the performance of classification criteria that include this MRI criterion leads to

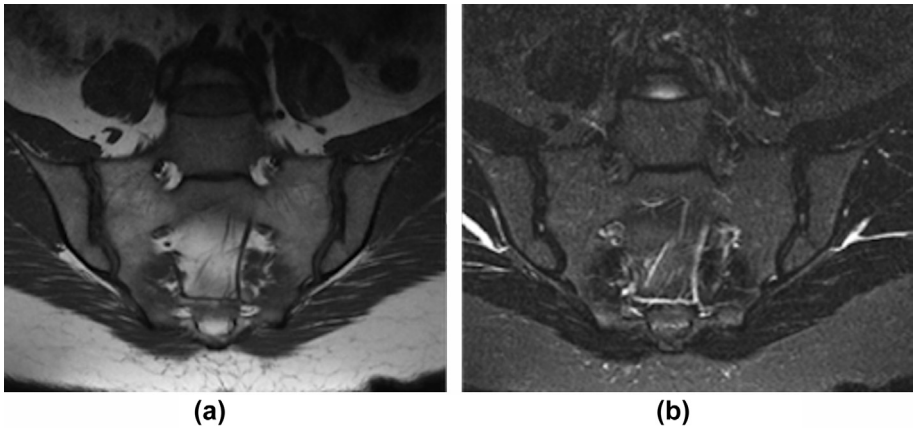

Figure 1 A 32-year-old woman with a 10 year history of chronic inflammatory back pain with normal (a) semi-coronal T1 and (b) STIR of the SIJs demonstrating maintained joint spaces, intact subchondral bone plate, and normal periarticular marrow signal intensity.

circular reasoning and culminates in very high performance characteristics.

MRI can also detect structural damage from prior inflammation, including subchondral sclerosis, erosions, peri-articular post-inflammatory fat metaplasia in the subchondral marrow and erosion cavity, and bony bridges/ankyloses. Of note, structural changes can already be seen on MRI in 60–90% of SpA patients within the first 2.5 years after symptoms onset.[15,19] In clinical practice, structural changes can therefore be vital in arriving at an imaging diagnosis, especially when BMO is non-specific.

Imaging differential diagnosis

It is important to recognise that SIJ periarticular BMO can occur in healthy patients possibly because of mechanical stress, as well as in a multitude of other conditions presenting with low back pain (Fig 1).[16,20–24] The most common abnormality to affect the SIJ is degeneration, often commencing in the third decade in patients exposed to increased stress across the SIJs. This includes mechanical workers, multiparous women, and those exposed to prior pelvic trauma. Presence and extent of degeneration on imaging does not necessarily correlate with clinical symptoms. Imaging findings on MRI include joint space loss, subchondral sclerosis, subchondral cysts, anterior osteophytosis, and BMO.[23–27] The latter usually presents as a thin band of high signal intensity on T2FS or STIR sequences paralleling the joint space anteriorly. Accessory facet joints of the SIJs can also be a source of symptoms, and are predisposed to the early development of degenerative changes.[26]

Osteitis condensans ilii (OCI) may be symptomatic and present with low back and pelvic pain. It is most common in multiparous women and is thought to be related to the increased stress across the SIJs during pregnancy and childbirth. On imaging, a broad region of dense sclerosis with triangular type configuration can be seen in the iliac subchondral bone, usually most pronounced antero-inferiorly with a thin band of BMO surrounding the sclerotic bone and minor irregularity of the iliac cortex without erosions.[22,28–30]

Fractures, including post-traumatic, insufficiency, and stress fractures, may be a source of BMO. In the case of trauma, there is usually no uncertainty regarding the underlying pathology. Insufficiency fractures occur with normal stress on weakened bone such as in osteoporosis, while stress fractures occur with abnormal stress on normal bone. Both can present with acute to subacute pain and demonstrate BMO on MRI on either side of a low signal intensity fracture line on T1 images.[31,32]

Diffuse idiopathic skeletal hyperostosis (DISH) may be associated with structural changes within the spine and along the superior/anterior aspect of the SIJs with bridging ossification that may simulate axial SpA.[33,34] Blood vessels crossing through the SIJ can be mistaken for active inflammation on semicoronal STIR images by inexperienced

Table 1
Differential diagnosis for BMO on MRI of sacroiliac joint.

