

UPDATE ON MRI OF SPONDYLOARTHRITIS. PART ONE: THE SACRO-ILIAC JOINT

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In recent years, there has been an increased trend toward the use of advanced medical imaging for the diagnosis and assessment of SpondyloArthritis (SpA) (1, 2). MRI of the sacro-iliac (SI) joints has become a key-imaging technique for the detection of early non-radiographic axial SpA and has been shown to contribute to optimized clinical decision-making (3). The current paper aims at summarizing recent advances in the understanding of the disease, the questions from the clinicians, as well MRI protocols and findings in SpA. Pitfalls and differential diagnosis for SI changes will be addressed.

What does the radiologist need to know about SpA?

- Tremendous changes in the field of SpA have occurred over the last decade and have been triggered by the development of several effective therapies (4). Drug development and registration require appropriate classification criteria to better delineate the target population and drug efficacy.

- SpA is a heterogeneous group of chronic inflammatory rheumatic diseases that comprises ankylosing spondylitis (AS), psoriatic arthritis, arthritis/spondylitis associated with inflammatory bowel disease, and reactive arthritis (2). AS is the disease prototype. At the other end of the spectrum, Undifferentiated SpA includes patients with typical features of SpA that do not fulfill the criteria of the other previously mentioned entities.
- The pathogenic hallmark of SpA is inflammation at the entheses, the attachment sites of ligaments, fascia or tendons onto the bone (2).

Anatomic targets for axial SpA are numerous and include bony areas adjacent to joints (osteitis), capsule (capsulitis), tendons (enthesitis), and synovial tissue (synovitis) (Fig. 1) (6). Within the SI joints, SpA involvement frequently demonstrates a patchy distribution with multiple focal areas of inflammation or quiescent disease (Fig. 2).

- The dissemination of changes of different age (from edema to fatty infiltration) at numerous target sites is suggestive of SpA. No single MRI finding is specific of



Fig. 1. — Fat-saturated intermediate-weighted coronal image of the SI joints in a 34-yo man with SpA. Left SI joint synovitis: widening and increased signal intensity in the joint space (large arrow). Osteitis: extensive marrow edema-like changes in adjacent bone (arrows). Enthesitis: increased signal intensity in marrow and soft tissue adjacent to ligamentous insertion (arrowhead).

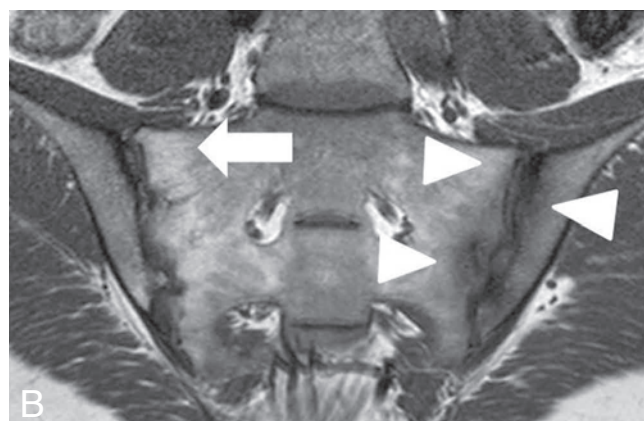
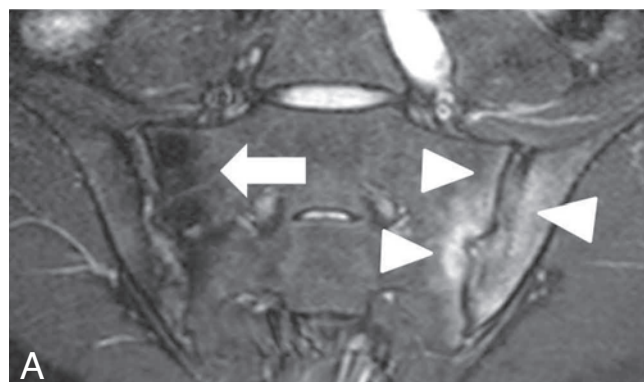


Fig. 2. — Fat-saturated intermediate-weighted (A) and T1-weighted coronal (B) images in a 24-yo woman with SpA. Active inflammation of the left SI joint: edema-like marrow changes on both sides of the widened SI joint (arrowheads). Non-active involvement of the right SI joint: fat-like signal intensity marrow changes near the right SI joint. An MR study obtained 21 months earlier (not shown) had demonstrated active right SI joint disease.

