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A Rheumatologist's Guide to Interpreting Imaging in Spondyloarthritis





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Foreword
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Imaging plays an important role in the diagnosis, management and follow-up of patients with spondyloarthropathies and has been an integral component of the classification criteria for spondyloarthritis (SpA). Modified New York criteria (1984),[1] Amor criteria (1990/1991)[2] and the European Spondyloarthropathy Study Group criteria (ESSG) (1991)[3] used radiographs for defining sacroiliitis. A major limitation of radiographs is the inability to detect early inflammatory lesions, before the structural damage has occurred. Magnetic resonance imaging (MRI) has emerged as an excellent imaging modality which, in addition to the chronic structural changes, can also detect active/ongoing inflammatory changes early in the disease course. This has led to earlier diagnosis of SpA in patients with inflammatory back pain (IBP) and timely initiation of treatment, thereby preventing structural damage. In 2009, The Assessment of Spondyloarthritis International Society (ASAS) laid down the classification criteria for axial-SpA which included MRI in the imaging arm of the criteria, which had never been used in the earlier criteria.[4] With the use of MRI, non-radiographic axial-SpA has emerged as an important entity.[5]

Sacroiliitis is the most characteristic feature of axial-SpA. There are 4 grades of sacroiliitis on plain radiographs of pelvis, according to the severity (discussed further). Appearance of sacroiliitis on MRI depends on its stage – acute or chronic. Four types of acute lesions in sacroiliac joint (SIJ) have been described – bone marrow edema (also called osteitis), synovitis, capsulitis and enthesitis. Similarly, there exist four types of chronic lesions – fatty metaplasia, erosions, sclerosis and ankylosis.[6]

Sacroiliac joint has an upper ligamentous part and lower cartilaginous part (Fig. 1).[7] The ligamentous part connects ilium and sacrum with the help of strong ligaments and lacks synovial membrane. So it is not a true synovial joint and hence no inflammation of the joint occurs in this part. But, enthesitis can occur involving the ligaments present in this part of SIJ (*see* Fig. 47). The lower cartilaginous part is the true synovial joint with the presence of hyaline articular cartilage, synovial membrane and joint capsule. Thus, it is the lower cartilaginous part of the SIJ where true sacroiliitis occurs.

Conventional radiography is an inexpensive and well-established imaging technique. Anteroposterior projection of the X-ray of pelvis with the patient in supine position and the

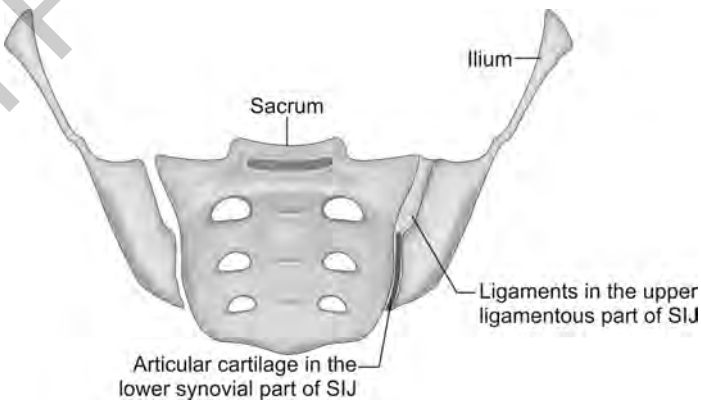


Fig. 1: Anatomy of the SIJ, showing the upper ligamentous part and lower synovial part. (SIJ: sacroiliac joint).

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tube angulated 15–30° in the cephalad direction is considered appropriate for imaging the SIJ.[8] In addition, radiographs of the cervical, thoracic and lumbar spine should be obtained in anteroposterior and lateral projections. Although the Modified Stoke Ankylosing Spondylitis Spine Score (mSASSS)[9] includes only cervical and lumbar spine in the evaluation of structural changes, it is advisable to image the thoracic spine also because of the presence of prominent structural changes in this part of the spine (*see* Fig. 16).

Computed tomography (CT) helps in better visualization of the structural changes such as erosions and new bone formation, in axial, sagittal and coronal planes as compared to radiographs, but early inflammatory changes cannot be detected.