Category	Description
Normal	Possible related to normal mechanical stress
Anatomical variants	Accessory sacroiliac joints, transitional lumbosacral vertebra (predispose to mechanical stress and premature degeneration)
Spondyloarthritis	
Alternative rheumatic and metabolic disease	Degeneration/osteoarthritis Osteitis condensans ilii Crystal disease Paget's disease Diffuse idiopathic skeletal hyperostosis Systemic lupus erythematosus Bechet's disease Familial Mediterranean fever Insufficiency fracture Hyperparathyroidism
Trauma	Fractures including stress fractures Peripartum
Septic sacroiliitis	
Malignancy	Leukaemia, lymphoma, sarcoma, metastatic
Other	Imaging artefact

Table 2
MRI reporting categorisation system.

Category	Description
1	Normal
2	Alternate diagnosis, e.g. osteoarthritis (degeneration), DISH, OCI, stress fracture, insufficiency fracture, septic sacroiliitis, etc.
3	Indeterminate findings (not diagnostic for sacroiliitis), e.g. minor subchondral BMO, cortical irregularity without erosions, single erosion, isolated mild enthesitis, capsulitis.
4	Sacroiliitis A. Acute (Inflammatory): osteitis/BMO, enthesitis, capsulitis and/or synovitis B. Chronic (Structural changes): subchondral sclerosis, erosions, peri-articular post-inflammatory fat deposition, new bone formation, bony bridges/ankylosis C. Acute-on-chronic: active sacroiliitis with structural changes

readers. Septic sacroiliitis is usually easily discernible with unilateral widespread inflammation, crossing anatomical borders far into the bone and adjacent soft tissues. Additional aetiologies of BMO are outlined in Table 1. A full description of imaging characteristics is beyond the scope of this article.

There is thus significant overlap between imaging findings in axial SpA and these alternate pathologies particularly with respect to BMO. A global approach to image interpretation, incorporating acute and structural changes, in conjunction with clinical presentation is therefore essential for diagnosis.

Why is a categorisation system needed for MRI reporting?

MRI is being increasingly utilised in the diagnosis and monitoring of axial SpA, and are therefore a key tool in the clinician's toolbox. In one study of clinicians, diagnostic confidence for AS improved from 29% pre-MRI to 80% post-MRI ($p<0.001$).[35] Of the patients for whom biologics were proposed pre-MRI, only 52% were recommended biologics post-MRI. Additionally, among the patients for whom biologics were not recommended pre-MRI, 31% were recommended biologics post-MRI. Overall,

