Current role of conventional radiography of sacroiliac joints in adults and juveniles with suspected axial spondyloarthritis: opinion from the ESSR Arthritis and Pediatric Subcommittees

Sudol-Szopinska, I.; Herregods, N.; Zejden, A.; Jans, L.; Giraudo, C.; Boesen, M.; ... ; Jurik, A.G.

Current Role of Conventional Radiography of Sacroiliac Joints in Adults and Juveniles with Suspected Axial Spondyloarthritis: Opinion from the ESSR Arthritis and Pediatric Subcommittees

Iwona Sudoł-Szopińska, MD, PhD[1] Nele Herregods (2nd first), MD, PhD[2] Anna Zejden, MD[3] Lennart Jans, MD, PhD[4] Chiara Giraudo, MD, PhD[5] Mikael Boesen, MD, PhD[6,7] Fabio Becce, MD[8] Alberto Bazzocchi, MD, PhD[9] Paolo Simoni, MD, PhD, MBA[10] Maria Pilar Aparisi Gómez, MBChB, FRANZCR[11,12] Jacob Jaremko, MD, PhD, FRCPC[13] Mario Maas, MD, PhD[14] James Teh, MBBS, MRCP, FRCR[15] Kay-Geert Hermann, MD[16] Flavia Menegotto, MD[17] Amanda Isaac, MBChB, MRCS, FRCR[18] Monique Reijnierse, MD, PhD[19] Amit Shah, BSc (Hons), MBChB (Hons), FRCR[20] Winston Rennie (2nd last), MB, BS, MSc, MFSEM, FRCR[21] Anne Grethe Jurik, DMSc[3]

[1] Department of Radiology, National Institute of Geriatrics, Rheumatology and Rehabilitation, Warsaw, Poland
[2] Department of Radiology and Nuclear Medicine - Division of Pediatric Radiology, Princess Elisabeth Children's Hospital/Ghent University Hospital, Ghent, Belgium
[3] Department of Radiology, Aarhus University Hospital, Aarhus, Denmark
[4] Department of Radiology, Ghent University Hospital, Ghent, Belgium
[5] Department of Medicine – DIMED, University of Padova, Padova, Italy
[6] Department of Radiology, Copenhagen University Hospital, Bispebjerg and Frederiksberg, Copenhagen, Denmark
[7] Department of Clinical Medicine, Faculty of Health and Medical Sciences, University of Copenhagen, Copenhagen, Denmark
[8] Department of Diagnostic and Interventional Radiology, Lausanne University Hospital, University of Lausanne, Lausanne, Switzerland
[9] Diagnostic and Interventional Radiology, IRCCS Istituto Ortopedico Rizzoli, Bologna, Italy
[10] Pediatric Imaging Department, Reine Fabiola Children's University Hospital, ULB, Brussels, Belgium
[11] Department of Radiology, Auckland City Hospital, Auckland District Health Board, Grafton, Auckland, New Zealand
[12] Department of Radiology, IMSKE, Valencia, Spain
[13] Department of Radiology and Diagnostic Imaging, Faculty of Medicine and Dentistry, University of Alberta Hospital, Edmonton, AB, Canada
[14] Department of Radiology & Nuclear Medicine, Amsterdam UMC, location AMC – University of Amsterdam, Amsterdam, Netherlands
[15] Radiology Department, Nuffield Orthopaedic Centre, Oxford University Hospitals NHS Trust, Oxford, United Kingdom
[16] Department of Radiology, Charité – Universitätsmedizin Berlin, Berlin, Germany
[17] Bristol Royal Hospital for Children Paediatric Radiology Department, University Hospitals Bristol and Weston NHS Foundation Trust (UHBW), Bristol, United Kingdom
[18] School of Biomedical Engineering and Imaging Sciences, King's College London, London, United Kingdom
[19] Department of Radiology, Leiden University Medical Center, Leiden, Netherlands
[20] Department of Radiology, University Hospitals of Leicester NHS Trust, Infirmary Square, Leicester, United Kingdom
[21] Department of Radiology, University Hospitals of Leicester NHS Trust, Loughborough University, Loughborough, United Kingdom

Address for correspondence Iwona Sudoł-Szopińska, MD, PhD, Department of Radiology, National Institute of Geriatrics, Rheumatology and Rehabilitation, St. Spartańska 1, 02-637 Warsaw, Poland (e-mail: sudolszopinska@gmail.com).

Semin Musculoskelet Radiol 2023;27:588–595.

Abstract

This opinion article by the European Society of Musculoskeletal Radiology Arthritis and Pediatric Subcommittees discusses the current use of conventional radiography (CR) of the sacroiliac joints in adults and juveniles with suspected axial spondyloarthritis (axSpA). The strengths and limitations of CR compared with magnetic resonance imaging (MRI) and computed tomography (CT) are presented.

Based on the current literature and expert opinions, the subcommittees recognize the superior sensitivity of MRI to detect early sacroiliitis. In adults, supplementary pelvic radiography, low-dose CT, or synthetic CT may be needed to evaluate differential diagnoses. CR remains the method of choice to detect structural

Keywords
- radiographs
- axial spondyloarthritis
- spondyloarthropathy
- sacroiliitis

Issue Theme ESSR-ESNR Spine Issue; Guest Editors, Radhesh Lalam, MBBS, MRCS, FRCR and Filip M. Vanhoenacker, MD, PhD

Thieme Medical Publishers, Inc., 333 Seventh Avenue, 18th Floor, New York, NY 10001, USA

DOI https://doi.org/10.1055/s-0043-1772169.
ISSN 1089-7860.

changes in patients with suspected late-stage axSpA or established disease and in patients with suspected concomitant hip or pubic symphysis involvement. In children, MRI is the imaging modality of choice because it can detect active as well as structural changes and is radiation free.