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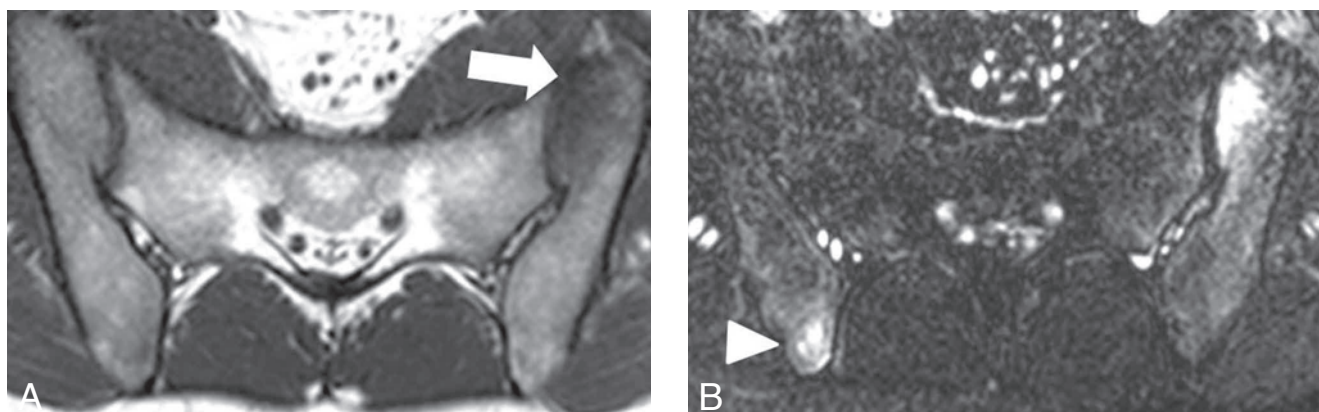
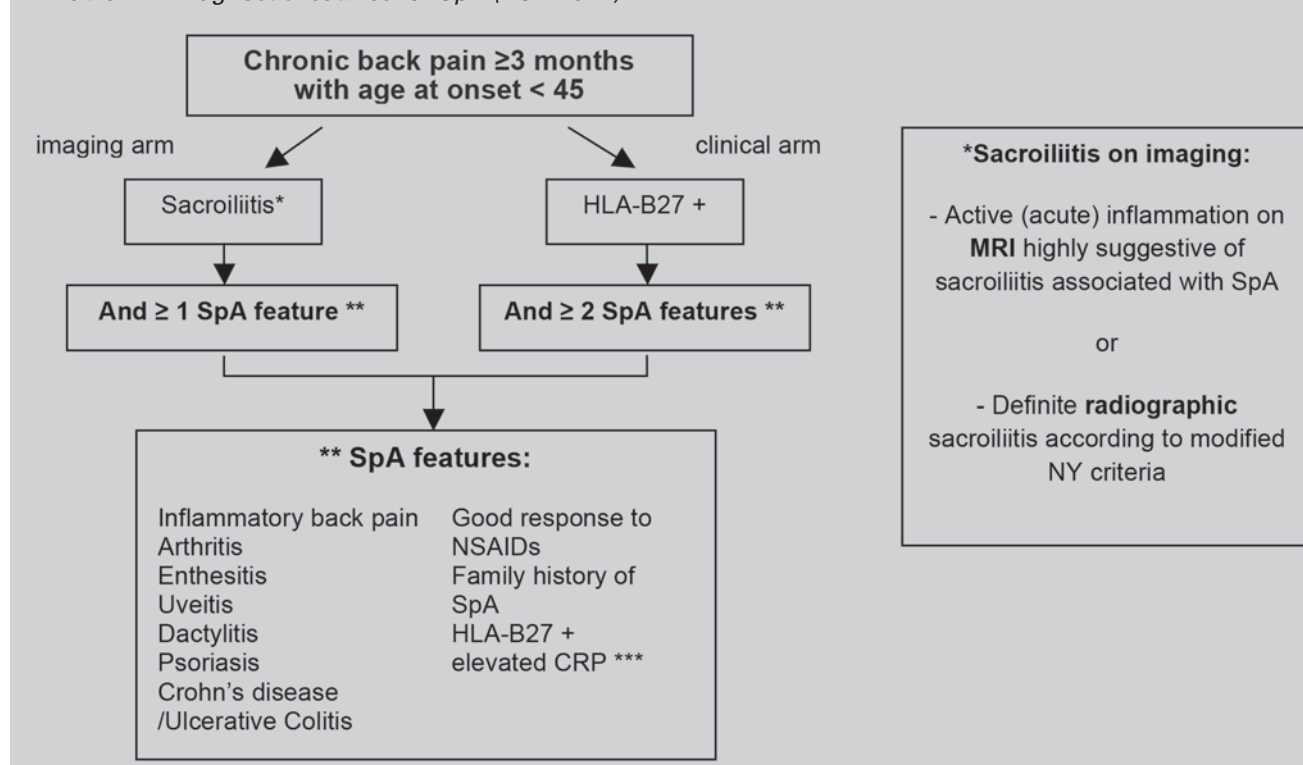


