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Imaging for Diagnosis and Differential Diagnosis of Axial Spondyloarthritis

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Introduction

Spondyloarthritis refers to a group of inflammatory rheumatic diseases characterized by shared clinical features, such as inflammatory involvement of the axial skeleton, a specific pattern of peripheral joint involvement (usually asymmetric mono- or oligoarthritis, predominantly involving the lower extremities), enthesitis, and dactylitis.[1] Common extra-musculoskeletal manifestations include acute anterior uveitis, psoriasis, and inflammatory bowel disease (Crohn's disease and ulcerative colitis).

Axial spondyloarthritis (axSpA) denotes the subset of spondyloarthritis with predominant involvement of the spine and sacroiliac joints. The term axSpA encompasses both non-radiographic disease (no definite structural damage on X-rays of the sacroiliac joints) and radiographic disease, which has historically been referred to as ankylosing spondylitis. In clinical practice, these entities represent a spectrum. axSpA may initially present without X-ray changes and in some patients, may later progress to classic ankylosing spondylitis.

In this article, we will review the approach to diagnosing (versus classifying) axSpA and examine the role of imaging modalities in diagnosing axSpA and distinguishing it from common mimics.

Epidemiology

AxSpA typically begins in early adulthood, most commonly in the third decade of life. The prevalence of axSpA in the general population ranges from 0.3–1%, with variations depending on ethnicity and prevalence of the HLA-B27 gene. Notably, there is a sex difference between non-radiographic and radiographic axSpA: radiographic axSpA (ankylosing spondylitis) shows a male predominance (~2:1), whereas non-radiographic axSpA affects men and women almost equally.[1] A hallmark problem in axSpA care has been diagnostic delay. Historically, patients have waited many years from symptom onset to diagnosis, with global estimates placing the average delay at approximately 6–8 years.[2]

Such delays occur mainly due to attribution of back pain to mechanical/degenerative causes and a lack of awareness about the condition. Although increased awareness and the availability of magnetic resonance imaging (MRI), which supports early diagnosis, have begun to shorten the diagnostic delay in some regions, it remains unacceptably prolonged for many patients.

Paradoxically, while delayed diagnosis remains an issue, overdiagnosis of axSpA has emerged as a concern in recent years. Heightened awareness and reliance on MRI have led some patients with mechanical or degenerative back pain to be incorrectly diagnosed with axSpA. A recent interim report from a German telemedicine project (IMPROVE-axSpA) found that approximately one-third of patients carrying a diagnosis of axSpA were reclassified as not having the disease after expert re-evaluation, with other conditions deemed the cause of their symptoms.[3] Overdiagnosis is often driven by misinterpretation of imaging. For example, overcalling nonspecific bone marrow edema (BME) on MRI as evidence of axSpA. Both delayed diagnosis and overdiagnosis can be harmful: delayed diagnosis allows the progression of inflammation and structural damage, whereas overdiagnosis can expose patients to unnecessary treatments and psychological burden. Recognizing this dual challenge, clinicians must use a balanced approach to diagnosing axSpA, carefully integrating clinical and imaging findings.

Diagnosis and Classification

When evaluating a patient for possible axSpA, it is crucial to distinguish diagnostic criteria from classification criteria.[4] Diagnosis is the process by which a clinician, using all available information (history, exam, laboratory tests, imaging), determines whether an individual patient has axSpA with a certain level of probability. Classification criteria, on the other hand, are standardized definitions used primarily in research to create homogeneous study populations. The modified New York criteria for ankylosing spondylitis, established in 1984, require definite sacroiliitis visible on X-ray plus at least one clinical criterion.[5] This means that in traditional practice, a patient needed to have established structural damage in the sacroiliac joints to fulfill the “AS” criteria. In 2009, the Assessment of SpondyloArthritis International Society (ASAS) proposed new classification criteria for axSpA to promote the new spondyloarthritis concept and to enable recognition of earlier stages of the disease. Notably, patients can be classified as axSpA either by the imaging arm (active sacroiliitis on MRI or definite radiographic sacroiliitis, plus at least one SpA feature) or by the clinical arm (HLA-B27 plus at least two other SpA features).[6] These criteria introduced MRI as the method of visualizing active inflammation, aiming to identify axSpA before irreversible structural changes occur.