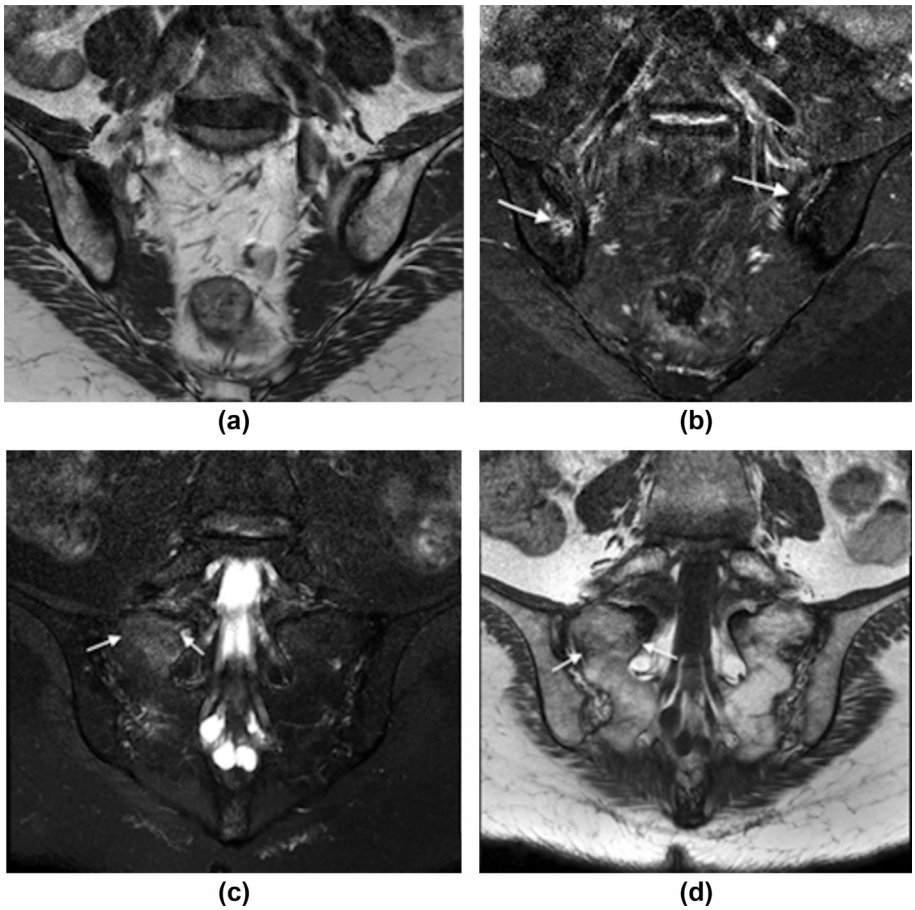

Figure 2 A 54-year-old woman referred with inflammatory back pain, history of degenerative disc disease and fibromyalgia. (a) Semicoronal T1 and (b) STIR images demonstrating bilateral joint space narrowing of the SIJs with associated mild to moderate subchondral BMO along the anterior iliac aspect of the right SI joint and anterior sacral aspect left SIJ (arrows), without evidence of erosive disease or post-inflammatory fat accentuation. Features are in keeping with degenerative disease. Additional image of the same patient, (c) semicoronal STIR demonstrates localised BMO (arrows) along the superior right alae extending to involve the body of the first sacral vertebra with associated traversing low signal intensity line (small arrows) and confirmed on semicoronal T1 (d), representing an insufficiency fracture.

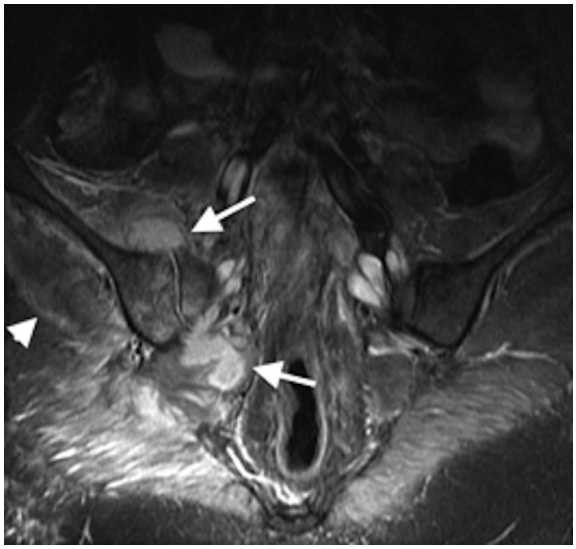

Figure 3 A 35-year-old woman with systemic lupus erythematosus on steroids developed acute-onset right SIJ pain with limited range of motion and fever. Coronal T2FS image shows right-sided diffuse subchondral BMO and periarticular high SIJ collections (arrows) extending superiorly and inferiorly from right SIJ and surrounding myositis (arrowhead).

40% of patients had a change in treatment recommendation after MRI.[35] The MRI report therefore significantly impacts diagnosis, clinical decision-making, and subsequent management, including the use of biologic drugs. Equally important, the MRI report profoundly impacts the individual patient, carrying with it all the implications of receiving (or not receiving) a particular diagnosis. The importance of an accurate interpretation could not be more important.

The radiological diagnosis of sacroiliitis is a global assessment of both the acute and chronic changes of sacroiliitis in conjunction with the provided clinical history and clinical findings. The current ASAS MRI definition of a positive MRI, which focuses on BMO for assessment of sacroiliitis, should not be automatically equated with the presence of SpA. In our experience however, with an overwhelming stream of publications, the ASAS classification criteria for axial SpA, and thereby the ASAS definition of a positive MRI, continue to have a significant impact on diagnosis in clinical practice. Basing MRI diagnosis solely on the presence of BMO may lead to over-diagnosis as many conditions may cause a similar appearance on MRI (Table 1). Additionally, in the absence of BMO, the diagnosis may be overlooked despite the presence of structural changes. The indispensable role of MRI in the diagnostic work-up of axial SpA, accompanied by the many potential pitfalls discussed herein, led the authors to propose the following categorisation system for MRI reporting in clinical practice (Table 2).

Category 1: Normal. There are no abnormal findings of spondyloarthritis or alternative diagnosis (Fig 1).