Among the various imaging modalities, MRI is the only modality that can depict both active inflammatory and structural changes, as well as their anatomical distribution. A field strength of at least 1.5 Tesla should be used in the evaluation of SpA.[10] Out of the various sequences of MRI, T1 weighted and short tau inversion recovery (STIR) sequences are sufficient for imaging the SIJ.[11] The images of the SIJ must be obtained in the oblique coronal plane, parallel to the long axis of the sacrum, and in the axial plane. T1 and T2 sequences are fat-sensitive, which means that fat appears bright on these sequences. Bone marrow is composed of fat in addition to the hematopoietic tissue and the proportion of fat in the marrow increases with age. T1 sequence, being fat-sensitive, provides a good contrast between the bright marrow fat and dark cortical line. Due to this, erosions are best visualized on T1.[6,10] On the other hand, STIR sequence inherently suppresses fat and gives bright signal with water.[10] Therefore, inflammation/marrow edema appears bright against a dark marrow signal due to the suppression of marrow fat. T2 weighted sequences do not have much role in the imaging of SpA unless the images are fat-suppressed (fat-suppressed T2W sequence give similar images as STIR) since both, the inflammation and fat, appear bright.

Sacroiliitis on radiographs is defined by the Modified New York criteria (Table 1).[1,12] Four grades of sacroiliitis have been described. Grade-1 is the mildest grade of sacroiliitis with doubtful changes on the radiograph and a high degree of inter-observer variability. Grade-2 is suggestive of definite sacroiliitis which is defined by the presence of sclerosis of articular margins of SIJ and the subarticular bone in the presence of normal joint space. As soon as the width of joint space gets altered, it is termed grade-3. Joint space can either be widened (due to extensive erosions) or narrowed (due to sclerosis of joint margins). Grade-4 sacroiliitis is the most severe form where there is obliteration of the joint space due to bony ankylosis. Ankylosis can either be patchy or may involve the whole of SIJ. Spine radiographs are helpful in visualizing the structural changes which include erosions at the corner of the vertebral bodies (also called Romanus lesions).[13,14] As the corner erosions heal, sclerosis occurs which

Table 1: Grades of radiographic sacroiliitis. For defining AS according to modified New York criteria, there should be either bilateral grade-2 sacroiliitis or unilateral grade-3 or 4 sacroiliitis.[1]

Grade	*Joint space*	*Additional features*
1	Normal	Doubtful changes
2	Normal	Definite changes - sclerosis of joint margins
3	Widened or narrowed	Sclerosis, erosions
4	Obliterated	

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appear on radiographs as radiopaque shadows in the corners of the vertebral bodies (shiny-corner sign).[13] Squaring is the straightening of anterior border of the vertebral bodies due to calcification of the anterior longitudinal ligament. Calcification of annulus fibrosus of the intervertebral discs leads to the formation of syndesmophytes. Latter can be either bridging or non-bridging depending on whether the calcification of annulus is complete or not, respectively. In addition, sclerosis and erosions of the vertebral endplates, disc calcifications, bony bridging, intervertebral ankylosis and ossification of various spinal ligaments can be seen in SpA.

Magnetic resonance imaging is extremely capable of depicting the active bone marrow edema or osteitis earlier than conventional radiography or CT, thus aiding in the early detection of SpA. Bone marrow edema is the earliest stage of inflammation which appears in the subchondral zone of the cartilaginous part of the SIJ.[6] It is considered as an essential criterion for defining sacroiliitis on MRI according to the ASAS criteria. It appears on MRI as bright signal on STIR and dark signal on T1. Synovitis appears as a bright intense signal on STIR within the SIJ cavity. Synovitis cannot be visualized on T1 sequence, but on injection of contrast, the inflamed synovium shows contrast enhancement and gives a bright signal. Similarly, capsulitis appears bright on STIR and contrast-enhanced T1 sequences, best appreciated in the coronal section at the superior edge of the SIJ. Enthesitis may be seen as bright signal intensity of the tendinous insertions with associated bone marrow edema at the underlying site of attachment of the entheses. Use of contrast in SpA imaging is of no added advantage. It leads to enhancement of acute lesions, which can also be visualized on STIR without contrast injection.[15] Moreover, contrast injection increases the cost and time taken for the MRI and it cannot be used in patients with derangement of renal function.

