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Imaging the Patient With Sacroiliac Pain

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Abstract

Sacroiliac (SI) region pain is a common clinical presentation and is often due to pathology involving the SI joints, usually of inflammatory, infective, neoplastic, or post-traumatic etiology. The SI joints have a unique anatomic layout and composition and can be imaged with a variety of techniques including conventional radiographs, computed tomography, isotope bone scintigraphy, and magnetic resonance imaging. This article reviews a range of common SI joint conditions, illustrated by multimodality imaging findings. We also discuss strategies for choosing the optimal imaging modality, pearls, and pitfalls of imaging and discuss an algorithm for approaching the patient with suspected inflammatory back pain.

Résumé

La douleur sacro-iliaque est un tableau clinique courant, souvent attribuable à une pathologie de l'articulation sacro-iliaque d'origine inflammatoire, infectieuse, néoplastique ou post-traumatique. La disposition anatomique et la composition de l'articulation sacro-iliaque sont uniques, et diverses techniques d'imagerie peuvent être utilisées pour examiner cette région, notamment la radiographie classique, la tomodensitométrie, la scintigraphie osseuse et la résonance magnétique. Dans cet article, nous passons en revue diverses affections courantes de l'articulation sacro-iliaque, illustrées à l'aide de résultats d'examens d'imagerie multimodale. Nous examinons également les stratégies à appliquer pour choisir la modalité d'imagerie la plus appropriée, ainsi que différents pièges et astuces de l'imagerie. En outre, nous expliquons une façon d'aborder les patients chez qui une douleur lombaire d'origine inflammatoire est soupçonnée.

Key Words: Computed tomography; Magnetic resonance imaging; Sacroiliac joint; Sacroiliitis; Sacrum; Spondyloarthritis

Low back pain not uncommonly arises secondary to pathology in the sacroiliac (SI) joints, which can include inflammatory, infective, neoplastic, and post-traumatic conditions. Many patients with lower back or SI region pain will present to their primary care physician, specialist rheumatologist, or orthopaedic surgeon. The initial challenge for the physician is to confirm origin of symptoms from the SI joint. The criterion standard for confirmation of SI pain is relief of symptoms after image guided SI joint injection [1]. Clinical evaluation of the SI joint should include the posterior superior iliac spine distraction test, pelvic compression and distraction, Gaenslen's test and the flexion, abduction, and external rotation test [2]. SI joint pain can be differentiated from discogenic lower back pain by the lack of neurological features and a normal straight leg raising test. Piriformis syndrome can also cause similar posterior thigh and buttock pain but can be differentiated by application of the passive flexion, adduction, and internal rotation test. Following a thorough clinical assessment and appropriate laboratory investigations, imaging forms the next major step in the investigation of patients with suspected inflammatory back pain (IBP) or SI joint pathology and various imaging modalities are available to the clinician [3,4]. Increasingly, advanced imaging modalities such as magnetic resonance imaging (MRI) are being used to detect early changes of sacroiliitis and expedite diagnosis in

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patients with IBP, allowing prompt commencement of disease modifying therapy [3,5,6].

Imaging Technique

The SI joints have a unique anatomical composition and layout, consisting of cartilaginous and ligamentous components similar to a secondary cartilaginous joint but with a synovial joint component on the iliac side of the distal third of the joint [7]. The sigmoid shape and oblique orientation of the SI joints also pose challenges to planar imaging techniques such as conventional radiography or planar isotope bone scintigraphy due to the overlap of adjacent osseous structures surrounding the joints, which can render interpretation of subtle changes difficult. Nevertheless, many patients presenting with SI pain would have undergone initial imaging with conventional radiographs of the lumbar spine, pelvis, or SI joints. Radiographic features such as erosions, sclerosis, and ankylosis are typically seen in advanced inflammatory sacroiliitis and are graded from 0 (normal) to 4 (ankylosis) according to the modified New York criteria (Figure 1) [8]. However, many of these radiographic changes lag considerably behind symptoms, often only manifesting years after initial presentation. Recent guidelines strongly recommend further imaging with MRI in patients with suspected IBP but who have no radiographic changes, due to its superior sensitivity in detecting early inflammatory changes [3,4].

Advances and Developments in Imaging Techniques

Cross-sectional modalities such as MRI, computed tomography (CT), or single-photon emission computed tomography (SPECT) have many advantages over conventional radiography in imaging the SI joints. The ability to image the SI joints in different planes allows complete visualization of the joint and images can be acquired or reconstructed along axial or coronal planes relative to the orientation of the sacrum (Figures 2 and 3) [4]. Of these modalities, MRI has emerged as the preferred imaging modality for SI joint pathology due to multiplanar imaging capability and superior soft tissue and bone marrow contrast on short tau inversion recovery (STIR) and fat-saturated T2-weighted sequences, which are essential for detecting early inflammatory changes [4–6]. The use of intravenous contrast, although not essential, helps increase sensitivity for detection of active inflammation or soft tissue involvement in suspected cases of infection. Technical advances in musculoskeletal MRI, including more robust fluid sensitive sequences with higher resolution, better fat suppression techniques and metal artifact reduction sequences for postoperative imaging have also been beneficial to imaging SI joint pathology. More recently, dual-energy CT techniques for detecting bone marrow oedema at acute fracture sites have been described and can identify areas of acute pathology such as sacroiliitis in a similar manner to fluid sensitive MR sequences [9].