Category 2: Alternate diagnosis. MRI demonstrates features consistent with an alternate diagnosis and which may

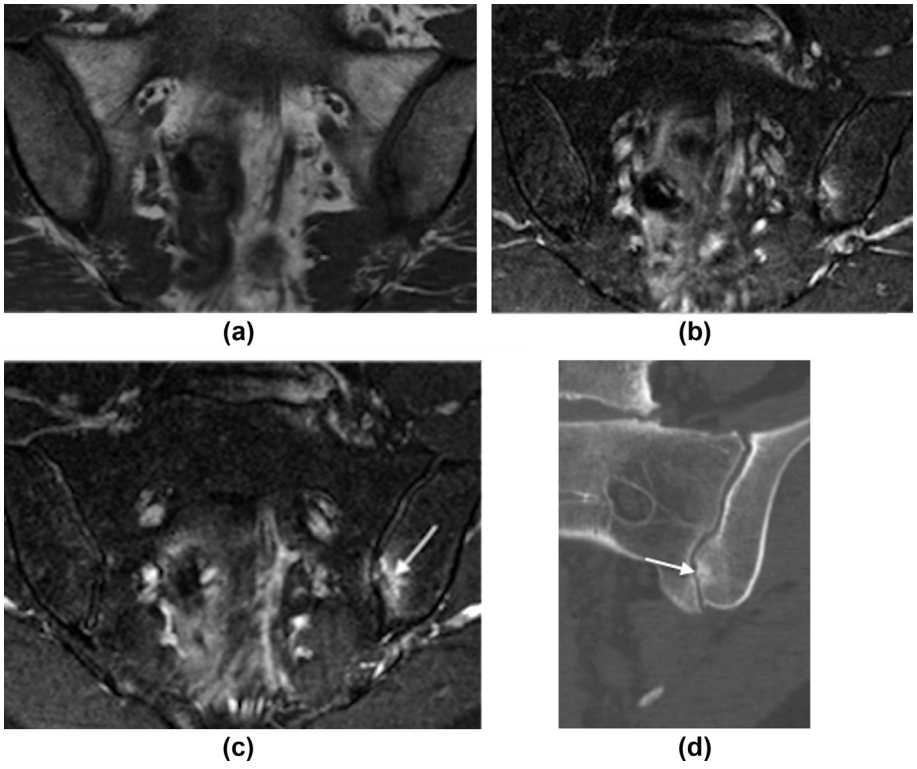

Figure 4 A 48-year-old female patient with inflammatory back pain, positive HLA-B27, recurrent iritis, high pretest probability of AS with semicoronal (a) T1 (b) and (c) STIR demonstrating moderate subchondral BMO left ilium with a subtle low signal intensity line (arrow image c) in keeping with a stress fracture confirmed on a follow-up CT examination (d) demonstrating fracture (arrow) with surrounding reactive sclerosis. Patient later provided an additional history of attendance of a workout boot camp after which she developed symptoms.

explain the patient's symptoms. Alternative diagnoses include degenerative disease, OCI, fractures, and infection (Figs 2–4). Findings have to be reviewed in conjunction with patient's presentation and clinical findings. Review of prior imaging may be helpful, e.g., prior CT examinations which may have been performed for alternate reasons, and may provide useful structural assessment of the SIJs to supplement the findings on MRI.

Category 3: Indeterminate. MRI demonstrates findings that may be suspicious for sacroiliitis, but are not diagnostic, and do not fulfil one of the other categories, i.e., normal, alternative diagnosis, and acute/chronic sacroiliitis (Fig 5). Findings may include isolated findings, such as minor subchondral BMO, cortical irregularity without erosions, single erosion on one image without additional findings, isolated mild enthesitis, or isolated capsulitis. Category 3 cases give the interpreter the option of calling such findings "indeterminate" rather that attributing a diagnosis when faced with uncertainty. These patients can be reassessed clinically, and follow-up imaging performed at 6–12 months if there is ongoing clinical concern. This timeline was selected as studies have demonstrated little change over short-term interval follow-up with few patients progressing from a negative MRI to a positive study[37,38]; however, prior studies have not evaluated patients with indeterminate imaging findings for the most appropriate follow-up intervals. A 6–12 month time interval may also allow additional clinical features to become apparent or presenting symptoms to resolve.