It is important to remember that meeting the ASAS classification criteria does not automatically equate to a clinical diagnosis; clinicians must still exclude other causes and consider the total clinical picture. Conversely, a patient who does not neatly fulfill classification criteria may still be diagnosed with axSpA by an expert clinician. In summary, while classification criteria are useful guides, and have improved early recognition, a practical diagnostic approach must remain individualized.

To apply the ASAS classification criteria, patients must first have an established diagnosis of axSpA. In practice, diagnosing axSpA is a clinical decision that is supported by investigations. Clues such as chronic back pain starting before age 45, the inflammatory character of back pain (improvement with exercise, no improvement with rest, night pain, morning stiffness of more than 30 minutes, and alternating buttock pain), peripheral arthritis, enthesitis, acute anterior uveitis, psoriasis, inflammatory bowel disease, a positive HLA-B27, and elevated C-reactive protein levels all increase suspicion. However, none of these features is specific or diagnostic on its own. Indeed, even the concept of “inflammatory back pain” has limitations, as many patients with mechanical back issues can experience inflammatory-type back pain symptoms.[7] Likewise, HLA-B27 is prevalent in ~5–15% of the healthy population, thus, while it greatly increases the pre-test probability in a patient with compatible symptoms, it is not a definitive test. Given the lack of a single clinical or lab “gold standard” for axSpA, imaging plays a pivotal role by providing objective evidence of inflammation or structural change in the sacroiliac joints and spine. Imaging findings, when interpreted within the proper clinical context, can confirm the diagnosis of axSpA or suggest alternative pathologies. The diagnostic approach, therefore, relies on a synthesis of clinical assessment, laboratory results, and imaging studies.

Role of Imaging in axSpA

Imaging undeniably plays an important role in diagnosing and assessing axSpA, often being the only possibility to objectively confirm the presence of inflammatory involvement of the sacroiliac joints or spine.[8]

X-rays

The typical imaging evaluation for suspected axSpA begins with conventional X-rays of the pelvis (sacroiliac joints).[9] X-rays have been used for decades to detect structural changes consistent with axSpA, such as erosions, sclerosis, changes of the joint space, and eventual ankylosis. If the initial X-rays are normal or equivocal and clinical suspicion remains high, MRI of the sacroiliac joints is the next step. The stepwise approach of performing X-rays followed by MRI is reflected in recommendations and represents a practical strategy to maximize diagnostic yield. However, in settings where MRI and X-rays are equally available, X-rays can be omitted due to their limitations outlined below.

Radiographic changes take time to develop, and in the early stages of axSpA (the first few years of symptoms), X-rays are often normal. In fact, a significant proportion of axSpA patients, especially women, may never develop advanced radiographic sacroiliitis even after many years, remaining in the non-radiographic category. Therefore, the sensitivity of X-rays for detecting early disease is quite low.[10] Even when structural changes exist, they can be subtle, and inter-reader reliability for grading sacroiliitis on X-ray is only moderate at best. Changes such as sclerosis can also be due to other causes (for example, osteitis condensans ilii [OCI] or degenerative changes in general), which can confuse interpretation. Therefore, a normal X-ray does not rule out axSpA, and an abnormal X-ray with mild changes is not always definitive. Because of these issues, radiography is increasingly seen as an initial screening tool. If it shows definite changes, a diagnosis of radiographic axSpA can be made; however, if the findings are negative or equivocal, further imaging is warranted.

Magnetic Resonance Imaging

MRI has revolutionized the diagnosis of axSpA by allowing the visualization of active inflammation in the sacroiliac joints and spine. The hallmark MRI finding in active axSpA is BME in the subchondral bone on fat-suppressed T2-weighted sequences, such as Short Tau Inversion Recovery (STIR).[11] This appears as bright areas in the usually dark bone marrow and represents osteitis (**Figure 1**). MRI can also show capsulitis, enthesitis, and inflammatory signals in the joint space or in the erosion cavity in the sacroiliac joints, as well as inflammatory lesions in the spine, such as spondylitis, facet arthritis, costovertebral or costotransverse arthritis, and enthesitis. In addition to inflammation, MRI can depict structural lesions, including erosions (appearing as dark defects in the bright marrow fat), subchondral fat deposition (bright signal on T1), sclerosis (low signal on both T1 and T2), and ankylosis. One specific structural lesion visualized by MRI is the phenomenon of "backfill", which is the replacement of an erosion cavity by tissue with fat signal. This appears as a high T1 signal filling the joint space where bone has eroded (**Figure 1**). Backfill is considered a reparative change and is a specific sign of chronic axSpA damage, often preceding new bone formation across the joint.