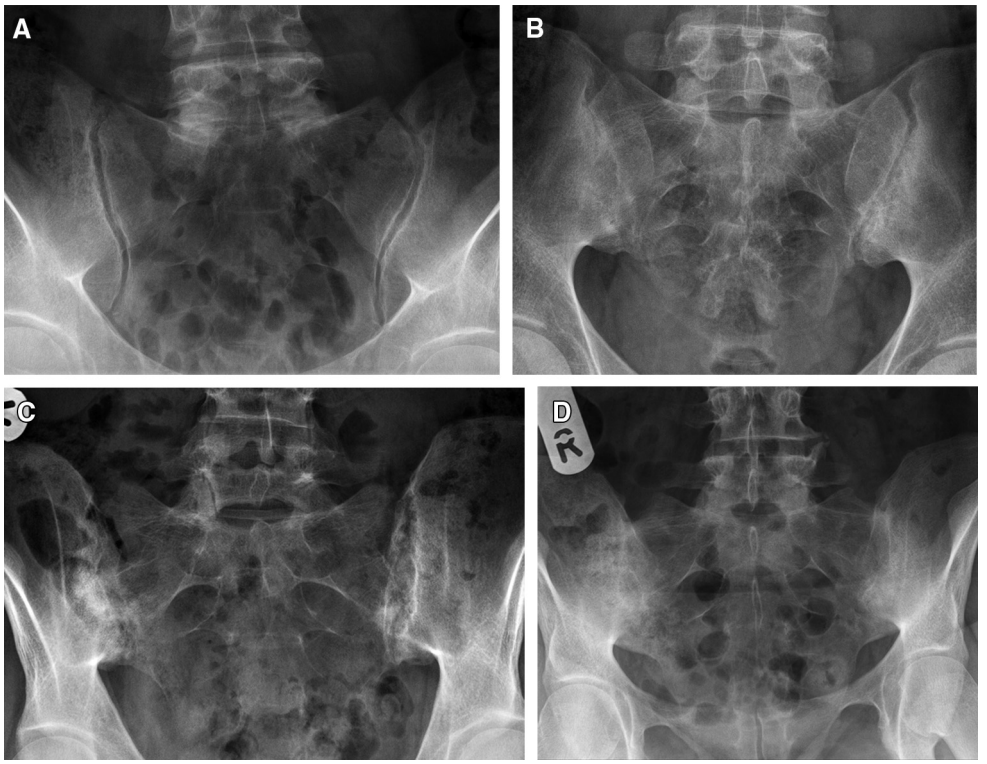

Figure 1. Spectrum of sacroiliitis severity on radiographs graded according to the New York criteria. (A) Grade 1 changes with subtle blurring of the joint margins. (B) Grade 2 changes in left sacroiliac joint with erosions and mild periarticular sclerosis. More severe Grade 3 changes are present on the right with partial ankylosis evident. (C) Grade 3 changes bilaterally with severe joint erosions, sclerosis, and joint space widening. (D) Grade 4 changes demonstrating complete ankylosis of both sacroiliac joints.

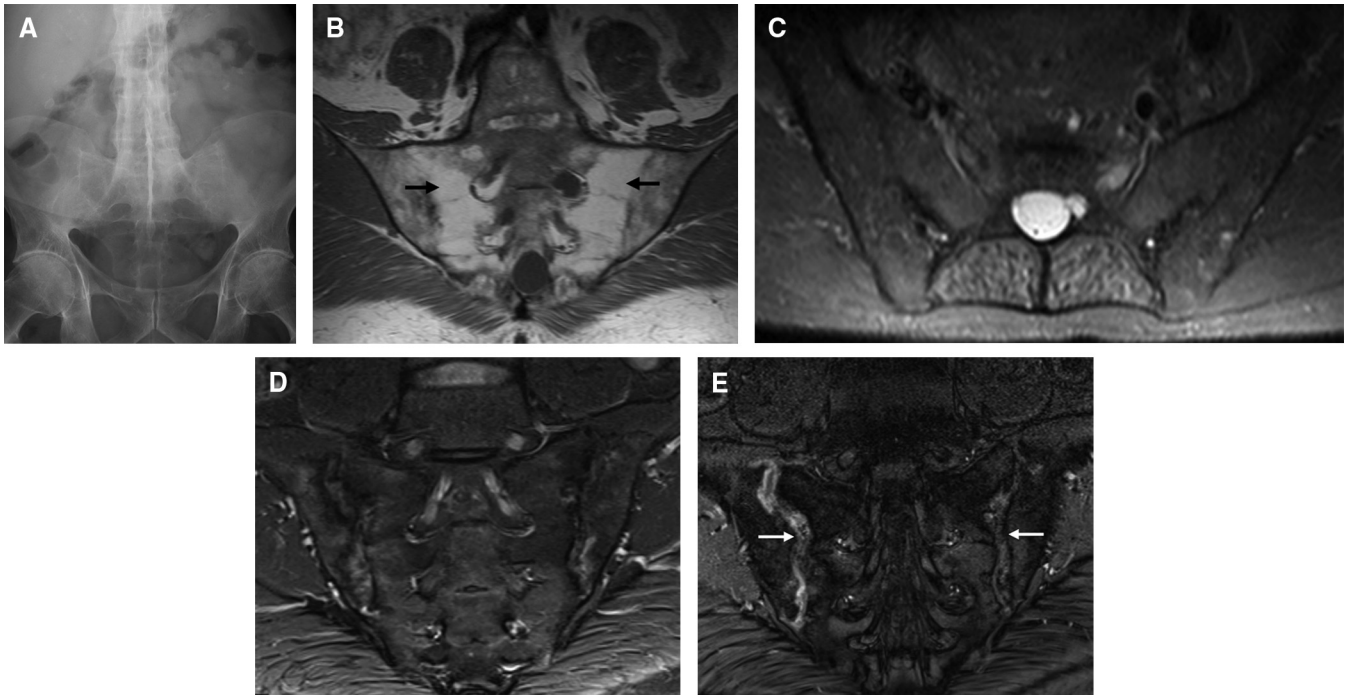

Figure 2. Inflammatory sacroiliitis. (A) Ankylosing spondylitis with diffuse syndesmophytic ankylosis of the spine and sacroiliac joint fusion. (B) Corresponding coronal T1-weighted magnetic resonance imaging demonstrates subchondral fatty replacement and bony fusion consistent (black arrows) with end stage ankylosis from previous sacroiliitis. (C) Axial short tau inversion recovery sequence confirms lack of bone marrow oedema to suggest acute disease activity. (D) Coronal short tau inversion recovery and (E) coronal T1-weighted fat saturated postcontrast sequences in a different patient with ankylosing spondylitis show symmetrical bilateral joint erosions, bone marrow oedema and joint enhancement (white arrows) consistent with active sacroiliitis. Bony ankylosis has not yet occurred in this patient, who would benefit from disease modifying therapy.

Choice of Imaging Modality

The choice of imaging modality will be largely influenced by the clinical picture and availability of imaging modalities to the clinician or radiologist. Conventional radiography is the first-line modality in most instances and serves as a useful baseline for future comparison. However, as discussed previously, the absence of radiographic changes do not exclude an underlying inflammatory or infective process and many patients with suspected inflammatory back pain will proceed to further imaging, usually with MRI [4,10]. In patients with suspected infection, MRI with intravenous gadolinium contrast or planar or SPECT-CT isotope bone scintigraphy are the modalities of choice, with MRI offering better assessment of anatomical changes and periarticular soft tissue structures over SPECT-CT without ionizing radiation exposure [4,10]. MRI, CT, and isotope bone scintigraphy are all useful in the detection of stress fractures of the sacrum and pelvis and the modality choice in this setting will be largely dictated by individual preference and expertise. CT is helpful in situations in which there is a contraindication