Fig. 3. — Transverse oblique T1-weighted image (A) of the SI joints demonstrates abnormal signal intensity in marrow adjacent to the left sacro-iliac joint suggestive of sacro-iliitis. The corresponding fat-saturated (B) also demonstrates active enthesitis in right posterior iliac wing that was not seen on the T1-weighted SE images.

Table I. — Diagnostic features for SpA (from ref 1).



SA. Distribution and patterns of lesions in the musculoskeletal system observed over time in patients with SpA mimic those observed in the nervous system in patients with Multiple Sclerosis

- Diagnostic criteria and classification systems for SpA have evolved over decades and have reached maturity. The Assessment of SpondyloArthritis international Society (ASAS) has developed and validated classification criteria that include MRI findings (Table I) (5). Back pain lasting for more than three months with

an age of onset before 45 years is a determinant clinical feature. Active inflammatory lesion of the SI joints at MRI or radiographic sacroiliitis is required for the fulfillment of the imaging criterion "sacro-iliitis" in the ASAS classification criteria for axial SpA.

What does the rheumatologist want to know from imaging?

- Imaging can provide both diagnostic as well as prognostic criteria to the clinician.

- In the setting of suggestive axial pain of more than 3 months duration in a patient with less than 45 years of age at onset of symptoms, the rheumatologist may prescribe MRI of the SI joints to look for signs of active inflammation (7).
- More specific structural osseous changes are depicted in more advanced cases, and rarely occur within the two first years after the onset of the disease (8). These osseous changes are better detected with radiography or CT than with MRI. They include