After the resolution of bone marrow edema, the area involved gets replaced by fat as an attempt towards healing. This is called fatty metaplasia and appears bright on T1 and dark on STIR. Fatty infiltration begins from the subchondral part of the SIJ and progresses medially. This may lead to an appearance of a bright signal on STIR at the periphery of the fatty lesion, representing resolving bone marrow edema (*see* Fig. 39).[11] Erosions are best visualized on T1 sequence appearing as defects in the bony outline. Sclerosis gives dark signal on all the sequences and is not enhanced by contrast injection. Ankylosis gives rise to obliteration of the joint space of SIJ. It can be patchy, involving only a part of the SIJ or may be extensive involving the whole of the SIJ. All the lesions can also be seen at other sites including spine and peripheral joints.

In the spine, inflammation appears in the form of bone marrow edema at the corners of the vertebral bodies (called spondylitis).[13] Spondylitis appears bright on STIR and is seen at anterior and posterior corners of the vertebrae. Spondylitis can lead to erosions, which appear dark on T1, and these lesions are the MRI counterpart of radiographic Romanus lesions. Spondylitis may also heal with fatty metaplasia at the corners (also called fatty Romanus lesions). Ultimately sclerosis of the corners may occur, giving rise to dark signals on all the sequences, which is the MRI counterpart of radiographic shiny corner sign.

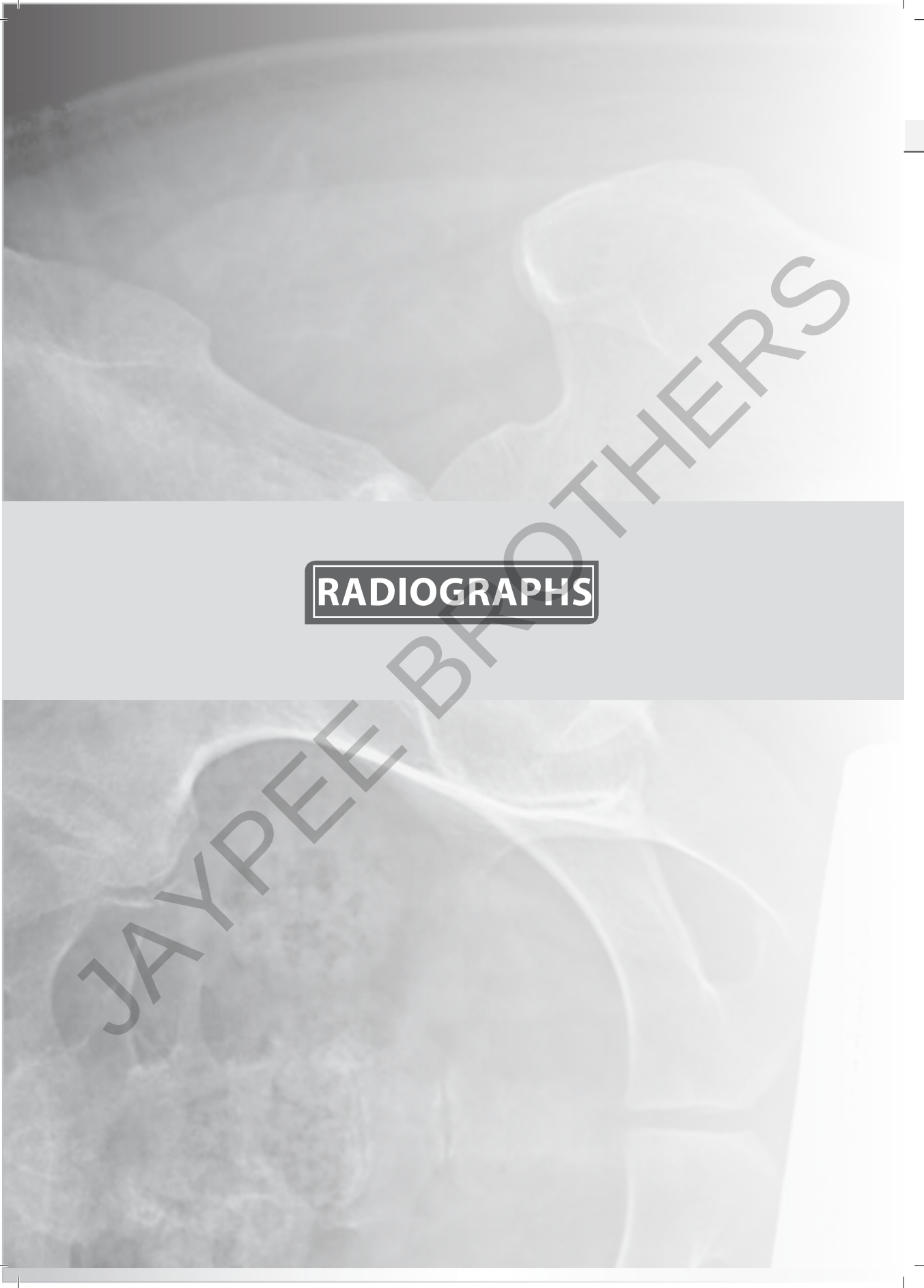
Different lesions may appear similar on different sequences of MRI. For example, a bright lesion in the subarticular region of SIJ is bone marrow edema on STIR images and fatty metaplasia on T1. Bone marrow edema suggests active disease which requires appropriate treatment. On the other hand, fatty metaplasia may not be associated with active disease, but is