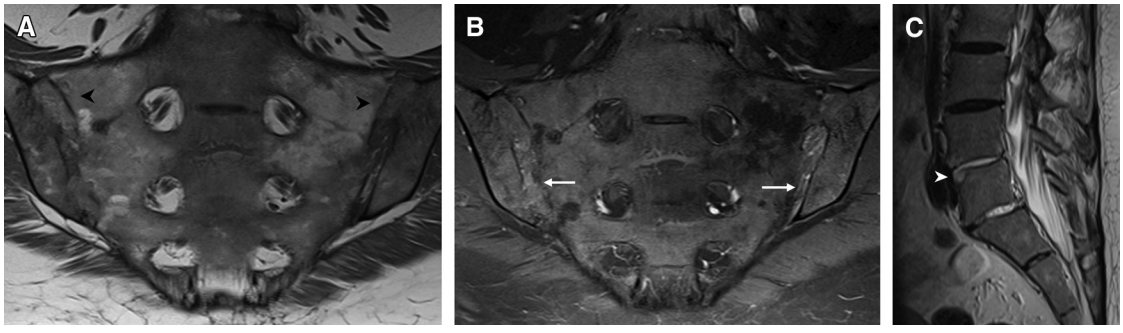

Figure 3. Ankylosing spondylitis with active sacroiliitis. (A) Axial T1-weighted image shows subchondral fatty infiltration around both sacroiliac joints with partial ankylosis consistent with chronic sacroiliitis (black arrowheads). (B) Axial fat saturated T1-weighted postcontrast image shows mild enhancement within both sacroiliac joints indicating active inflammation. (C) Sagittal T2-weighted magnetic resonance imaging lumbar spine demonstrates signal hyperintensity and erosion within the anteroinferior endplate of L4 and anterosuperior endplate of L5 vertebral bodies (white arrowhead) consistent with Romanus lesions (shiny corner sign).

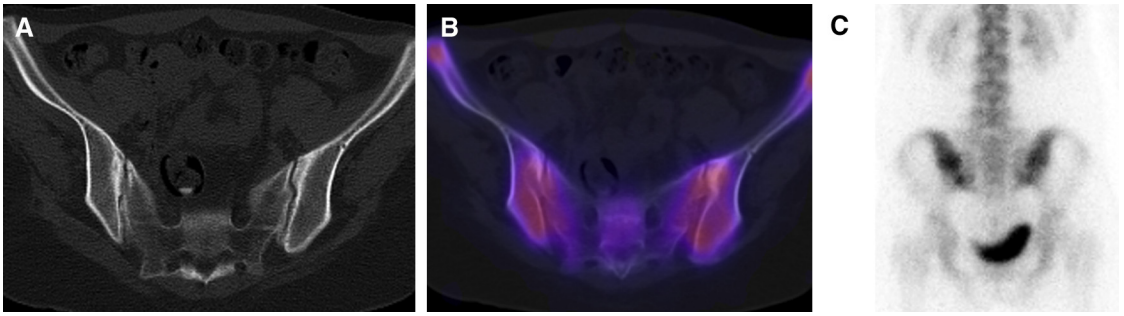

Figure 4. Ankylosing spondylitis with bilateral symmetric sacroiliitis on technetium 99m single-photon emission computed tomography (SPECT) computed tomography (CT) bone scan. (A) Axial CT image shows bilateral subchondral erosions and sclerosis. (B) Fused axial SPECT-CT and (C) posterior planar bone scan image demonstrates increased radiotracer uptake around both sacroiliac joints consistent with sacroiliitis. This figure is available in colour online at http://carjonline.org/.

to MRI and provides excellent delineation of periarticular erosions, sclerosis, or osseous metastasis (Figures 4 and 5). Abdominal and pelvic CT imaging is also obtained in many other clinical situations and SI joint disease can often be picked up incidentally in such settings.

Clinical Conditions Presenting With SI Pain

SI Pathology

Inflammatory Sacroiliitis

Inflammatory sacroiliitis is a central component of spondyloarthritis (SpA) comprising ankylosing spondylitis (AS), inflammatory bowel disease–associated SpA, reactive arthritis, psoriatic arthritis, and undifferentiated SpA. There is considerable overlap between these conditions but all are characterized by involvement of the SI joints. The pattern of involvement can be unilateral or bilateral and ranges in severity from mild to severe inflammation resulting in partial or complete ankylosis. The pattern of sacroiliitis in AS is typically bilateral and symmetrical in 85%-90% of cases (Figures 2-4) [3,11]. Other SpA subgroups are less commonly bilateral and have a tendency to affect the SI joints in a unilateral or asymmetric manner however, most eventually progress to AS (Figures 5 and 6) [3,11,12]. Radiographic changes are not seen until later in the course of

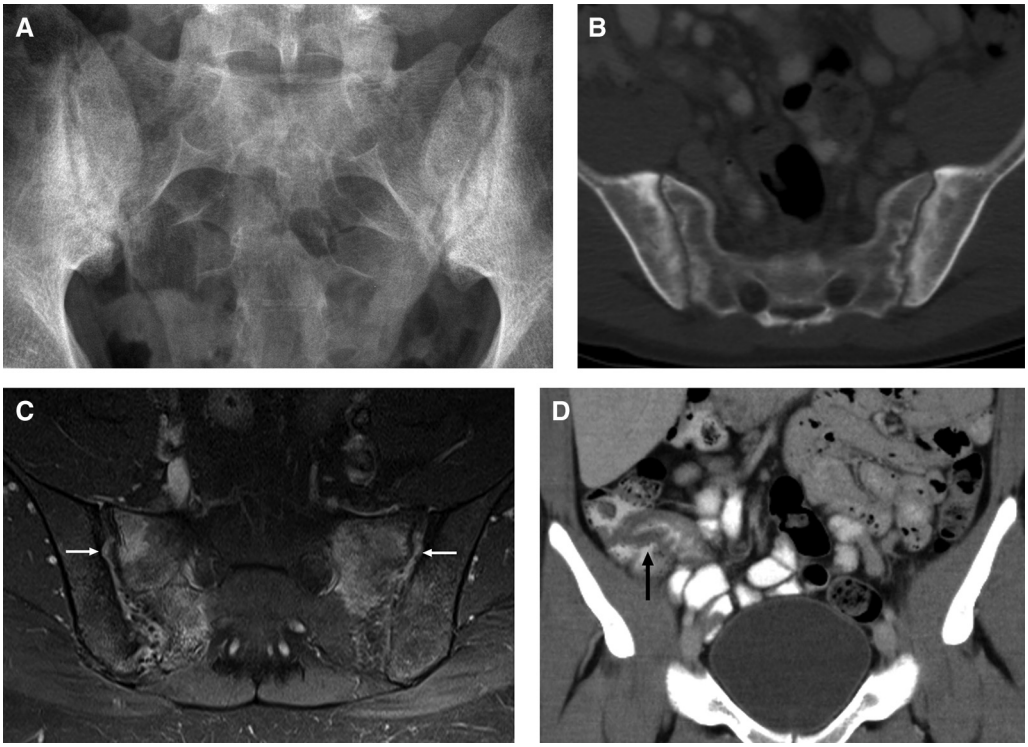

Figure 5. Enteropathy associated sacroiliitis in a patient with Crohn's disease. (A) Radiograph and (B) axial computed tomography shows bilateral sacroiliac joint erosions and subchondral sclerosis. (C) T1-weighted fat saturated postcontrast sequence shows enhancement within both sacroiliac joints and sacral alae (white arrows) consistent with active inflammation. (D) Coronal contrast-enhanced computed tomography abdomen shows circumferential mural thickening of the terminal ileum (black arrow) in keeping with terminal ileitis.