Category 4: Sacroiliitis. Findings are consistent with the presence of acute (active inflammation), chronic (structural changes), or acute-on-chronic sacroiliitis in the appropriate clinical context and after the exclusion of category 2 pathologies (Fig 6).[15,40]

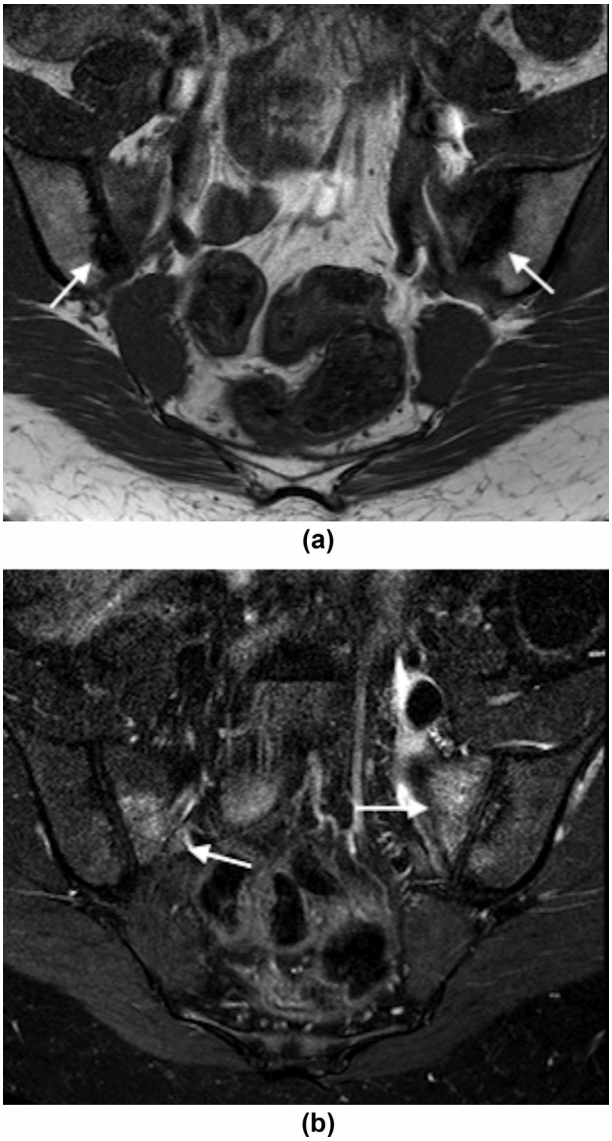

Figure 5 A 34-year-old woman with a 2 year history inflammatory back pain. Semicoronal (a) T1 sequence demonstrate moderate subchondral sclerosis present on the iliac aspect anteriorly (arrows), mild joint space loss without erosive disease, (b) STIR demonstrating prominent subchondral BMO, left greater than right without erosions, capsulitis, or enthesitis identified. Imaging is non-diagnostic without additional clinical information. The imaging differential is OCI with BMO related to a recent additional mechanical stress such as postpartum changes, OCI with superimposed sacroiliitis is less likely but remains within the differential. A prior CT abdomen 1 year previous, not shown, had demonstrated classical features of OCI with triangular sclerosis along iliac aspects of both SIJs.

Discussion

To the authors' knowledge, this is the first categorisation system being proposed for clinical use in the reporting of MRI examinations performed to assess for axial SpA. It provides several potential benefits. Firstly, the system will remind the assessor that the presence of BMO does not necessarily indicate the presence of SpA, and encourage consideration of the wider differential for SIJ pathology, including BMO. Secondly, having an "indeterminate" category would potentially reduce the temptation or perceived "pressure" to assign a diagnosis of SpA when findings are uncertain. Uncertainty often exists, even with the trained reader. In fact, disagreement between local and central readers in clinical trials, as well as between central readers, has been reported to occur in 20–30% of cases.[36] We performed an initial preliminary retrospective review of 60 patients referred by a rheumatologist for suspected axial SpA. All patients had obtained MRI examination of the entire spine and SIJs. The examinations were reviewed by an MSK radiologist with 15 years' experience, blinded to initial imaging diagnosis, and categorised using our proposed system herein based on imaging and the clinical information provided at the time of study. This was then compared with the initial report, performed by a combination of both musculoskeletal and cross-sectional fellowship trained radiologists, which is reflective of the practice in most academic centres. We found that the categorisation system reduced the number of positive diagnoses by 40% and re-categorised patients into category 2 or 3 (unpublished data). This requires more detailed evaluation, and a larger retrospective study is underway.