Imaging of the sacroiliac joints (SIJs) is important for the diagnosis and classification of axial spondyloarthritis (axSpA), encompassing both non-radiographic axSpA and radiographic axSpA, commonly known as ankylosing spondylitis (AS).[1,2] Structural changes in the SIJs visible on conventional radiography (CR) are an essential part of the widely accepted modified New York (mNY) criteria for AS.[3] According to the European Alliance of Associations for Rheumatology recommendations,[4] CR of the SIJs is recommended as the first imaging method to diagnose sacroiliitis as part of axSpA. If the diagnosis of axSpA cannot be established based on clinical features and CR, and axSpA is still suspected, magnetic resonance imaging (MRI) of the SIJs is recommended to detect non-radiographic sacroiliitis.[4]

In recent years, MRI has become an established technique for detecting structural as well as active inflammatory SIJ changes, giving rise to the potential of substituting CR with MRI in adults and children.

In this overview, the strengths and limitations of CR compared with MRI and computed tomography (CT) in the diagnosis of axSpA in adults and juveniles are presented, in addition to the current recommendations of the Arthritis and Pediatric Subcommittees of the European Society of Musculoskeletal Radiology (ESSR) on the use of radiography in adults and children with suspected axSpA.

Part 1: Current Role of Radiography for Sacroiliitis in Adults

Sacroiliitis is a hallmark of axSpA with characteristic imaging features on CR and MRI, respectively (►**Figs. 1** and **2**).[1,2] The diagnosis of axSpA is usually based on clinical symptoms and

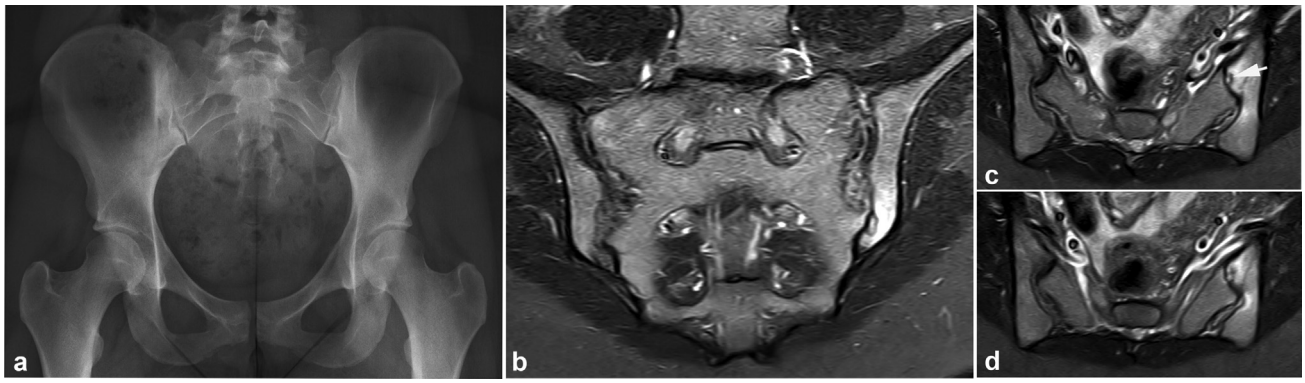

Fig. 1 A 20-year-old woman positive for human leukocyte antigen (HLA)-B27 with non-radiographic axial spondyloarthritis who complained of buttock pain for 10 months. (**a**) Pelvic radiograph without signs indicating sacroiliitis except slight subchondral sclerosis in the ileum at the left sacroiliac joint (SIJ). (**b-d**) Supplementary magnetic resonance imaging, semi-coronal and two semi-axial short tau inversion recovery images, show subchondral bone marrow edema at the inferior part of the left SIJ with edema within an erosive cavity in the iliac bone (arrow).

Fig. 2 A 33-year-old man positive for human leukocyte antigen (HLA)-B27 diagnosed with radiographic axial spondyloarthritis/ankylosing spondylitis 5 years previously. (**a**) Pelvic radiograph shows changes compatible with grade 3–4 at the right sacroiliac joint (SIJ) and grade 3 at the left SIJ. (**b-c**) Supplementary magnetic resonance imaging, semi-coronal short tau inversion recovery (STIR) and T1-weighted image, show persistent joint spaces on both sides but erosive changes including fat within erosive cavities (arrows on the T1-weighted image). In addition, there are signs of activity in the form of subchondral bone marrow edema at both joints (arrows on the STIR images).