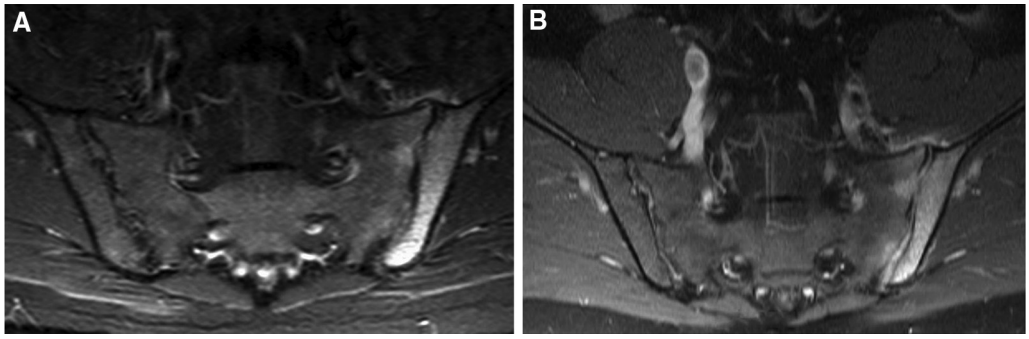

Figure 6. Acute left sacroiliac joint pain in a previously well patient without constitutional symptoms. (A) Axial short tau inversion recovery image shows unilateral bone barrow oedema surrounding the left sacroiliac joint consistent with unilateral sacroiliitis. (B) Marked enhancement is seen on T1-weighted postcontrast sequences. Appearances were initially highly concerning for infection and aspiration was performed but yielded no organisms on microbiological analysis. A diagnosis of reactive sacroiliitis was made following exclusion of other causes.

AS and accounts for an average delay in 5-7 years to diagnosis [4]. Fat-suppressed fluid-sensitive MRI sequences such as STIR and fat-saturated T2-weighted imaging are highly sensitive for the detection of periarticular or subchondral bone marrow oedema, which is central to the diagnosis of active sacroiliitis. Gadolinium contrast-enhanced fat-suppressed T1-weighted sequences can improve sensitivity and diagnostic confidence for detection of early disease activity but routine contrast administration for all patients is not required [4,5,13]. In chronic sacroiliitis, periarticular fat replacement can be seen as high signal intensity areas on T1-and T2-weighted sequences with corresponding low signal on STIR and fat-suppressed sequences (Figure 2B). Partial or complete ankylosis are seen as bony bridges across the SI joints in chronic sacroiliitis (Figures 1D and 2A).

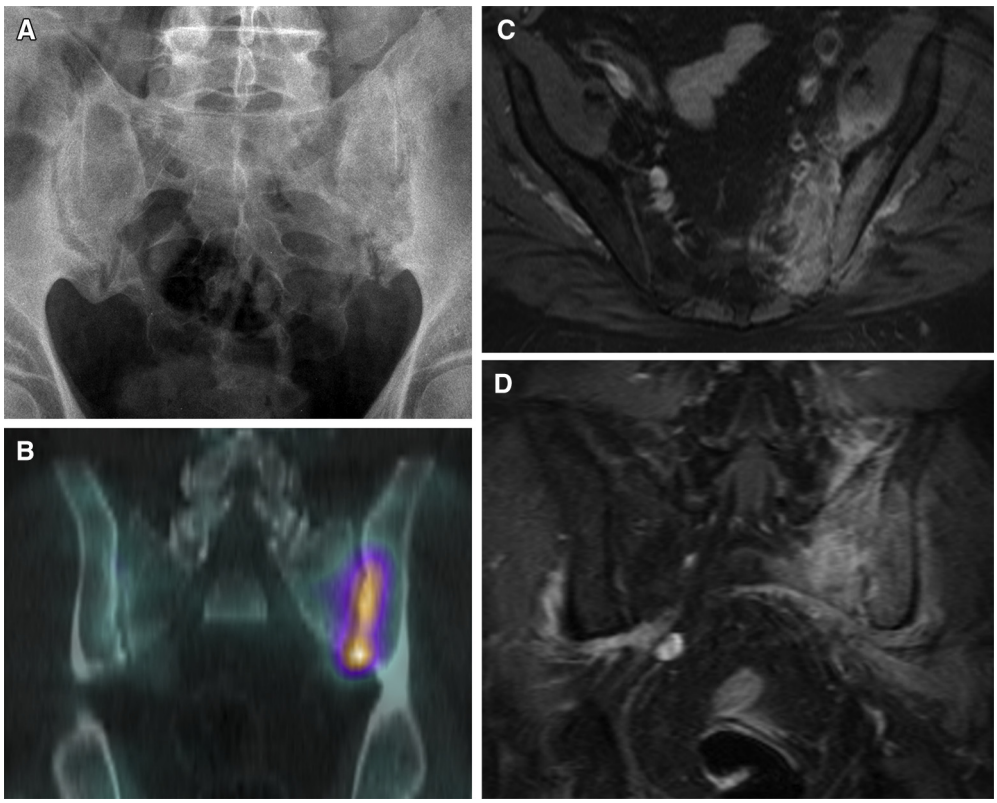

Figure 7. Infective sacroiliitis in a 65-year-old man with monoclonal gammopathy and left-sided gluteal pain and pyrexia. (A) Radiograph demonstrates unilateral erosion and widening of the left sacroiliac joint. (B) Fused coronal technetium 99m single-photon emission computed tomography-computed tomography bone scan image showing increased radiotracer uptake in the left sacroiliac joint. (C) Axial short tau inversion recovery and (D) coronal T1-weighted postcontrast magnetic resonance imaging demonstrating extensive bone marrow oedema and enhancement involving the left sacroiliac joint and surrounding soft tissue structures highly suspicious for septic sacroiliitis. *Staphylococcus hominis* was cultured on bone biopsy samples. This figure is available in colour online at http://carjonline.org/.