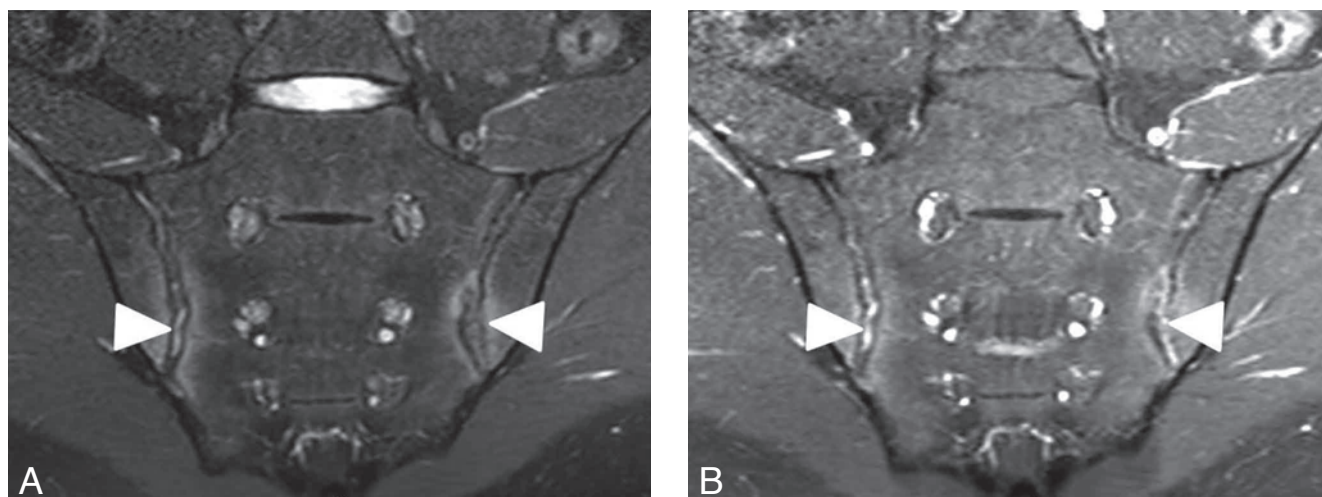


Fig. 4. — Coronal oblique fat-saturated proton-density (A) and enhanced fat-saturated T1-weighted (B) images of the SI joints in a 22-yo man with SpA. Synovitis appears as abnormal signal intensity in the SI joint space (arrowheads in A) with enhanced signal after iv contrast administration (arrowheads in B).

osseous erosions, trabecular bone sclerosis and ligament ossification with subsequent interosseous ankylosis. The presence of structural osseous changes does not implicate active disease.

- Serial MR imaging may help to evaluate changes in imaging signs of inflammation in response to specific treatments.

How to optimize MRI protocols in the setting of SpA?

MRI acquisition protocols tailored to suspected SpA should at least maximize sensitivity for the detection of edema and include the SI joints (8). MRI of the SI joints should include one T1-weighted as well as one fluid-sensitive fat-saturated sequence (Table II). The fat-suppressed intermediate-weighted sequence has a better signal-to-noise ratio than the STIR sequence but is more susceptible to artifacts. STIR will be favored for large field-of-view images (pelvic ring imaging). Additional sequences include fat-saturated T1-weighted or gradient-echo T2*-weighted sequences for better detection of osseous erosions (Table II).

Gadolinium-enhanced fat-saturated T1-weighted sequences enable better detection of capsulitis and synovitis (9). The use of gadolinium-enhanced sequences does not appear to consistently modify the work-up of SpA patients because erosions, capsulitis and synovitis very rarely occur, if ever, without bone marrow edema (9). Dynamic contrast-enhanced MR imaging can provide

additional information and correlates well with clinical history, degree of inflammatory back pain, and physical examination findings in patients with acute sacro-iliitis (10). There is a correlation between the degree of uptake detected at MR imaging and the inflammatory cellularity in patients with SpA, making dynamic MR imaging helpful in monitoring pharmacologic treatment of patients with inflammatory arthropathies (11).

Diffusion-weighted MR imaging may also be effective in quantifying inflammatory changes at involved skeletal sites (12). Areas of active disease consistently demonstrate hyperintense signal on ADC maps although inflammation may appear as hypo-, iso- or slightly hyperintense signal on diffusion-weighted images (12).

The coronal oblique plane is the imaging plane of reference; the transverse oblique plane enables better assessment of anterior soft tissues (useful for lesion characterization) and of posterior entheses (useful for lesion detection) (8). These 2 planes are angulated around a L-R axis to be

parallel or perpendicular to the longitudinal axis of the SI joint.