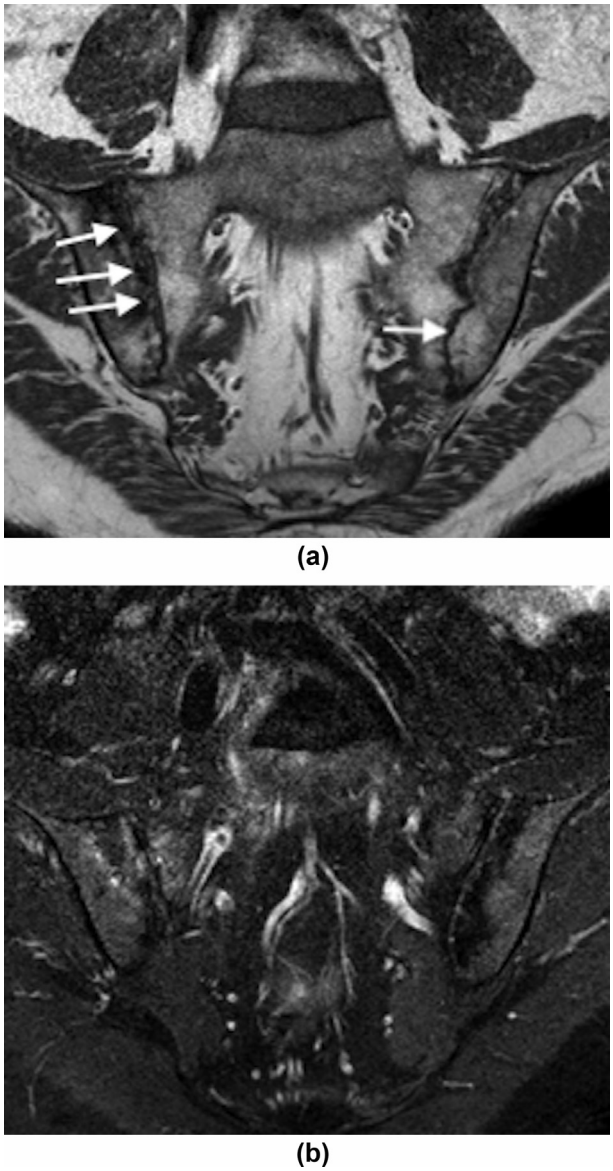

Figure 6 A 24-year-old woman with lower back pain, with mixed mechanical and inflammatory features on history, negative HLA-B27, and normal inflammatory markers, but chronic bilateral iritis. Semi-coronal (a) and (b) STIR demonstrate narrowed SIJ spaces bilaterally, with bilateral extensive erosive disease (arrows) on both sides of the articulation but without bony ankylosis. Bilateral post-inflammatory fat accentuation of moderate severity is seen. Asymmetrical, predominantly right-sided, subchondral BMO of moderate severity is in keeping with acute-on-chronic sacroiliitis.

Thirdly, the categorisation system can help guide clinical care, and serve as a universal tool for clinical decision-making. Like other reporting systems, it should be reviewed in conjunction with history and clinical findings. For example, in the appropriate clinical context, an "indeterminate" category may prompt a repeat MRI at a later time (e.g. 6–12 months) to assess for the evolution of disease. A time period of at least 6 months should be considered as imaging findings may demonstrate little change with shorter time intervals.[37] On the other hand, patients in one of the "definite" diagnostic categories would not need repeat imaging (unless clinically indicated).

Fourthly, the system introduces a universal vocabulary for communication between radiologists and clinicians, and within each group. This can reduce misinterpretation and miscommunication of the MRI report.

Finally, the categorisation system would also increase awareness of SpA among radiologists not yet familiar with this entity, and potentially reduce false-negative interpretations. In the authors' experience, it is not uncommon to receive solely an orthopaedic or neurological structural interpretation of an MRI ordered for SpA. In a study from the UK, only 75% of radiologists reported awareness of axial SpA, whereas awareness of the definitions for positive MRI of the spine and SIJ were reported by 25% and 31% respectively.[39] Increased awareness would potentially lead to improved diagnosis, especially in early disease.

The proposed system needs to be validated in clinical practice. Our next steps are to assess the impact of the system on MRI reporting by radiologists, as well as the impact on clinical care. Future research will also look at sensitivity to change of category, and factors affecting such change.

In conclusion, to our knowledge, this is the first categorisation system being proposed for clinical use in the reporting of MRIs performed to assess for axial SpA. It presents several advantages: it will potentially reduce false-positive and false-negative diagnoses, allow for an "indeterminate" MRI interpretation, serve as a tool for decision-making to guide clinical care, introduce a vocabulary for communication between healthcare providers, and increase awareness of SpA among radiologists. The system needs to be validated in clinical practice, and further research is currently underway.

Conflicts of interest

The authors declare no conflict of interest.

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