Table 1 Classification criteria and gradings based on radiography

Modified New York criteria for AS (1984)[1,3]	
Radiographic grading of sacroiliitis	**Radiographic findings**
0	Normal
1	Suspicious changes
2	Minimal abnormalities: small localized areas with erosion or sclerosis, without alteration of the joint width
3	Unequivocal abnormalities: moderate or advanced sacroiliitis with one or more erosions, evidence of sclerosis, widening, narrowing, or partial ankylosis
4	Severe abnormality: total ankylosis
Positive radiographic criterion	Sacroiliitis grade 2 or more bilaterally or sacroiliitis grade 3–4 unilaterally
Clinical criteria	1. Low back pain and stiffness >3 months that improves with exercise but is not relieved by rest 2. Limitation of motion of the lumbar spine in the sagittal and frontal planes 3. Limitation of chest expansion relative to normal values correlated for age and sex
AS/axSpA grading based on combined radiographic and clinical findings	1. Definite AS/axSpA if the radiographic criterion is associated with at least one clinical criterion 2. Probably AS/axSpA if three clinical criteria are present or a radiologic criterion is present without any signs or symptoms satisfying the clinical criteria

Abbreviations: AS, ankylosis spondylitis; axSpA, axial spondyloarthritis.

signs combined with biochemical findings and characteristic imaging features. Unfortunately, diagnosis is often considerably delayed. In a recent meta-analysis of 64 publications from 2005 to 2019, the estimated mean diagnostic delay was 6.7 years. This delay did not vary based on the year of publication.[5] The diagnosis was mainly based on CR and clinical assessment using the mNY criteria (►**Table 1**). Interestingly, there was no improvement in the delay in diagnosis in 11 studies in which the MRI findings according to the Assessment of SpondyloArthritis International Society (ASAS) classification criteria were used.[5] Delayed diagnosis can be associated with greater morbidity and disability. Therefore, early diagnosis is important. Key factors to improvement are awareness of axSpA as a cause of back pain, especially in young individuals, earlier admission to specialist rheumatologists, and an appropriate imaging strategy. The use of sensitive imaging methods may help avoid a delayed diagnosis.

On CR, only the structural changes of sacroiliitis can be depicted, with features including blurred margins, erosions, subchondral sclerosis, joint space widening/narrowing, and ankylosis. On MRI, however, early inflammatory changes can be detected (►**Fig. 1**), often occurring several years before the appearance of sacroiliitis by radiography. Therefore, radiography is not suitable for the early diagnosis of axSpA, but it remains the method of choice for easy and inexpensive detection of structural changes in patients with suspected established disease. An advantage of CR is that it can be useful for classifying and grading structural SIJ changes using the mNY criteria in patients with established radiographic axSpA[3] (►**Table 1**).

Radiographic interpretation of the SIJs, however, can be challenging due to several unique anatomical features of the joint. The orientation of the SIJs means it cannot be visualized in two perpendicular planes. Special radiographic projections, such as oblique or angulated views, were not shown to be superior to the anteroposterior (AP) view for diagnosing sacroiliitis.[6–8] Therefore, the SIJs are usually assessed on an AP angulated SIJ projection or an AP pelvic radiograph, as recommended by ASAS,[1] where the joint spaces are not clearly delineated as they are oriented obliquely, with the anterior part located laterally and the posterior part more medially (►**Fig. 3**). Furthermore, superimposed bowel gas may hide the joints or mimic structural bone changes. These features often contribute to equivocal SIJ findings, especially in the initial stages of axSpA when established structural changes may be absent.

Given the challenges in interpreting radiographs, agreement in the recognition of radiographic sacroiliitis was shown to be only moderate for both trained readers ($\kappa = 0.54$) and for experienced rheumatologists/radiologists ($\kappa = 0.55$),[9] with additional training not leading to further improvement.[10] Discordant reporting particularly occurs for grade 1 and grade 2 sacroiliitis changes according to the mNY criteria,[6,10,11] and the highest concordance reporting rates are for definitely normal (grade 0) or definitely abnormal (grade 4) SIJs.[10] Of the mNY grading criteria, erosions, which are highly specific axSpA lesions,[12] were found to have the lowest interreader agreement (25%).[11] The misinterpretation of patients with grade 2 sacroiliitis may have diagnostic and therapeutic consequences because bilateral grade 2 changes represent a positive radiograph for sacroiliitis (►**Table 1**).

Agreement in the detection of structural changes was generally shown to be superior by cross-sectional imaging in MRI and CT rather than CR.[13–16] These imaging methods have higher sensitivity than radiography in detecting sacroiliitis.[13,14] In addition, analysis using artificial intelligence

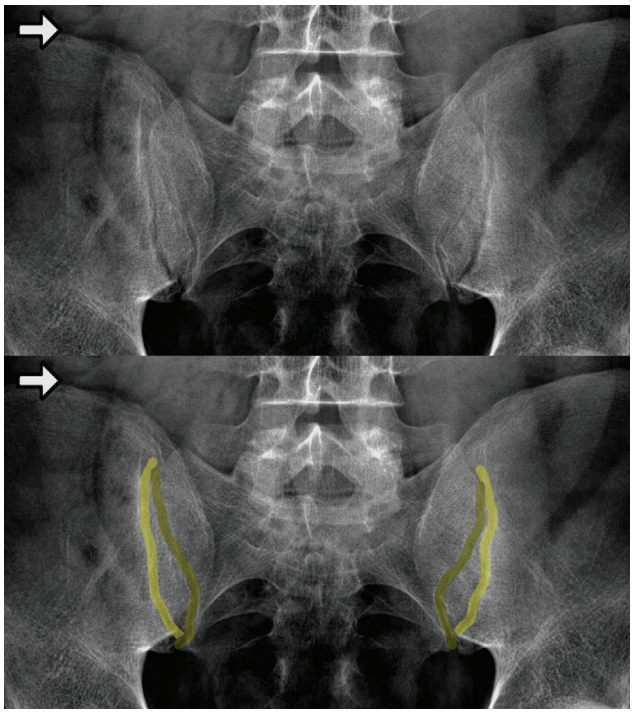

Fig. 3 A 38-year-old man. Anteroposterior radiograph of the sacroiliac joints (SIJs) shows normal SIJs with uniform width and smooth outlines bilaterally. The anterior part of the joint space is marked in light yellow, the posterior part in dark yellow (reproduced with permission from Medisfera, Radiographic Atlas of Inflammatory Rheumatic Diseases. Otwock, Poland).[41]

with a neural network algorithm to detect erosion and ankylosis by CT was shown to have a higher sensitivity and specificity than generally obtainable by CR.[17]