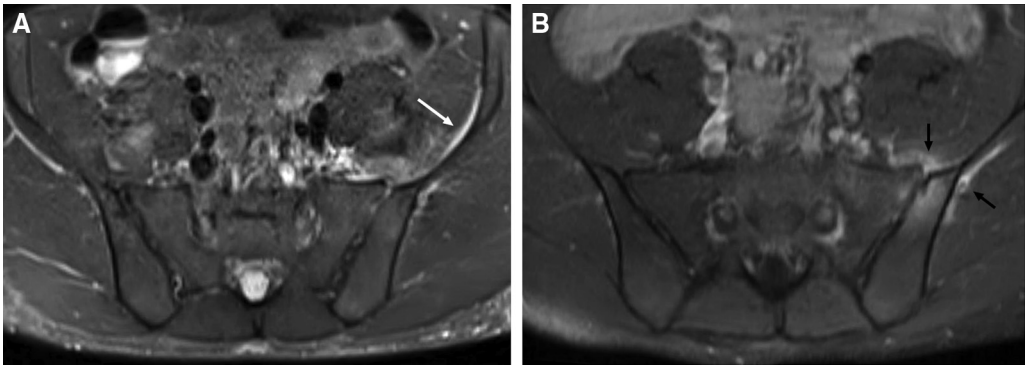

Figure 8. Unilateral infective sacroiliitis in a 25-year-old man presenting with pyrexia and severe left sacroiliac joint pain. He gave a history of repeated intramuscular injections for chronic back pain. (A) Axial short tau inversion recovery image shows subtle areas of bone marrow oedema on both sides of the left sacroiliac joint with a trace amount of fluid along the left iliacus and gluteal muscles (white arrow). (B) Axial fat-saturated T1-weighted postcontrast image demonstrates enhancement of the left sacroiliac joint and muscles (black arrows) raising concern for infective sacroiliitis. *Bacteroides fragilis* was cultured on aspiration.

Infective (Septic) Sacroiliitis

Infective sacroiliitis should be considered when there is unilateral sacroiliitis and soft tissue involvement in the setting of a compatible clinical history of pyrexia, leukocytosis, elevated inflammatory markers, or bacteremia. Pathogens usually reach the SI joints by hematogenous spread and less commonly by local extension from adjacent soft tissue or bone [10,14]. Many factors predispose to infective sacroiliitis and include infective endocarditis, seeding from other sites of infection, joint injections, or trauma [10]. Radiographic changes are usually not apparent until days to weeks following symptom onset and negative initial radiographs should not provide false reassurance to the clinician. When there is suspicion for infection, further imaging with MRI, CT, or isotope bone scintigraphy is indicated. MRI is again the preferred modality as it

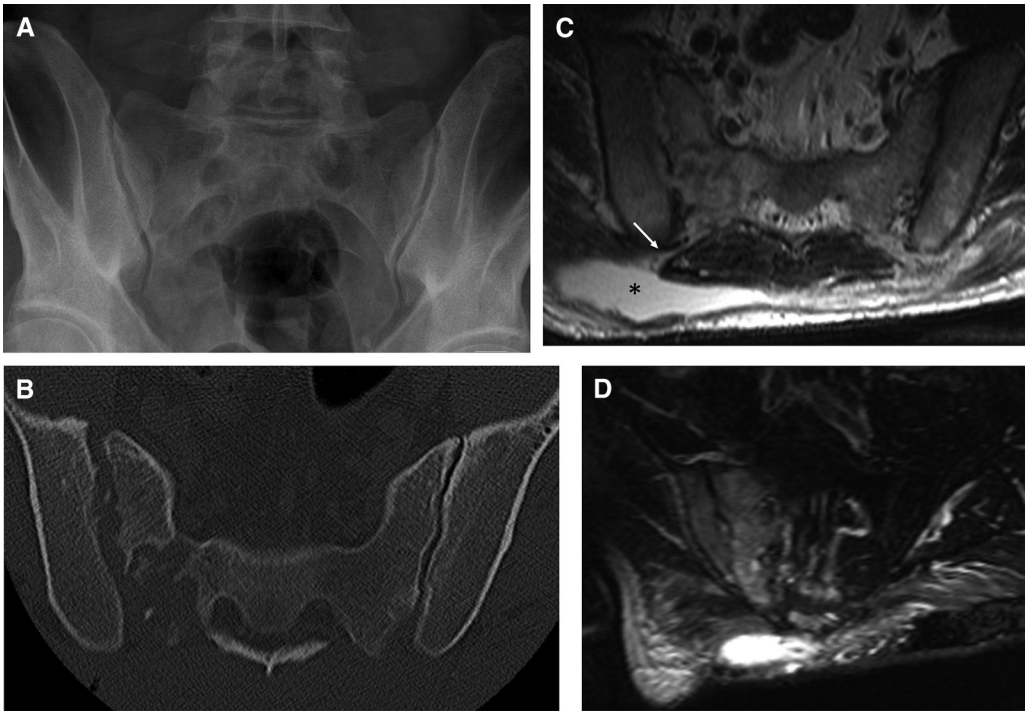

Figure 9. Unilateral right tuberculous sacroiliitis in a 40-year-old man on immunosuppressive therapy for inflammatory bowel disease with repeated presentations for right gluteal pain. (A) Initial pelvic radiograph revealed no significant abnormality. (B) Follow-up axial computed tomography pelvis was performed 4 weeks later showing widening, erosion and destruction of the right sacroiliac joint. (C) Axial T2-weighted magnetic resonance imaging shows a discharging sinus from the joint (white arrow) leading into a subcutaneous fluid collection (asterisk) consistent with infective sacroiliitis and adjacent abscess formation. Cultures from aspirates grew *mycobacterium tuberculosis*. (D) Coronal short tau inversion recovery image shows bone marrow and soft tissue oedema surrounding the right sacroiliac joint.