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a lead indicator of radiographic progression. However, it may not require aggressive treatment. Thus, it is necessary to identify the sequence of MRI. Fat is the most important component that helps us in identifying the sequence of MRI. If the area of the subcutaneous fat is bright, then it is either T1 or T2. STIR suppresses fat strongly, so the subcutaneous area appears dark. In the MRI of the SIJ, it is helpful to look at the urinary bladder. If the content of the urinary bladder appears dark, then it is a T1W image. Urine appears bright on T2W images and STIR. Another way of differentiation is the visualization of the intervertebral discs and cerebrospinal fluid. Nucleus pulposus has high water content, which makes the central portion of the discs appear bright on T2W and STIR images and dark on T1W images. Similarly, the cerebrospinal fluid in the spinal canal appears dark on T1W images and bright on T2W and STIR images. In the presence of bright cerebrospinal fluid or urinary bladder, if the subcutaneous fat appears bright, then it is T2W image, otherwise it is either fat-suppressed T2 or STIR sequence.

In this book, we illustrate and discuss various features of SpA on different modalities of imaging. This book aims to serve as a guide to rheumatologists in interpretation of individual imaging features of SpA. The images have been collected during routine outpatient care of patients with SpA or suspected SpA, with their informed consent.

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RADIOGRAPHS

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Fig. 2: Radiograph of pelvis, anteroposterior projection showing a normal SIJ with regular joint margins, normal joint space and no sclerosis around the joint line. Hip joints and all the entheseal sites are normal.

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Fig. 3: Radiograph of pelvis, anteroposterior projection showing sclerosis of the joint margins of right SIJ with normal joint space (grade-2 sacroiliitis). In addition to periarticular sclerosis, there is irregularity of joint margins and narrowing of the joint space in left SIJ (grade-3 sacroiliitis).