A German group compared radiography with MRI for the detection of structural SIJ lesions in different ways. In a study using radiography as the reference standard and the same definition of lesions/grades by CR and MRI, respectively, the sensitivity of T1-weighted MRI was 84% and its specificity 64% for fulfilling the mNY criteria, with similar figures for the overall detection of structural damage.[16]

In a subsequent study, CR and T1-weighted MRI were compared using low-dose CT findings as the reference standard to detect structural SIJ lesions encompassing erosions, sclerosis, and joint space changes (including ankylosis). MRI showed a better absolute agreement with CT compared with CR for erosions (88.2% versus 70.9%), joint space changes (92.7% versus 80.9%), and overall positivity for the presence of structural changes (89.1% versus 70.0%), but not for sclerosis (83.6% versus 86.4%).[14]

In the most recent study, the researchers compared the value of different SIJ imaging approaches in the diagnosis of axSpA, using the clinical diagnosis by experts as the reference standard: CR, CT, MRI (both short tau inversion recovery [STIR] and T1-weighted images), conventional radiographs and MRI, and CT and MRI.[13] The results confirmed that radiography was inferior to MRI. CR showed the lowest sensitivity (66.3%) compared with MRI (82%) and CT (76.4%). It also had a lower specificity of 67.6%, compared with MRI (86.5%) and CT (97.3%). In routine clinical practice, MRI is often performed after CR in case of negative or equivocal radiographic findings, and both imaging modalities are therefore often assessed simultaneously. However, this study showed that the combination of radiography and MRI did not outperform MRI alone.[13]

In all three studies, the interrater reliability at the patient level was lowest for radiography. In the latter two studies, there was a κ value of 0.33/0.52 for radiography compared with 0.62/0.67 for MRI and 0.62/0.88 for CT.[13,14,16] The reliability for detecting erosions and joint space alterations, analyzed in two of the studies, was found to be better by MRI than by radiography,[14,16] whereas the reliability for detecting sclerosis varied, with MRI found superior to radiography in the study using radiography as a reference standard.[16] The opposite was observed in the study using CT as the reference standard.[14]

The addition of a cartilage sequence optimized for giving high contrast at the joint margins/bone-cartilage border, such as a dedicated gradient-echo or a fat-suppressed T1-weighted sequence, seems to improve the sensitivity of MRI to detect erosions.[18,19] The use of three-dimensional (3D) MR-volumetric interpolated breath-hold examination (VIBE) was shown to increase the sensitivity for detecting erosions compared with T1-weighted images (95% versus 79%) without a decrease in specificity (93%) using low-dose CT as a reference.[18] In addition, the agreement at the patient level was higher using MR-VIBE compared with T1-weighted MRI, with κ values of 0.71 and 0.56, respectively, and slightly better by CT (0.77).

The specificity of bone marrow edema (BME) is limited, so clinical features that may suggest infection, degenerative change, and mechanical stress induced change should always be considered.[13,20] One of the most challenging differential diagnoses is osteitis condensans ilii (OCI).[21,22] It is characterized by a predominant iliac sclerosis on pelvic radiography. It mainly occurs in postpartum women, but it can also be seen without a history of pregnancy and in men. Concomitant BME and fat deposition are frequent, often occurring peripheral to sclerosis.[22] Only a predominantly anterior location of sclerosis and BME, as well as the absence of definite erosions, may differentiate OCI from axSpA on MRI[21] (►**Fig. 4**). However, the joint margins can appear irregular on MRI, and supplementary pelvic radiography or CT may be needed for differentiation between OCI and axSpA. The presence of subchondral sclerosis at the load-related area of the SIJ supports the diagnosis of OCI as well as female sex, negative human leukocyte antigen (HLA)-B27 status, low levels of inflammatory markers, and the absence of clinical features of SpA.

Other advantages of pelvic radiography are the concomitant visualization of the hips and pubic symphysis, which are relatively frequently affected in axSpA. The presence of osteitis or enthesopathy at the symphysis and cam-like new bone formation at the hips can support the radiographic diagnosis of axSpA. Other causes of pain, such as hip dysplasia and lumbosacral transitional vertebra with pseudoarthrosis, may be seen on radiography, but the detection of anatomical variants at the SIJ, such as accessory joints, usually requires cross-sectional imaging. The ongoing development and use of synthetic CT using specific MRI sequences that permit the creation of radiograph-like or CT-like images may in the future diminish

Fig. 4 A 39-year-old woman, complaining of low back pain since her third childbirth 4 years previously, with osteitis condensans ilii (OCI). (**a-c**) Semi-coronal T1-weighted image, short tau inversion recovery (STIR), and semi-axial STIR MR images. There is manifest bilateral iliac sclerosis in the anterior portion of the joints (slim arrows) with adjacent fat deposition in the sacrum and left ileum (arrows on the T1-weighted image). There is subtle bone marrow edema adjacent to the iliac sclerosis and anteriorly in the sacrum on both sides (arrows on the STIR images). (**d**) Radiograph of the sacroiliac joints (SIJs) showing typical OCI changes in the form of bilateral iliac sclerosis corresponding to the load-related portion of the SIJ with preserved joint spaces and no erosions.