An important aspect of practical imaging application is the standardization of protocols and reporting. Recently, an international task force, a collaboration between ASAS and the Spondyloarthritis Research and Treatment Network (SPARTAN), developed a standardized MRI protocol for the sacroiliac joints to maximize diagnostic utility.[12] The consensus recommended that MRI to evaluate the sacroiliac joints for signs of axSpA should include at least four sequences, as depicted in **Figures 1 and 2**:

1. A semi-coronal T1-weighted sequence to assess structural damage,
2. A semi-coronal T2-weighted fat-suppressed sequence, such as STIR, to detect active inflammation,
3. An erosion-sensitive sequence in the semi-coronal plane to enhance visualization of cortical bone erosions, which can be a T1 fat-suppressed gradient echo, known as Volumetric Interpolated Breath-hold Examination (VIBE), Liver Acquisition with Volume Acceleration (LAVA), or T1 High-Resolution Isotropic Volume Examination (THRIVE), depending on the MRI manufacturer, and
4. An additional T2-weighted fat-suppressed semi-axial sequence for further evaluation of inflammatory lesions.

Most MRI scanners now can accommodate these sequences within a single exam of a reasonable duration.

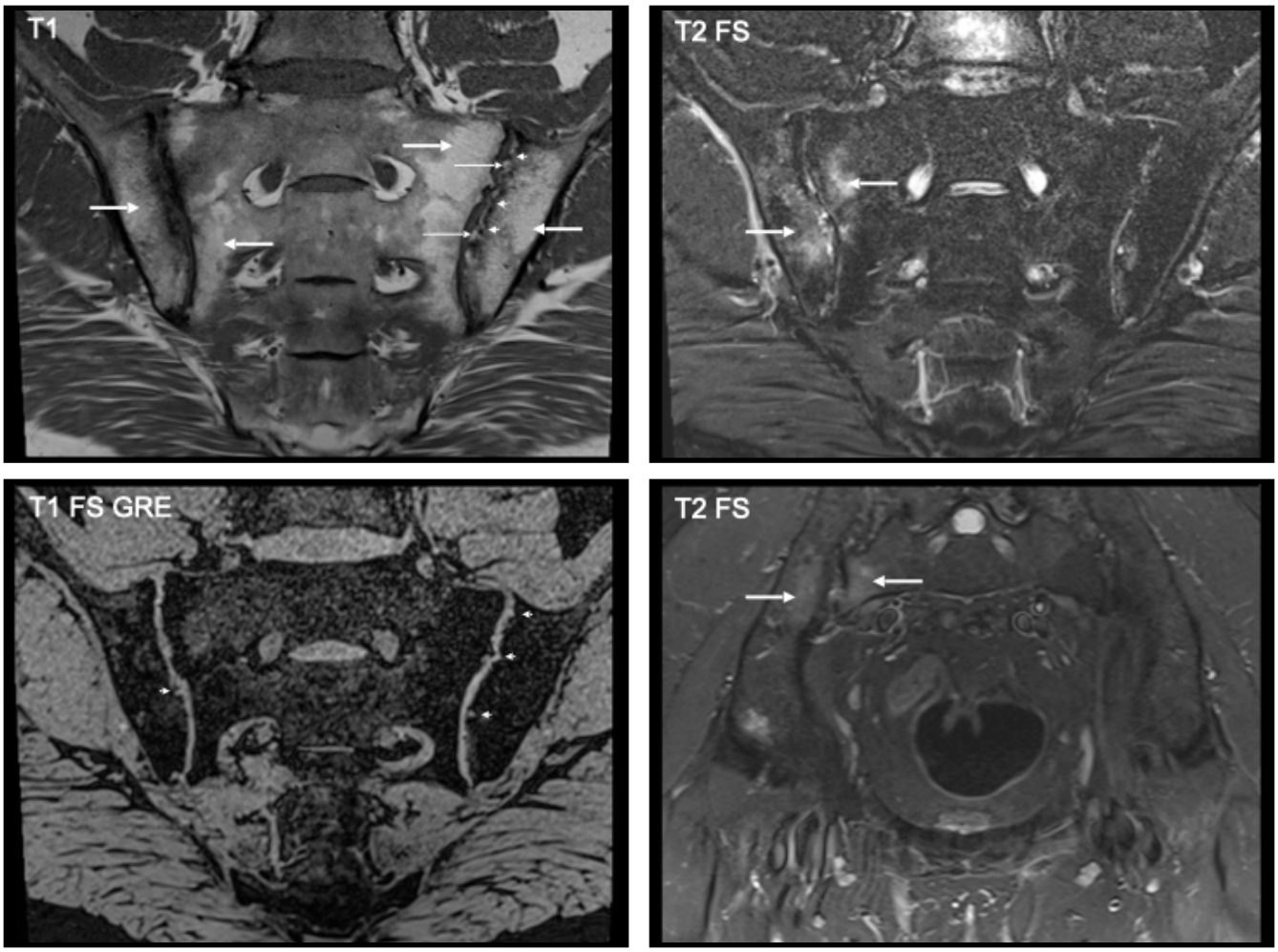

Figure 1. Typical patterns of MRI changes in the sacroiliac joints in axial spondyloarthritis; *courtesy of Denis Poddubnyy, MD, PhD, MSc (Epi)*.