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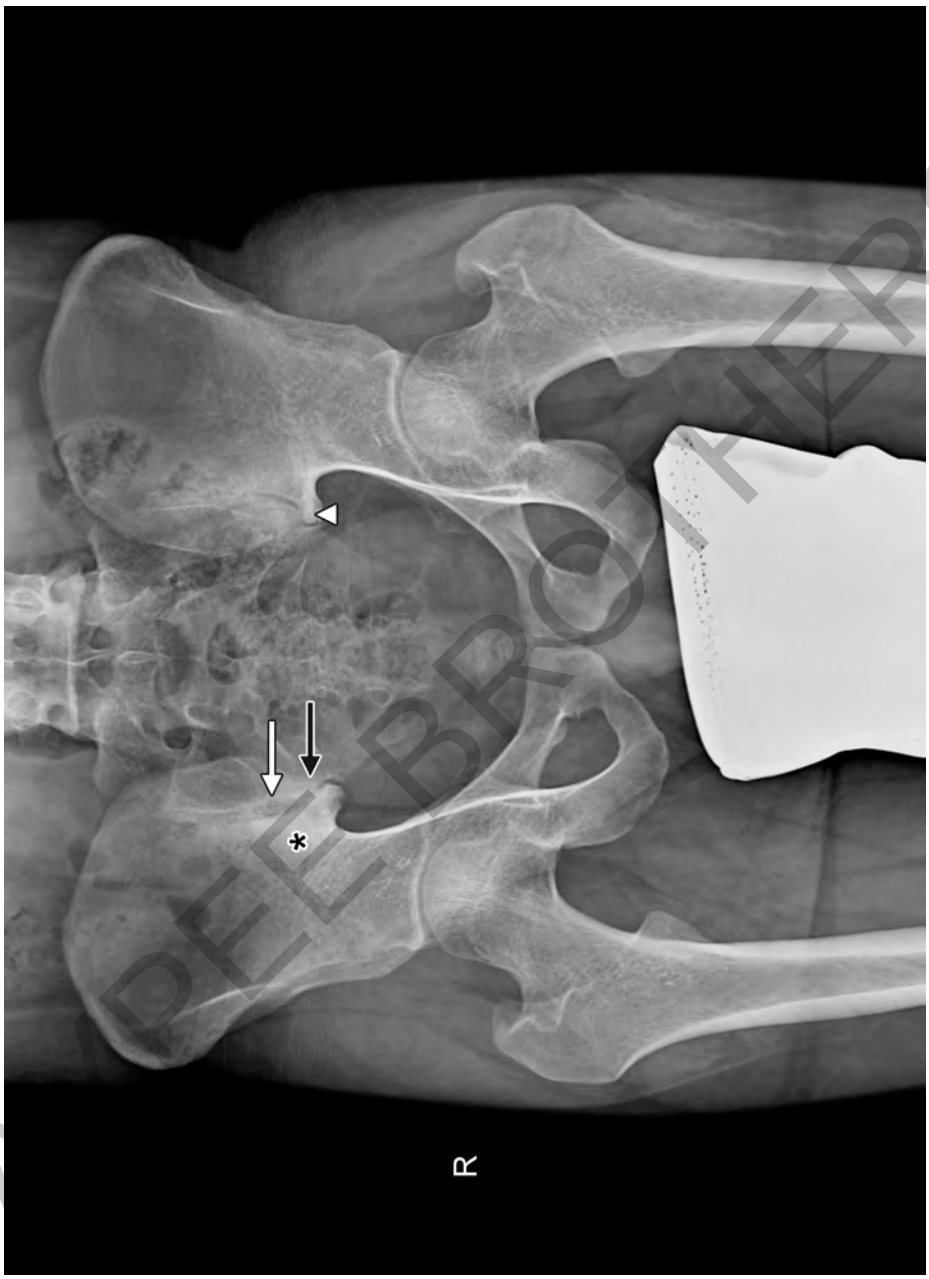


Fig. 4: Radiograph of pelvis, anteroposterior projection showing periarticular sclerosis of right SIJ (asterisk) with widening of the lower part of joint space (white arrow) with narrowing of joint space in the lowest part of right SIJ (black arrow) [grade-3 sacroiliitis]. Lowest part of left SIJ shows mild sclerosis (arrowhead) [grade-1 sacroiliitis].