the need for supplementary CR or CT.[23] Morbée et al found synthetic CT to be a useful problem-solving technique in up to 70% of the cases, particularly for detecting degenerative osteophytes in the SIJs.[23]

The ability to use the mNY criteria is an undisputed advantage of using CR for evaluating the SIJs[3] (►**Table 1**). It has been elaborated to classify AS changes, but is also used in the classification/grading of SIJ changes associated with inflammatory bowel disease and reactive and psoriatic arthritis. There is no available similar scale for structural changes such as subchondral fat deposition and fat metaplasia in erosive cavities detected on MRI.[24] However, based on a subset of patients from the original ASAS cohort, quantitative SIJ MRI lesion cut-offs with positive predictive values of 95% for the clinical diagnosis of axSpA were obtained, consisting either of erosions occurring in three SIJ scorings areas (with the joint divided into quadrants) or erosion at the same location for two consecutive slices; alternatively five areas with fat lesions, fat lesions at the same location for three consecutive slices, or presence of a deep (i.e., > 1 cm depth) fat lesion.[25] Similar cut-offs were obtained for active inflammatory changes (only detectable by MRI) consisting of BME highly suggestive of axSpA in four SIJ quadrants or at three consecutive SIJ slices.[25] Both active and structural MRI lesions typical of axSpA are relevant for the diagnosis and should be interpreted together.

The effect of replacing the detection of sacroiliitis on CR by structural lesions on MRI has also been analyzed in relation to the ASAS classification of axSpA patients. It resulted in only minor changes regarding positive or negative ASAS classification.[15,26] MRI may therefore also be a reasonable alternative to radiography when using the ASAS classification.[15] However, in current clinical practice, CR of the SIJ remains crucial for differentiating between radiographic and non-radiographic axSpA using the mNY and ASAS criteria, respectively.[1,8]

In conclusion, MRI and CT are more sensitive and specific than CR for the diagnosis of axSpA, and MRI allows the detection of early pre-radiographic changes. Despite this, CR still plays an important role. It is easily accessible and less expensive than other imaging techniques to detect structural changes. It also allows grading of sacroiliitis changes in accordance with the mNY criteria. CR, CT, or synthetic CT may also be required to help differentiate sacroiliitis from other SIJ changes.

Part 2: Current Role of Conventional Radiography for SIJs in axSpA in Juveniles

Juvenile spondyloarthritides (JSpA) are a group of related inflammatory diseases affecting the axial skeleton, with symptom onset before 16 years of age and a strong association to HLA-B27.[27–29] The International League of

Associations for Rheumatology classification of juvenile idiopathic arthritis (JIA) includes seven subtypes[28] in which JSpA is represented in enthesitis-related arthritis, psoriatic arthritis, arthritis associated with inflammatory bowel disease, and some types of undifferentiated arthritis.[30,31]

In contrast to adult SpA, where inflammatory back pain and early axial involvement is typically seen, JSpA is generally characterized by peripheral arthritis and enthesitis of the lower extremities in the early course of the disease. Involvement of the SIJs and spinal joints typically occurs later. The most frequently involved joints are the knee, ankle, and hip.[27–33] Despite this, Weiss et al found that active sacroiliitis by MRI is common at diagnosis in JSpA and also frequently asymptomatic. HLA-B27 positive children with elevated C-reactive protein levels have the highest probability of sacroiliitis.[34]

The clinical diagnosis of sacroiliitis is difficult, and diagnosis largely depends on imaging. Features of active inflammation that can be seen are BME, joint space fluid/postcontrast enhancement, inflammation in an erosion cavity, capsulitis, and enthesitis. Structural changes include erosion, sclerosis, fat lesion, backfill, and ankylosis, more common at later stages.

We believe CR is of little value for diagnosis of sacroiliitis in children for several reasons.[34–39] By its nature as an imaging modality depicting bones more clearly than soft tissue structures, radiography is intrinsically unlikely to detect active lesions sensitively, and primarily it shows late structural damage. Because in children the disease duration is typically relatively short at presentation, structural damage may not be present at initial imaging. Furthermore, the SIJs in especially younger children are not fully ossified yet, with primarily cartilage along the joint space, so substantial cartilage destruction is needed before osseous changes will be seen. Also, ankylosis is rarely seen in children. And more importantly, the presence of structural lesions on CR does not help to inform whether there is ongoing active inflammation or not.

Marteau et al published recommendations from the French societies for rheumatology, radiology, and pediatric rheumatology with a multidisciplinary task force of 16 French experts.[38] They concluded that a radiographic view specifically designed to assess the SIJs is not recommended because the results are not interpretable in skeletally immature patients and radiation exposure is significant.[38]

Jaremko et al showed that specificity and reliability for diagnosis of juvenile-onset SpA is far superior for MRI of the SIJs compared with radiography. They concluded that where available, MRI should replace CR as the first line of investigation.[36] They found that bone erosion was the most useful diagnostic feature on CR (positive likelihood ratio [LR] = 3.5), although more specific on MRI (LR = 6.7). Joint space narrowing also had some utility on CR (LR = 2.0) but was rarely seen and had poor reader reliability. Subchondral sclerosis was common but was the least specific feature for both modalities.[36]

According to Weiss et al, CR also results in a significant proportion of both false-negative and false-positive findings compared with MRI.[35] The sensitivity of CR in their study ranged from 25 to 77.8%, specificity from 60.8 to 92.2% across raters. The misclassification rate ranged from 6 to 17% for negative radiographs/positive MRI scans and from 48 to 74% for positive radiographs/negative MRI scans. They also concluded that MRI is the imaging modality of choice for detecting early inflammatory changes of the SIJs given its superiority for detection of sacroiliitis[35] (►**Fig. 5**).