Subchondral bone marrow oedema is observed in the middle part of the cartilaginous compartment of the right sacroiliac joint, indicated by arrows on the T2-weighted sequence with fat suppression (T2 FS). This is accompanied by erosions, indicated by arrowheads on the T1-weighted sequence and the erosion-sensitive T1-weighted fat supressed gradient echo sequence (T1 FS GRE). Additionally, backfill is noted, shown by a thin arrow on T1, along with fat lesions in the bone marrow, indicated by a thick arrow on T1.

Furthermore, the ASAS has recently emphasized the need for optimal communication between rheumatologists and radiologists. They have defined a set of relevant clinical information that should be provided to the radiologist when requesting imaging for patients with suspected axSpA. This information includes the presence of mechanical stress factors, HLA-B27 status, and key clinical features to aid in accurate interpretation.[13]

Likewise, radiologists are encouraged to use structured reporting for sacroiliac joint images. They should note the presence or absence of active inflammation (BME on MRI) and structural lesions (erosions, fat metaplasia, sclerosis, ankylosis). Additionally, they should provide an overall impression of whether the findings are suggestive of axSpA or more consistent with alternative diagnoses.[14]

The strength of MRI is its ability to facilitate early diagnosis. A patient with only a few months of inflammatory back pain can already show definite sacroiliitis on MRI, even though X-rays might remain normal for years. MRI evidence of sacroiliitis, such as active lesions, especially if paired with structural lesions like small erosions, greatly increases the probability of axSpA. Thus, MRI has become the key