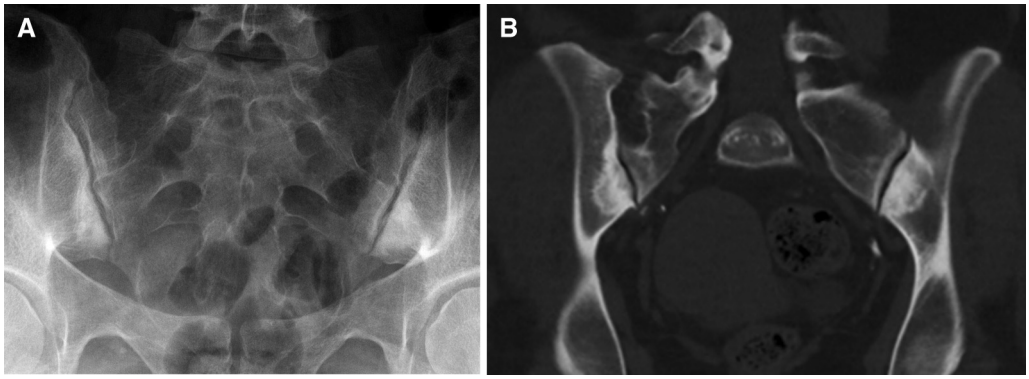

Figure 10. Osteitis condensans ilii. (A) Pelvic radiograph in a middle age female shows triangular areas of sclerosis along the inferior iliac margins of the sacroiliac joints without joint erosion or widening. (B) Coronal computed tomography with bone windows confirms radiographic findings, consistent with osteitis condensans ilii.

clearly shows the extent of soft tissue involvement in addition to erosive changes and bone marrow oedema within the SI joint and bones (Figures 7-9). Intravenous gadolinium contrast is particularly helpful in demonstrating the extent of abnormal soft tissue enhancement and abscess formation and should routinely be performed in all suspected cases of infective etiology [4,10].

Non–SI Pathology and Mimickers

A variety of noninflammatory conditions, ranging from benign to sinister causes, can mimic true SI joint pain and present in a similar manner. A large retrospective study of patients undergoing MRI for suspected sacroiliitis showed that spinal degenerative changes including degenerative disc disease, disc herniation and facet joint arthrosis were the most common noninflammatory finding, seen in 44% of patients [15]. Detailed discussion of lumbar spine disease is beyond the scope of this article. However, the other less common conditions are outlined subsequently.

Osteitis Condensans Ilii

Osteitis condensans ilii is a benign cause of lower back pain, thought to arise from bone remodelling as a result of stress across the SI joints and is mostly seen in women of childbearing age [16]. Its clinical importance is that it can

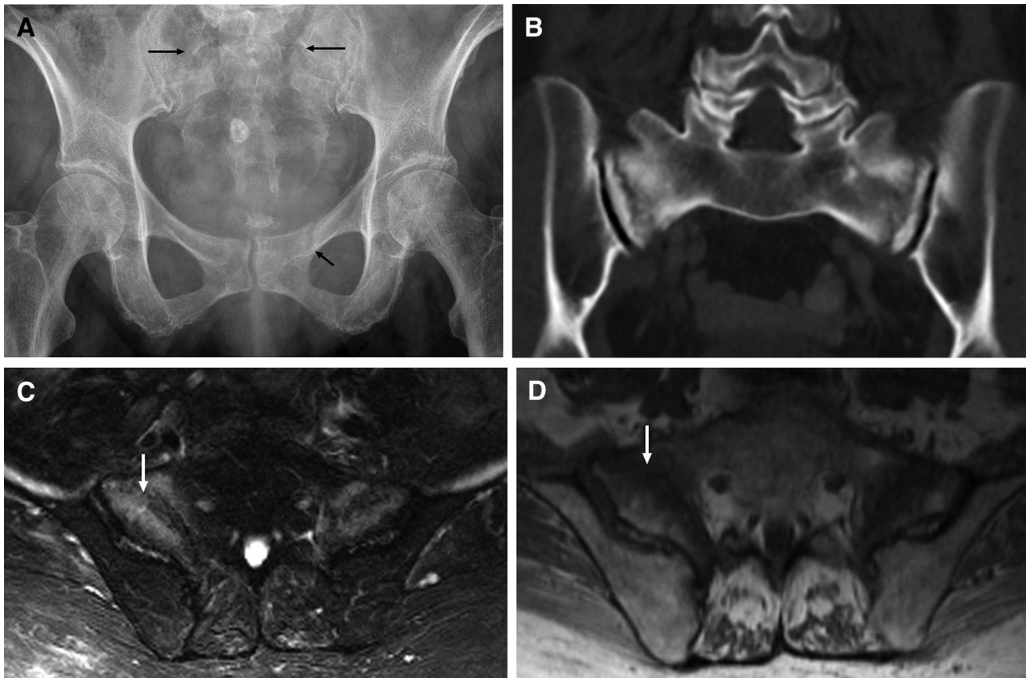

Figure 11. Sacral insufficiency fractures. (A) Pelvic radiograph in an elderly patient with chronic pelvic pain. Linear lucencies are noted through both sacral alae and the left superior pubic ramus, in a pattern compatible with insufficiency fractures. (B) Coronal computed tomography with bone windows confirms vertical fractures through both sacral alae. (C) Axial T2-weighted fat saturated and (D) T1-weighted magnetic resonance imaging images show T1 and T2 hypointense fracture lines (white arrows) with surrounding acute bone marrow oedema.

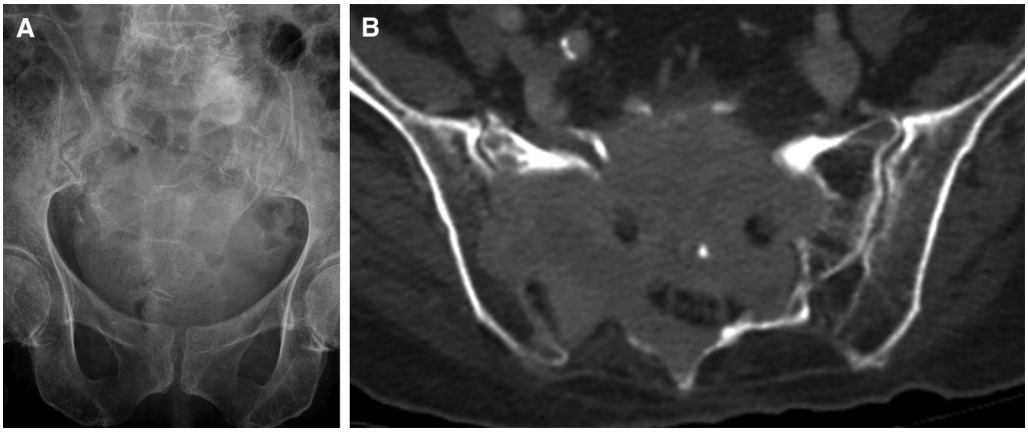

Figure 12. Sacral plasmacytoma. (A) Pelvic radiograph performed as part of a skeletal survey in a patient with monoclonal gammopathy shows an ill-defined lucency within the sacrum. (B) Axial computed tomography with bone windows shows a destructive soft tissue lesion within the sacrum, extending to involve the right sacroiliac joint. Following biopsy, this was confirmed to be a plasmacytoma.

present similarly to IBP from SpA or metastatic disease. The radiographic features of osteitis condensans ilii are characterized by bilateral and symmetric triangular areas of sclerosis affecting the auricular portion of the ilium (Figure 10) without any evidence of joint space narrowing, periarticular erosion or destruction. Management in most cases consists of conservative therapy.