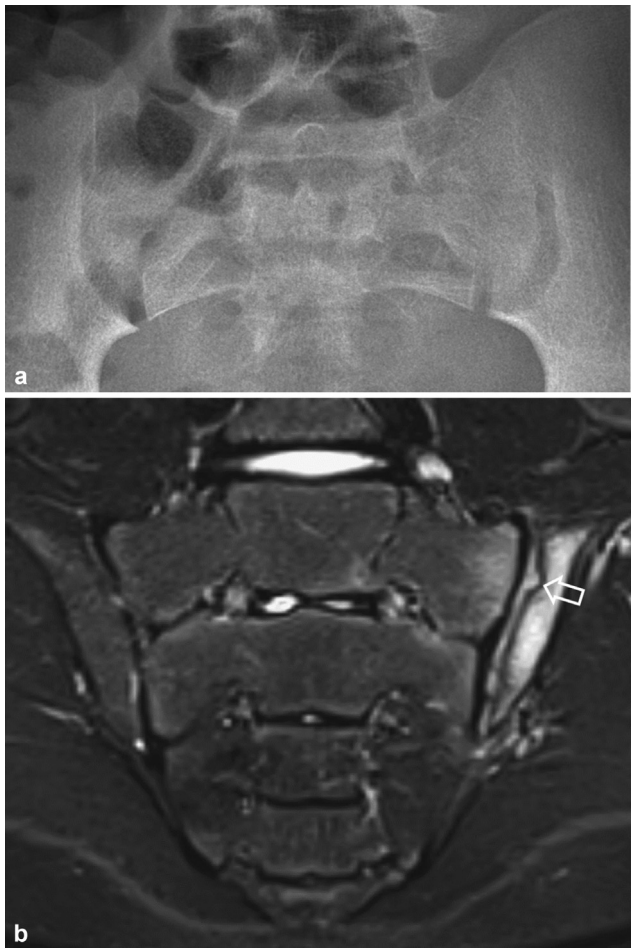

Fig. 5 A 14-year-old boy with active sacroiliitis associated with inflammatory bowel disease (colitis ulcerosa). (**a**) Radiograph shows a normal image; no lesions are seen. (**b**) Supplementary magnetic resonance semi-coronal short tau inversion recovery (STIR) image can depict early active lesions such as bone marrow edema, as seen here on both the iliac and sacral side of the left sacroiliac joint (SIJ). Also note the joint inflammation and the active erosions at the iliac side of the left SIJ (arrow).

MRI has even more value if an image with a larger field of view to depict the entire pelvis, either axial or coronal, has been added to the protocol including the hips, because the hip joint is commonly affected in children with JIA.[40] Therefore, in JSpA, CR should only be used when MRI is unavailable or contraindicated. The main MRI sequences used for imaging pediatric SIJs are similar to those in adults. Semi-coronal T1-weighted images and STIR sequences, and an axial STIR sequence are key sequences for evaluation.[40] Additional sequences such as diffusion-weighted images or 3D sequences (e.g., VIBE), which have shown to have additional value for detecting erosions in adults, are still being studied in children.

However, in some areas of the world, access to MRI is limited, and CR is still commonly performed. If present, sacroiliitis on CR in children shows similar features compared with adult

sacroiliitis: sclerosis, erosions, and very rarely, ankylosis.[41] Unlike in adult SpA, classification in children remains challenging. Many different classification systems have been proposed,[28,31,33] but none include imaging as a criterion, whereas imaging plays a key role in adult classification systems, such as the ASAS and mNY criteria.[1,3,42,43] Therefore, adult classification criteria have been applied to children as well.

Weiss et al recently aimed to define criteria for "unequivocal sacroiliitis" on pelvic radiography in skeletally immature children and adolescents by consensus between six musculoskeletal imaging experts. The consensus definition was formulated as "Unequivocal lesion (erosion, sclerosis, or ankylosis [partial or complete]) that must include at least one iliac bone. When sclerosis is present in isolation, if measurable, should extend $\geq$ 5 mm from the joint surface. The decision may be influenced by the presence of other lesions, which in themselves do not suffice to meet the criterion." They state that this definition has applicability to JSpA axial disease classification criteria when MRI is unavailable.[44]

In conclusion, MRI is the imaging modality of choice for detecting early sacroiliitis in JSpA because it can also detect early inflammatory lesions; CR should only be used when MRI is unavailable or contraindicated.

Based on the current literature, the ESSR Arthritis and Pediatric Subcommittees recommend the following clinical imaging strategy for the diagnosis of sacroiliitis:

In adults with suspected axSpA,

- CR remains the method of choice for easy and inexpensive detection of structural changes and assessment of differentials, including hip or pubic symphysis alterations.
- In areas where MRI poses feasibility problems, radiography can be used with the advantage that radiologists and rheumatologists are familiar with the mNY criteria.
- MRI should be the primary imaging method used in a specialist setting for suspected sacroiliitis.
- Supplementary pelvic radiography, low-dose CT, or synthetic CT may be needed to evaluate differential diagnoses, particularly OCI.