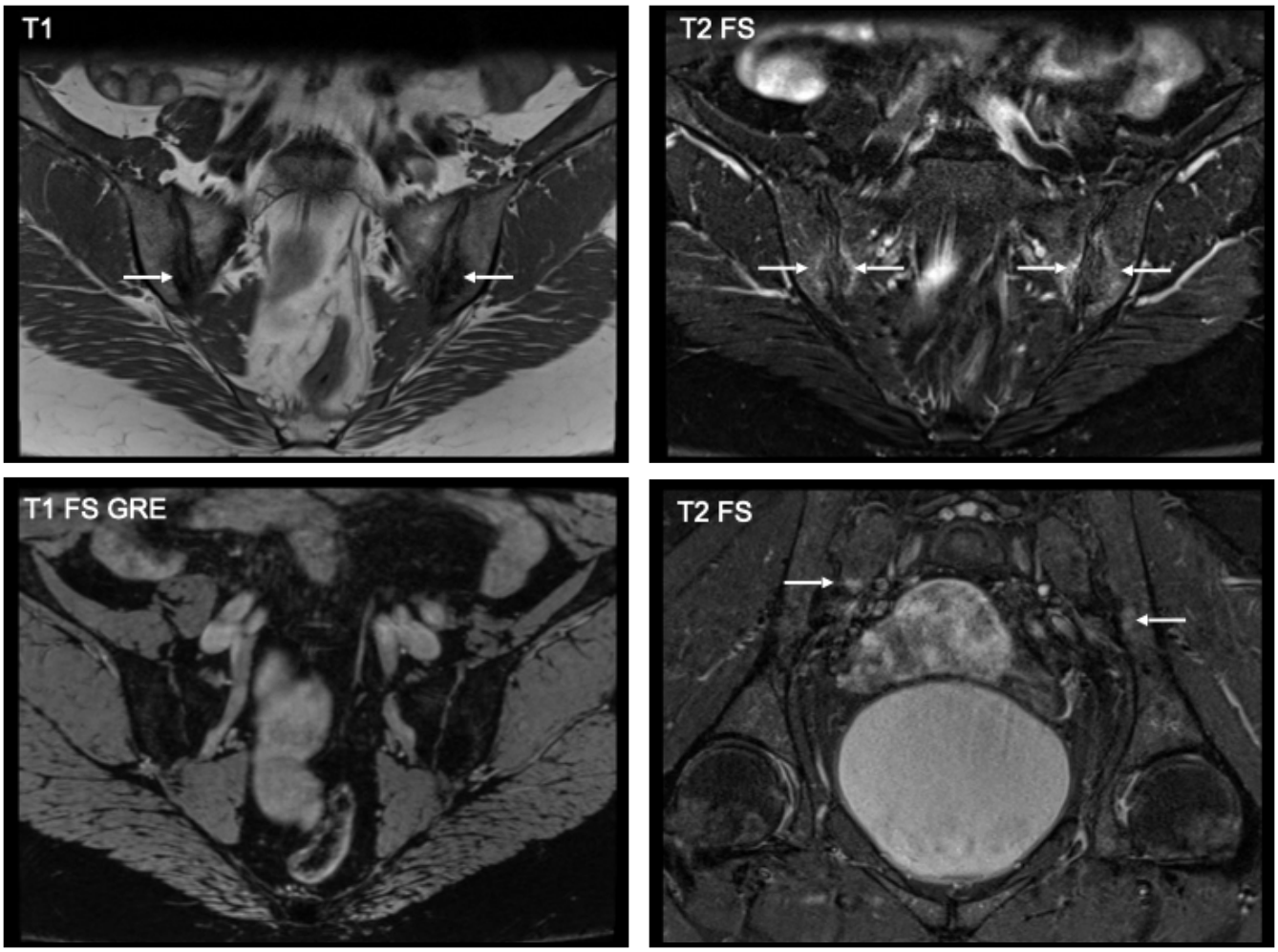

Figure 2. Typical patterns of MRI changes in the sacroiliac joints in osteitis condensans; *courtesy of Denis Poddubnyy, MD, PhD, MSc (Epi)*.

The pattern of mechanically induced changes includes bone marrow oedema in the ventral part of both sacroiliac joints, indicated by arrows on the T2-weighted sequence with fat suppression (T2 FS). This is accompanied by sclerosis, indicated by arrows on the T1-weighted sequence and the erosion-sensitive T1 FS GRE sequence. Of note, there is no evidence of erosive damage.

to identifying non-radiographic axSpA. Additionally, MRI is useful in difficult cases (e.g., young patients with persistent symptoms but normal X-rays,) as it can help re-classify these patients as having axSpA if the findings are positive.

Despite its benefits, MRI has challenges and pitfalls. The specificity of MRI changes, particularly BME, is limited. Mechanical stress on the sacroiliac joints can also produce BME lesions that mimic inflammation. Healthy athletes, postpartum women, and individuals with heavy physical workloads have been found to exhibit sacroiliac joint BME on MRI in the absence of axSpA.[15,16] Typically, these mechanical lesions occur at predictable locations (known as "mechanical load zones") in the sacroiliac joint. These zones include the anterior-inferior (ventrocaudal) corners of the joint and areas adjacent to the ligamentous part of the joint. Furthermore, mechanically induced lesions are not associated with erosive damage, backfill, or ankylosis, which differentiates them from axSpA-compatible lesions. Therefore, when interpreting MRI for suspected axSpA, it is important to look for the coexistence of active inflammation with structural changes, such as erosions or backfill or ankylosis, to confirm the true inflammatory nature of the lesions.