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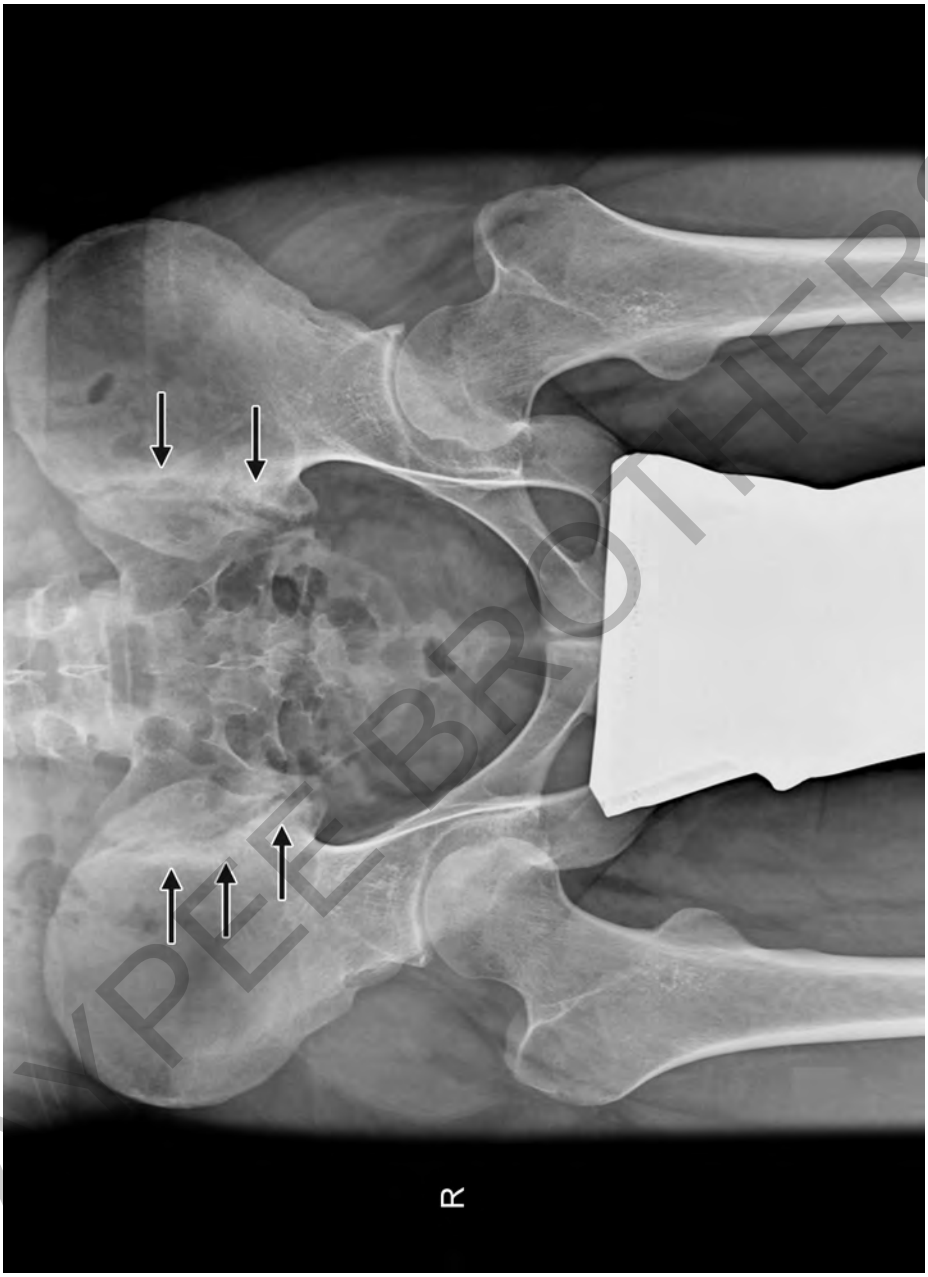


Fig. 5: Radiograph of pelvis, anteroposterior projection showing periarticular sclerosis (arrows) and irregular joint margins in both SIJ (grade-3 sacroiliitis).