In juveniles with suspected JSpA,

- MRI is the imaging modality of choice for detecting early sacroiliitis in JSpA because it can also detect early inflammatory lesions; CR should only be used when MRI is unavailable or contraindicated.

Conflict of Interest
None declared.

References

1 Sieper J, Rudwaleit M, Baraliakos X, et al. The Assessment of SpondyloArthritis international Society (ASAS) handbook: a guide to assess spondyloarthritis. Ann Rheum Dis 2009;68 (Suppl 2):ii1–ii44
2 Sieper J, van der Heijde D. Review: Nonradiographic axial spondyloarthritis: new definition of an old disease? Arthritis Rheum 2013;65(03):543–551
3 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(04):361–368
4 Mandl P, Navarro-Compán V, Terslev L, et al; European League Against Rheumatism (EULAR) EULAR recommendations for the use of imaging in the diagnosis and management of spondyloarthritis in clinical practice. Ann Rheum Dis 2015;74(07):1327–1339
5 Zhao SS, Pittam B, Harrison NL, Ahmed AE, Goodson NJ, Hughes DM. Diagnostic delay in axial spondyloarthritis: a systematic review and meta-analysis. Rheumatology (Oxford) 2021;60(04):1620–1628
6 Tuite MJ. Sacroiliac joint imaging. Semin Musculoskelet Radiol 2008;12(01):72–82
7 Omar A, Sari I, Bedaiwi M, Salonen D, Haroon N, Inman RD. Analysis of dedicated sacroiliac views to improve reliability of conventional pelvic radiographs. Rheumatology (Oxford) 2017;56 (10):1740–1745
8 Khmelinskii N, Regel A, Baraliakos X. The role of imaging in diagnosing axial spondyloarthritis. Front Med (Lausanne) 2018; 5:106
9 van den Berg R, Lenczner G, Feydy A, et al. Agreement between clinical practice and trained central reading in reading of sacroiliac joints on plain pelvic radiographs. Results from the DESIR cohort. Arthritis Rheumatol 2014;66(09):2403–2411
10 van Tubergen A, Heuft-Dorenbosch L, Schulpen G, et al. Radiographic assessment of sacroiliitis by radiologists and rheumatologists: does training improve quality? Ann Rheum Dis 2003;62 (06):519–525
11 Christiansen AA, Hendricks O, Kuettel D, et al. Limited reliability of radiographic assessment of sacroiliac joints in patients with suspected early spondyloarthritis. J Rheumatol 2017;44(01): 70–77
12 Hermann KGA, Ziegeler K, Kreutzinger V, et al. What amount of structural damage defines sacroiliitis: a CT study. RMD Open 2022;8(01):e001939
13 Diekhoff T, Eshed I, Radny F, et al. Choose wisely: imaging for diagnosis of axial spondyloarthritis. Ann Rheum Dis 2022;81(02): 237–242
14 Diekhoff T, Hermann KGA, Greese J, et al. Comparison of MRI with radiography for detecting structural lesions of the sacroiliac joint using CT as standard of reference: results from the SIMACT study. Ann Rheum Dis 2017;76(09):1502–1508
15 Bakker PAC, van den Berg R, Lenczner G, et al. Can we use structural lesions seen on MRI of the sacroiliac joints reliably for the classification of patients according to the ASAS axial spondyloarthritis criteria? Data from the DESIR cohort. Ann Rheum Dis 2017;76(02):392–398
16 Poddubnyy D, Gaydukova I, Hermann KGA, et al. Magnetic resonance imaging compared to conventional radiographs for detection of chronic structural changes in sacroiliac joints in axial spondyloarthritis. J Rheumatol 2013;40(09):1557–1565
17 Van Den Berghe T, Babin D, Chen M, et al. Neural network algorithm for detection of erosions and ankylosis on CT of the sacroiliac joints: multicentre development and validation of diagnostic accuracy. Eur Radiol 2023 May 23 (Epub ahead of print)
18 Diekhoff T, Greese J, Sieper J, Poddubnyy D, Hamm B, Hermann KA. Improved detection of erosions in the sacroiliac joints on MRI with volumetric interpolated breath-hold examination (VIBE): results from the SIMACT study. Ann Rheum Dis 2018;77(11): 1585–1589
19 Algin O, Gokalp G, Ocakoglu G. Evaluation of bone cortex and cartilage of spondyloarthropathic sacroiliac joint: efficiency of different fat-saturated MRI sequences (T1-weighted, 3D-FLASH, and 3D-DESS). Acad Radiol 2010;17(10):1292–1298
20 Kiil RM, Mistegaard CE, Loft AG, Zejden A, Hendricks O, Jurik AG. Differences in topographical location of sacroiliac joint MRI