Diagnosis of sacro-iliitis

Inflammatory lesions of the SI joints

- Active inflammatory lesions of the SI joints include bone marrow edema/osteitis and synovitis/capsulitis.
- Bone marrow edema/osteitis must be present to diagnose active inflammatory disease (Table III). It can involve several different target areas including the subchondral bone marrow (adjacent to the joint) (Fig. 2), the posterior fibrous component of the SI joints, and the posterior aspects of the iliac wings (enthesitis) (Fig. 3).
- Synovitis/capsulitis can be detected in the joint space and in its capsule. It is recognized on fat-saturated T1-weighted SE images after gadolinium intravenous injection because fat-suppressed fluid sensitive sequences cannot differentiate articular fluid from articular synovial pannus or inflamed capsule (Fig. 4) (9).

Table II. — Mandatory and optional MRI sequences for SI imaging.

- T1-weighted SE coronal oblique sequence
- Fat-saturated intermediate-weighted SE coronal oblique sequence.
- T1-weighted and fat-suppressed intermediate-weighted SE transverse oblique sequences (optional).
- Fat-saturated T1-weighted sequence or gradient-echo T2*-weighted sequence (optional)
- Gadolinium enhanced fat-saturated T1-weighted sequence (optional)

Table III. — Bone Inflammation (osteitis).

- Appears as bone marrow edema
- occurs early in disease course
- correlates with symptoms
- is detected exclusively at MRI*
- presents as high signal intensity on fat-saturated fluid-sensitive sequences
- needs to be visible at least on 2 consecutive slices or 2 foci on same slice for a definite diagnosis in sacro-iliac joints

* The potential value of FDG-Pet for the detection of bone inflammation remains to be assessed.

Table IV. — Structural changes.

- demonstrate a propensity to produce bone
- include fatty deposition/erosion/ossification near entheses and ankylosis
- occur late in disease course
- correlate poorly with symptoms
- are better seen on radiographs/CT than MRI (except for fatty deposition)
- remain poorly understood but could partly represent a healed or quiescent stage of inflammation.
- do not suffice for the definition of a positive MRI if without inflammatory changes

Structural lesions of the SI joints

- Structural changes of the SI joints include bone sclerosis, erosion, peri-articular fatty deposition and soft tissue ossification (Table IV).
- Bone sclerosis that generally predominates in subchondral area appears as dense areas on radiographs/CT images and with low signal on T1 and variable signal on fat-saturated fluid-sensitive sequences. Bone sclerosis may be associated with erosions.
- Erosion appears on CT images as area of resorption of subchondral bone plate that may become confluent and causes enlargement of joint space (Fig. 5). At MRI, it appears as high signal intensity lesions on fat-suppressed fluid-sensitive sequences in the region of the subchondral bone.
- Peri-articular fatty deposition appears as foci of increased signal on T1 and low signal on fat-suppressed sequences in the subchondral bone marrow (Fig. 2). It

cannot be recognized on CT images. Although non-specific, it could represent areas of previous inflammation.

- Soft tissue ossification appears as ligament/capsule ossification and joint space ossification. Joint ossification may start as small bony bridges arising from the subchondral bone plate that may unify from both sides and may become coalescent (Fig. 6).

Types and amount of lesions required for diagnosis

- Bone marrow edema must be present either on 2 consecutive sections or at two different areas on one section to be certain of its existence.
- The sole presence of synovitis, enthesitis and capsulitis without bone marrow edema (osteitis) is not sufficient for a positive MRI.

Pitfalls

Deficiency in fat saturation is the most frequent pitfall observed with MRI of the axial skeleton. Deficient fat saturation generates areas of high signal in bone marrow and or soft tissues of the most posterior aspect of the iliac wings and should not be confused with osteitis or enthesitis.

Anatomic variants can occur in the SI joints. Frequently, an accessory SI joint can be located at the postero-superior portion of the joint and may develop degenerative changes.