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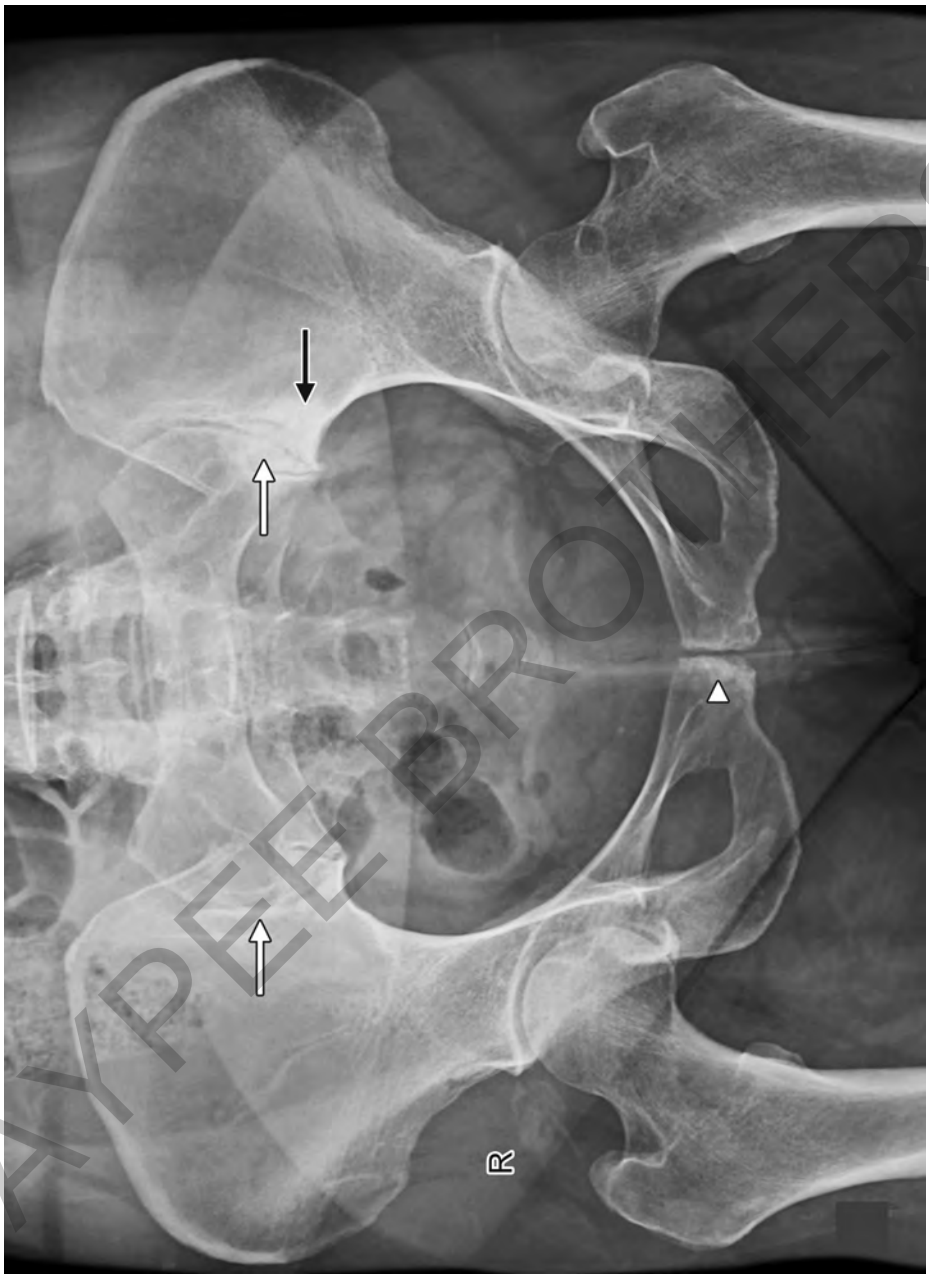
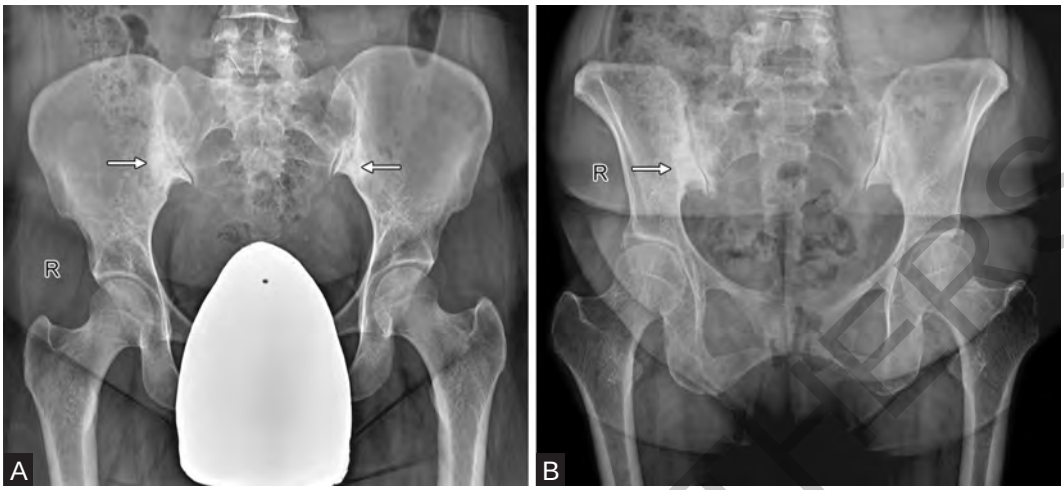


Fig. 6: Pelvic radiograph, anteroposterior projection of a multiparous 40-year old lady with AS showing periarticular sclerosis in right SIJ (white arrow) [grade-2 sacroiliitis]; sclerosis (white arrow) and narrowed joint space in left SIJ (grade-3 sacroiliitis). Note the triangular-shaped radiodensity in the ilium extending away from the left SIJ, suggestive of osteitis condensans ilii (black arrow). It is identified by its peculiar triangular shaped radiodensity and can be mistaken for inflammatory sacroiliitis. Sclerosis is also observed in pubic symphysis, more on right side (arrowhead).