Insufficiency (Stress) Fractures

Most insufficiency fractures occur in the pelvis and typically involve the parasymphyseal pubic bones and sacral alae in elderly patients with osteoporosis or in the setting of previous pelvic radiotherapy [17,18]. The iliac bones adjacent to the SI joints are less common sites of involvement but can also lead to SI pain [18]. Fracture lines are difficult to appreciate on conventional radiographs and these fractures are typically diagnosed on CT, isotope bone scintigraphy or MRI. Vertical lucent lines are seen in both sacral alae and a horizontal fracture line through the sacral body may be apparent on CT (Figure 11). The corresponding finding on isotope bone scintigraphy or positron emission tomography is classic H sign (‘‘Honda’’ sign) of increased radiotracer uptake along the fracture lines, seen in up to 40% of cases [19]. Acute insufficiency fractures on MRI typically show florid bone marrow oedema on STIR sequences. Irregular vertical hypointense fracture lines surrounded by bone marrow oedema through both sacral alae are seen in the later stages (Figures 11C and 11D). The

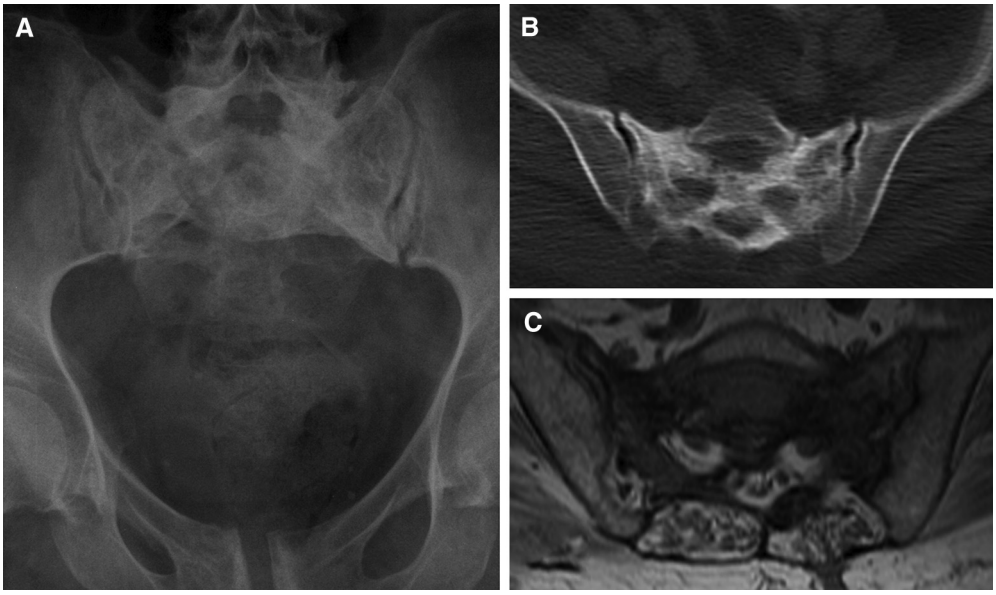

Figure 13. Sacral lymphoma. (A) Pelvic radiograph in a patient with lower back pain following a fall, showing diffuse sclerosis of the entire sacrum with trabecular coarsening, initially suspicious for Paget’s disease. (B) Axial computed tomography and (C) axial T1-weighted magnetic resonance imaging images confirm radiographic findings of diffuse sacral sclerosis and marrow replacement without evidence of sacroiliac joint involvement. Biopsy of this showed diffuse large B-cell lymphoma of bone.

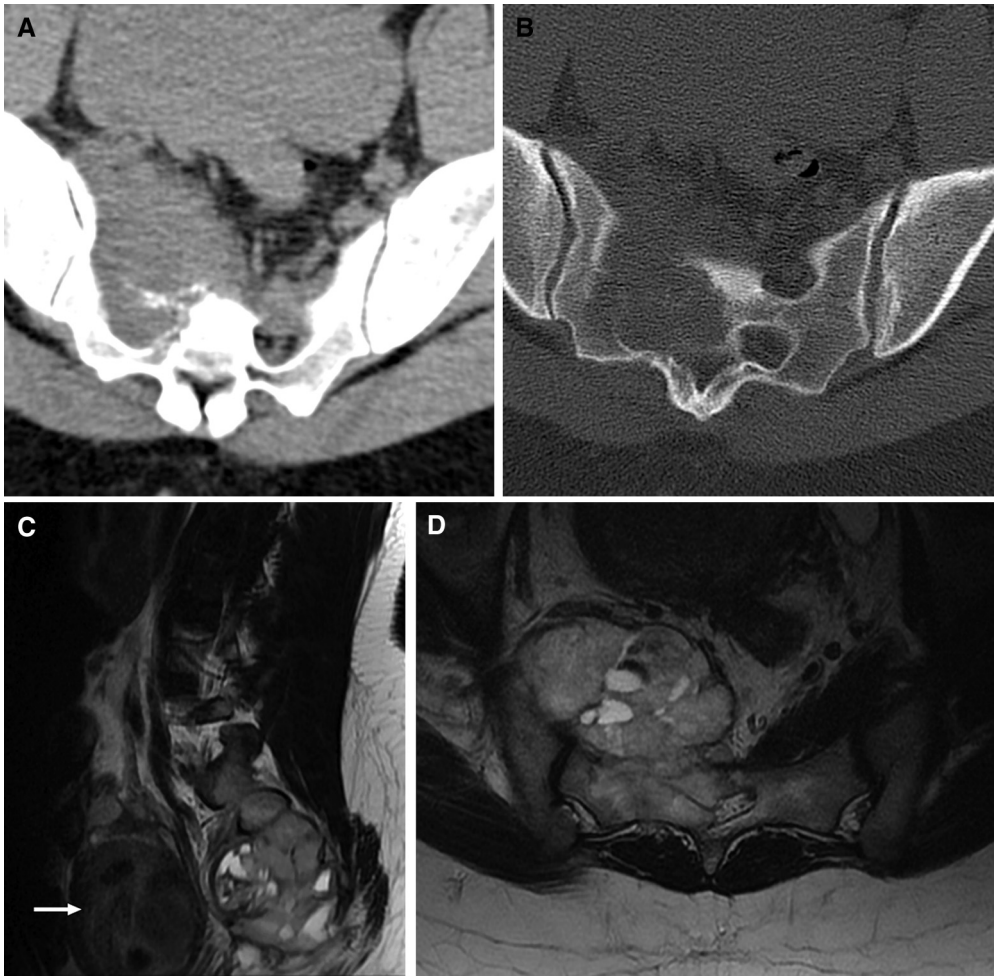

Figure 14. Sacral metastasis. Axial computed tomography in (A) soft tissue and (B) bone windows in a patient with known uterine sarcoma demonstrates a destructive soft tissue mass centred in the right sacral ala consistent with a metastatic lesion. (C) Sagittal and (D) axial T2-weighted magnetic resonance imaging of the lumbosacral junction confirms a large multilobulated solid and cystic mass arising from the sacrum with enlargement of the uterine fundus (white arrow) consistent with the known primary tumour.