Differential diagnosis

SI joint osteoarthritis (OA), the most frequent SI disorder, usually

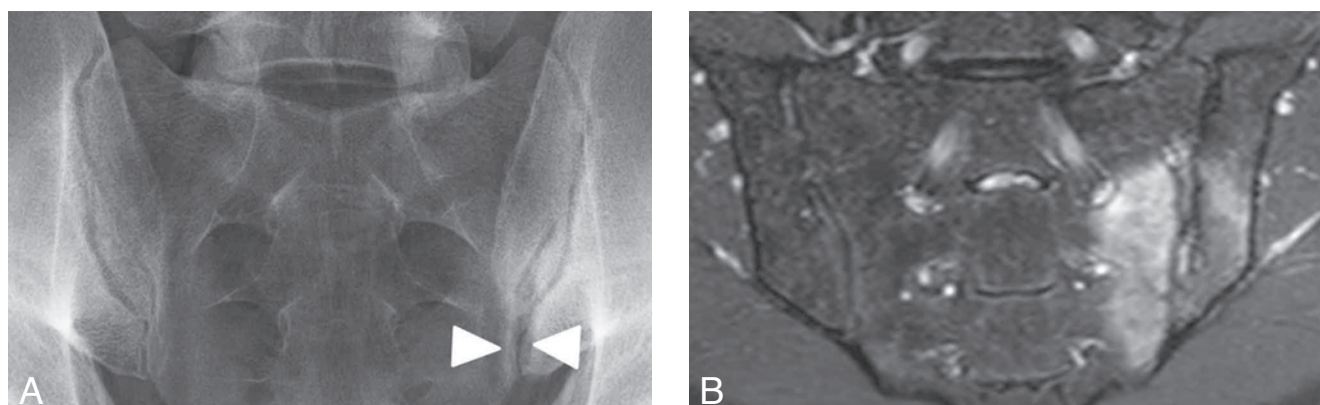


Fig. 5. — AP radiograph of the SI joints (A) from a 28-yo man with SpA demonstrates left SI joint erosion with enlargement of the joint space (arrowheads) and subchondral bone sclerosis. The corresponding fat-saturated intermediate-weighted image (B) demonstrates more obvious changes with edema-like signal intensity changes on both sides of the joint space and high signal intensity in the joint space.

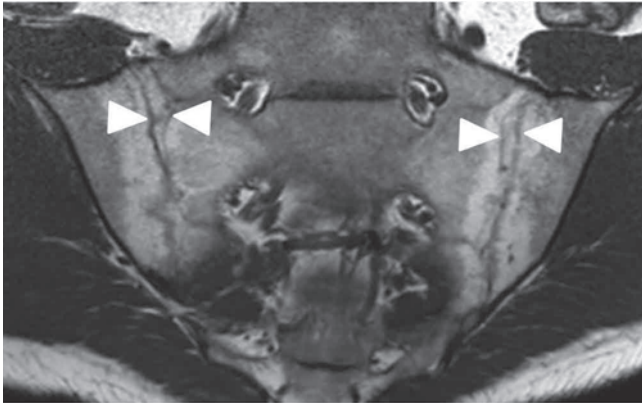


Fig. 6. — Coronal T1-weighted SE image in a 24-yo male patient with SpA demonstrates bilateral SI joints ankylosis with fat-like signal intensity changes in the joint space (arrowheads).

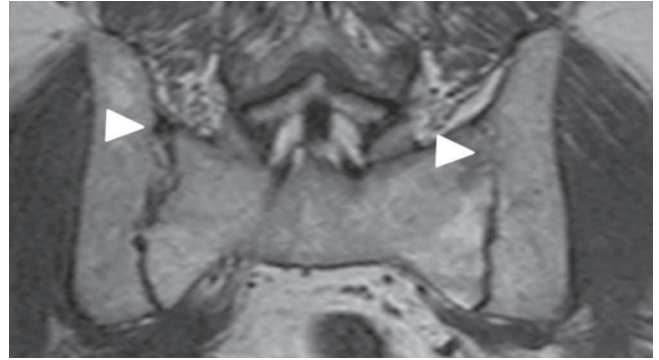


Fig. 8. — A T1-weighted SE image of the SI joints shows ankylosis (arrows) with preserved joint space in a 70-yo man with Forestier's disease. In Forestier's disease, SI ankylosis results from ligamentous ossification.