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Figs. 7A and B: Radiographs of pelvis, anteroposterior projection showing radiodensity along the iliac aspect of SIJ extending away from the joint (white arrows), suggestive of osteitis condensans ilii (bilateral in A, right sided in B).

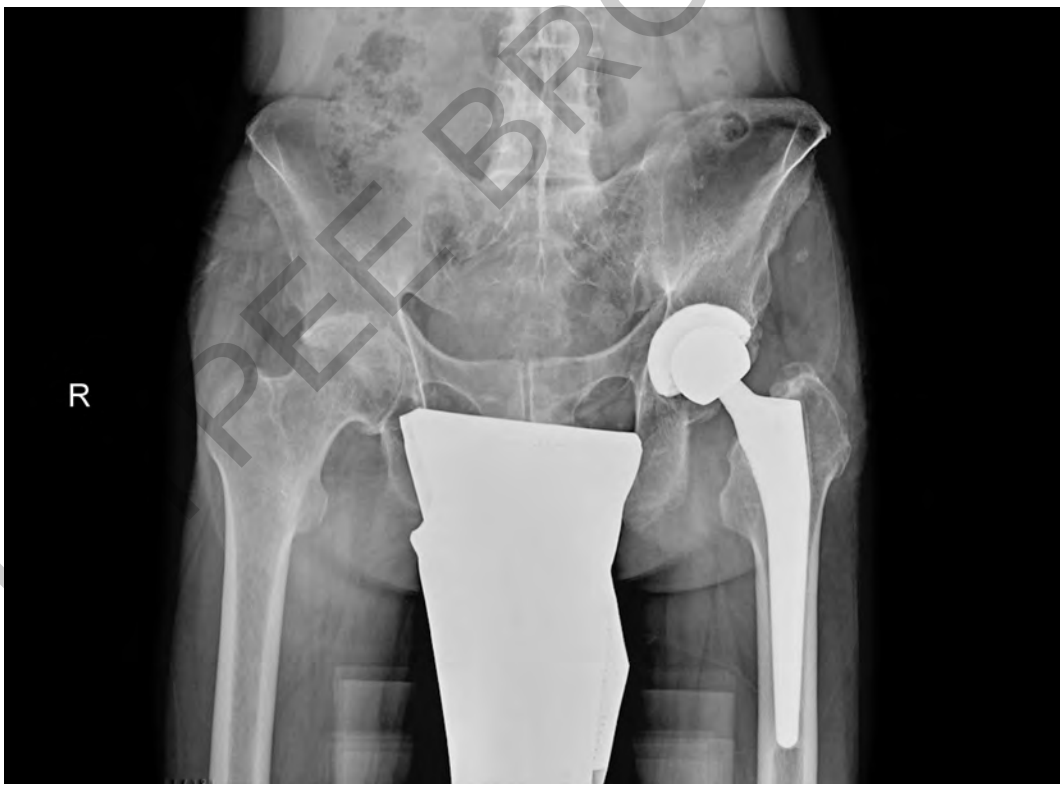


Fig. 8: Radiograph of pelvis, anteroposterior projection showing obliterated (ankylosed) SIJ on both sides (grade-4 sacroiliitis), reduced joint space of right hip, total hip replacement prosthesis on the left side due to severe damage of left hip joint (hip arthritis is a marker of severe disease in SpA).

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Figs. 9A and B: Radiographs of the cervical (A) and lumbar spine (B), lateral projections showing loss of normal concavity with straightening of the anterior borders of the vertebral bodies, suggestive of squaring (white arrows).

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A Rheumatologist's Guide to Interpreting Imaging in Spondyloarthritis

Salient Features

- Detailed illustration and explanation of various imaging findings in patients with spondyloarthritis
- Basic science of MRI and its sequences have been explained in a simple language which rheumatologists and internists can understand
- Various uncommon imaging features like entheseal inflammation and ligamentous ossification have been nicely illustrated
- Provides a vivid collection of plain radiographs, MRIs and CT scans obtained during care of patients with spondyloarthritis
- Both the axial and peripheral joints have been included.

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