presence of further fractures in characteristic locations such as the pubic rami support the diagnosis of insufficiency fractures.

Neoplasia or Metastasis

The sacrum is an uncommon but recognized site for both primary tumours and metastatic disease. Myeloma, lymphoma and metastases (Figures 12-14) are much more commonly seen than primary sacral tumours [20]. Indeed, a wide range of tumours can arise primarily from the sacrum including bone, neurogenic, and germ cell tumours. However, the most common characteristic primary tumours in this location are chordomas, giant cell tumour, and osteoblastoma [21].

Pearls and Pitfalls of SI Joint Imaging

Radiologists should be aware of certain practical tips pertaining to imaging of the SI joints, particularly with MRI. Although MRI is highly sensitive for detection of SpA, isolated changes of periarticular bone marrow oedema can also be seen secondary to mechanical back pain and the overall specificity of MRI for SpA is therefore lower (88%). Acute insufficiency fractures can be misleading on MRI as fracture lines may not be apparent in the early stages and florid STIR signal hyperintensity can be mistaken for metastatic or inflammatory disease. Readers should also be careful not to mistaken artifacts such as inhomogeneous fat suppression as bone marrow oedema or periarticular vessels as oedema or enhancement. Finally, it is also important to remember infection as a diagnosis in any case of unilateral sacroiliitis and contrast-enhanced MRI should be performed to detect early soft tissue changes.

Clinical Algorithm for Assessing Patients With Suspected Inflammatory Back Pain

In practice, diagnosing IBP presents a challenge to both the clinician and radiologist. Red flags in the clinical history

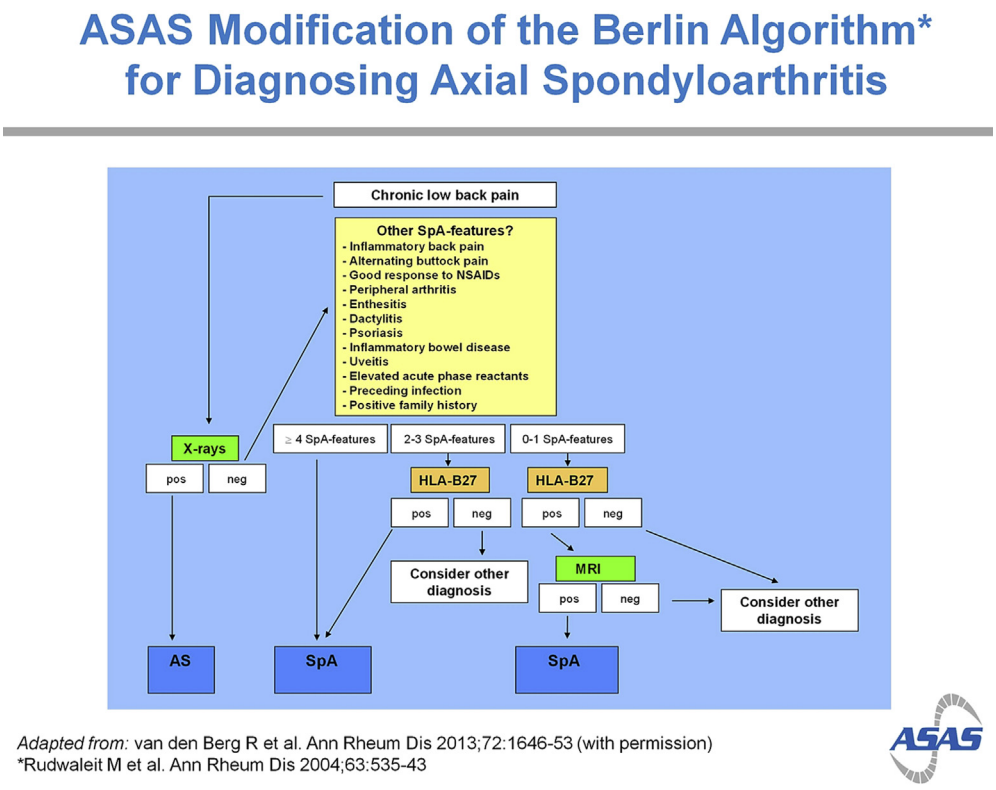

Figure 15. Assessment of SpondyloArthritis International Society (ASAS) diagnostic algorithm for diagnosing inflammatory spondyloarthritis combining clinical and imaging criteria [26]. AS = ankylosing spondylitis; MRI = magnetic resonance imaging; NSAIDs = non steroidal anti-inflammatory drugs; SpA = spondyloarthritis. Reproduced with permission from the ASAS [26]. This figure is available in colour online at http://carjonline.org/.

to suggest IBP have been described in the Calin criteria and comprise an age of onset under 40 years old, insidious onset of symptoms, duration greater than 3 months and early morning stiffness that is relieved by rest [22]. The Assessment of SpondyloArthritis International Society group more recently published a clinical algorithm for the diagnosis of axial spondyloarthritis combining both clinical and imaging parameters, with good specificity and sensitivity validated in large patient cohorts (Figure 5) [23,24]. These criteria can be applied if a patient has back pain of at least 3 months duration with an age of onset less than 45 years. Demonstration of sacroiliitis on imaging with the presence of $\geq$1 SpA feature or HLA B27 in association with $\geq$2 SpA features is required for classification purposes [25].

Conclusion

SI pain can arise from a wide variety of conditions, most commonly inflammatory or infective but can also be due to less common benign and malignant causes. Imaging investigations should be tailored to the individual clinical presentation and both clinicians and radiologists should aware of the merits of each imaging modality. Cross-sectional modalities, particularly MRI, are superior to conventional radiographs in the detection of sacroiliitis and other noninflammatory mimickers and can facilitate early diagnosis and treatment.

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