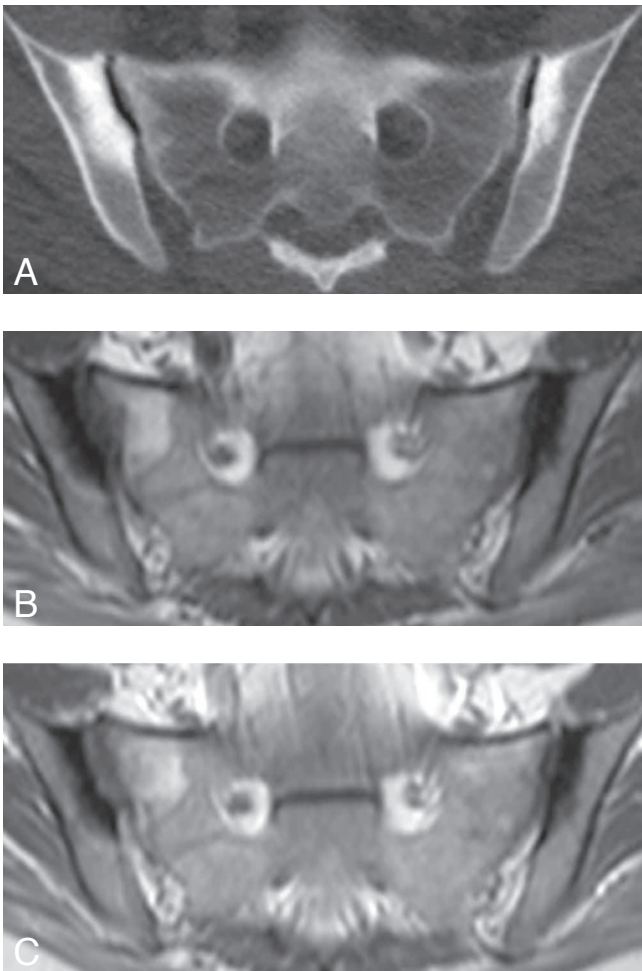


Fig. 7. — CT image (A) demonstrates condensing osteitis of the iliac bone (osteitis condensans ilii) in a 42-yo woman without SpA with well-delimited subchondral iliac bone sclerosis and an articular vacuum phenomenon. On the corresponding SE T1-weighted image (B), very low signal intensity is visible in sclerotic areas. On the enhanced T1-weighted image (C), the lack of signal enhancement in marrow and in widened joint space suggests absence of osteitis and synovitis.

remains localized in the anterior middle aspect of the joint where bio-mechanical stresses are predominant. Any bone and marrow changes can be observed on CT and MR images of SI osteoarthritis except synovitis in the joint. Variants of SI joint OA include osteitis condensans ilii (Fig. 7).

Septic SI arthritis is a rare condition that involves immunocompromized patients, drug abusers, women after birth delivery and paraplegic patients with skin ulcers. Presence of soft tissue abscess or of significant soft tissue changes are distinctive features from SpA. Metabolic disorders such as hyperparathyroidism and gout may also rarely involve in the SI joints.

Fracture of the sacral wings is a frequent condition in elderly patients and should not be confused with SpA. Ankylosis due to ligament ossification is extremely frequent in Forestier's disease (Fig. 8) and may start as early as in the third decade. In this situation, the joint space is usually respected unless very chronic, in contradistinction to case of quiescent inflammatory disease (Fig. 7).

Conclusion

MR imaging has been validated by international experts associations as a major diagnostic tool for the early detection, classification and monitoring of SpA patients. MR imaging of the SI joints plays a crucial role for the pre-radiological detection of these patients. Fat-saturated fluid-sensitive sequences are the most sensitive sequences for the detection of bone marrow edema adjacent to sacro-iliac and spine joints or entheses. The presence of foci of active and quiescent lesions

in the SI joints is a key-distinctive feature.

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