One of the most important differential diagnoses for axSpA is OCI.[17] OCI is a benign condition often observed in women, classically

postpartum, and is considered a prototype disease with mechanically induced changes in sacroiliac joints. On pelvic X-rays, OCI appears as triangular areas of sclerosis on the iliac side of the sacroiliac joints, usually bilateral and symmetric. On MRI, OCI can confuse matters by also displaying subchondral BME, as shown in **Figure 2**. In fact, studies have demonstrated that OCI can present with BME in the sacroiliac joints, sometimes quite extensively. However, the key distinguishing MRI features are the predominant localization of edema in the ventral mechanical load zone and the virtual absence of erosions.

Computed Tomography

Computed tomography (CT) provides exquisite bone detail and is considered the gold standard for visualizing structural changes in the sacroiliac joints. CT can confirm the presence of erosions and ankylosis with far greater sensitivity and specificity than X-rays.[18] Traditionally, CT has not been used routinely in axSpA diagnosis because of the high radiation dose a standard pelvic CT imparts, which is significantly higher than that of X-rays or MRI. However, recent advances in low-dose CT techniques and protocols have significantly reduced radiation exposure while preserving diagnostic yield. Modern low-dose CT of the sacroiliac joints can be performed with a radiation dose comparable to that of a set of X-rays, making it a feasible option for imaging these joints. Studies have shown that low-dose CT is more sensitive than X-rays for detecting sacroiliac erosions and offers excellent reliability, as the 3D detail of CT eliminates the projectional ambiguities of X-rays. For example, small erosions or posterior joint fusions that are not visible on X-rays can be readily identified on CT.

Therefore, CT could be used when MRI is contraindicated, such as in pacemaker patients, or when MRI is unavailable. CT can also be a problem-solver when MRI and X-ray findings conflict. For instance, if a patient has suggestive MRI changes, but normal X-rays, a CT scan can verify the presence of subtle erosions. Despite these advantages, CT is limited to showing chronic changes and does not reveal active inflammation. In addition, the availability of low-dose CT protocols might be limited. Thus, while CT is a valuable adjunct in difficult cases, current recommendations place it as a second-line option.

Future Directions

The landscape of imaging in axSpA continues to evolve, with ongoing efforts to improve diagnostic precision and reduce errors. One key direction is education and training, as the increased use of MRI has made it clear that accurate interpretation requires specific expertise. Misinterpretation of sacroiliac joint MRIs has contributed to overdiagnosis. To address this issue, rheumatology and radiology communities are emphasizing training in axSpA imaging. The ASAS group has developed an interactive online case library featuring MRI examples that span the spectrum of axSpA and its mimics. Clinicians can use this resource to hone their interpretative skills, with cases that include classic active sacroiliitis, OCI, degenerative joints, and more. This resource is available **here**. Such educational tools, along with workshops and courses on MRI reading, aim to standardize the identification of positive MRI findings for axSpA.

Another promising avenue is the use of artificial intelligence (AI) in imaging analysis. AI algorithms, particularly deep learning models, are being developed to detect sacroiliitis on radiographs and MRIs.[19,20] In the future, a trained algorithm might assist radiologists by flagging suspicious lesions or even quantifying inflammation. AI could also help reduce inter-reader variability, providing more consistent interpretations. While these tools are still in the research stages, they may eventually integrate into clinical practice as decision support systems.

Additionally, improvements in imaging technology itself are on the horizon.

Conclusion

In conclusion, imaging in axSpA is a dynamic field where improvements in technology, technique, and training are converging. For clinicians today, the focus should be on using the available imaging tools wisely: adhering to recommended approaches, being aware of pitfalls, and seeking expert input when in doubt. By doing so, rheumatologists can diagnose axSpA at the earliest appropriate time and thereby initiate therapy for those who need it while sparing those who do not. Ongoing research and innovation promise to make this balance easier to achieve, moving us toward an era of even more precise and personalized care in axSpA.

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