lesions in patients with early axial spondyloarthritis and mechanical back pain. Arthritis Res Ther 2022;24(01):75
21 Poddubnyy D, Weineck H, Diekhoff T, et al. Clinical and imaging characteristics of osteitis condensans ilii as compared with axial spondyloarthritis. Rheumatology (Oxford) 2020;59(12):3798–3806
22 Ma L, Gao Z, Zhong Y, Meng Q. Osteitis condensans ilii may demonstrate bone marrow edema on sacroiliac joint magnetic resonance imaging. Int J Rheum Dis 2018;21(01):299–307
23 Morbée L, Vereecke E, Laloo F, Chen M, Herregods N, Jans LBO. Common incidental findings on sacroiliac joint MRI: added value of MRI-based synthetic CT. Eur J Radiol 2023;158:110651
24 Maksymowych WP, Lambert RGW, Østergaard M, et al. MRI lesions in the sacroiliac joints of patients with spondyloarthritis: an update of definitions and validation by the ASAS MRI working group. Ann Rheum Dis 2019;78(11):1550–1558
25 Maksymowych WP, Lambert RG, Baraliakos X, et al. Data-driven definitions for active and structural MRI lesions in the sacroiliac joint in spondyloarthritis and their predictive utility. Rheumatology (Oxford) 2021;60(10):4778–4789
26 Maksymowych WP, Pedersen SJ, Weber U, et al. Central reader evaluation of MRI scans of the sacroiliac joints from the ASAS classification cohort: discrepancies with local readers and impact on the performance of the ASAS criteria. Ann Rheum Dis 2020;79 (07):935–942
27 Burgos-Vargas R. The juvenile-onset spondyloarthritides. Rheum Dis Clin North Am 2002;28(03):531–560, vi
28 Tse SM, Laxer RM. New advances in juvenile spondyloarthritis. Nat Rev Rheumatol 2012;8(05):269–279
29 Burgos-Vargas R. The assessment of the spondyloarthritis international society concept and criteria for the classification of axial spondyloarthritis and peripheral spondyloarthritis: a critical appraisal for the pediatric rheumatologist. Pediatr Rheumatol Online J 2012;10(01):14
30 Burgos-Vargas R, Rudwaleit M, Sieper JInternational League of Associations for Rheumatology. The place of juvenile onset spondyloarthropathies in the Durban 1997 ILAR classification criteria of juvenile idiopathic arthritis. J Rheumatol 2002;29(05): 869–874
31 Petty RE, Southwood TR, Manners P, et al; International League of Associations for Rheumatology. International League of Associations for Rheumatology classification of juvenile idiopathic arthritis: second revision, Edmonton, 2001. J Rheumatol 2004; 31(02):390–392
32 O'Shea FD, Boyle E, Riarh R, Tse SM, Laxer RM, Inman RD. Comparison of clinical and radiographic severity of juvenile-onset versus adult-onset ankylosing spondylitis. Ann Rheum Dis 2009;68(09):1407–1412
33 Sezen M, Baru K, Açıkel C, Kasapcopur O. The new proposal classification criteria for juvenile spondyloarthropathies. Pediatr Rheumatol Online J 2014;12(Suppl 1):45
34 Weiss PF, Xiao R, Biko D, Chauvin NA. Sacroiliitis at diagnosis of juvenile spondyloarthritis assessed by radiography, magnetic resonance imaging, and clinical examination. Arthritis Care Res (Hoboken) 2016;68(02):187–194
35 Weiss PF, Xiao R, Brandon TG, et al. Radiographs in screening for sacroiliitis in children: what is the value? Arthritis Res Ther 2018; 20(01):141
36 Jaremko JL, Liu L, Winn NJ, Ellsworth JE, Lambert RG. Diagnostic utility of magnetic resonance imaging and radiography in juvenile spondyloarthritis: evaluation of the sacroiliac joints in controls and affected subjects. J Rheumatol 2014;41(05):963–970
37 Hemke R, Herregods N, Jaremko JL, et al. Imaging assessment of children presenting with suspected or known juvenile idiopathic arthritis: ESSR-ESPR points to consider. Eur Radiol 2020;30(10): 5237–5249
38 Marteau P, Adamsbaum C, Rossi-Semerano L, et al. Conventional radiography in juvenile idiopathic arthritis: Joint recommendations from the French societies for rheumatology, radiology and paediatric rheumatology. Eur Radiol 2018;28 (09):3963–3976
39 Pagnini I, Savelli S, Matucci-Cerinic M, Fonda C, Cimaz R, Simonini G. Early predictors of juvenile sacroiliitis in enthesitis-related arthritis. J Rheumatol 2010;37(11):2395–2401
40 Herregods N, Anisau A, Schiettecatte E, et al. MRI in pediatric sacroiliitis, what radiologists should know. Pediatr Radiol 2023 March 1 (Epub ahead of print)
41 Sudoł-Szopińska I, Matuszewska G, Pracoń G. Radiographic Atlas of Inflammatory Rheumatic Diseases. Otwock, Poland: Medisfera; 2022
42 Lambert RG, Bakker PA, van der Heijde D, et al. Defining active sacroiliitis on MRI for classification of axial spondyloarthritis: update by the ASAS MRI working group. Ann Rheum Dis 2016;75 (11):1958–1963
43 Rudwaleit M, van der Heijde D, Landewé R, et al. The development of Assessment of SpondyloArthritis international Society classification criteria for axial spondyloarthritis (part II): validation and final selection. Ann Rheum Dis 2009;68(06):777–783
44 Weiss PF, Brandon TG, Lambert RG, et al. Consensus-driven definition for unequivocal sacroiliitis on radiographs in juvenile spondyloarthritis. J Rheumatol 2023 April 15 (Epub ahead of print)

Erratum: An erratum has been published for this article (DOI: 10.1055/s-0043-1776395).