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MRI Analogue Signs in the Imaging of the Spine and Sacroiliac Joints in Patients with Ankylosing Spondylitis ……..the Many Faces

Medical Science

KEYWORDS : Ankylosing spondylitis , MRI, spine , sacroiliac joints , early detection , sensitive

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ABSTRACT

Ankylosing spondylitis is an archetype of seronegative spondyloarthropathies (SpA).The spine and the sacroiliac joints are the primary targets of this chronic idiopathic inflammatory arthritis. MRI is the most sensitive technique in the detection of axial skeletal involvement, permitting earlier diagnosis. Assessment of structural changes in ankylosing spondylitis (AS) is essential for diagnosis, management (disease activity) and outcome. MRI of the sacroiliac joints has been shown to be much sensitive and superior compared to plain radiography in depicting sacroiliitis and shown to be of paramount importance in the earliest detection of active sacroiliitis.

INTRODUCTION

Ankylosing spondylitis is an archetype of the seronegative spondyloarthropathies (SpA) [1], and is a chronic, idiopathic, inflammatory arthritis with a propensity for affection of the axial skeleton. This group of arthritides is characterised by specific skeletal imaging findings, the presence of the HLA-B27 gene and by the absence of rheumatoid factor or nodules. These spondylo-arthropathies can be divided into 5 major groups: (i) ankylosing spondylitis, (ii) reactive arthritis/Reiter's syndrome, (iii) arthritis associated with inflammatory bowel disease, (iv) psoriatic arthritis and (v) undifferentiated spondylo-arthropathy [1,2]. The clinical presentation of SpA is heterogeneous, and no single shared distinguishing feature exists for the conditions comprising SpA; in daily practice, diagnosis is usually made on the basis of a combination of symptoms, the findings of physical examination, imaging and laboratory investigations. Individuals with the HLA-B27 antigen have a 20 fold greater risk of developing spondyloarthritis [3]. AS affects both men and women but is most frequently seen in men. The male to female ratio of ankylosing spondylitis is 3:1 [4]. The disease usually starts between the second and the fourth decades of life and is rarely found after the age of 40 years. The most important locations in AS are the sacroiliac joints and the spine. Involvement of the sacroiliac joints is a hallmark of ankylosing spondylitis [5-7]. The definite diagnosis of ankylosing spondylitis requires imaging evidence of sacroiliitis, which is defined as erosions, subchondral sclerosis, and irregular joint spaces and clinical features, including inflammatory back pain [5]. Conventional radiographs remain the most widely accepted and available screening method for ankylosing spondylitis; however, radiographs often show normal findings during the early stages of the disease, and several years may be required for sacroiliitis to become apparent on radiography [7-9].

The sacroiliitis grading system associated with the modified New York criteria is as follows:

-Grade 0: normal findings.
-Grade 1: suspicious changes.
-Grade 2: minimum abnormality, defined as small localized areas with erosion or sclerosis without alteration in the joint width.
-Grade 3: unequivocal abnormality (severe erosions, pseudo-widening of the joint space
and partial ankylosis).
-Grade 4: complete ankylosis.

Modified New York Criteria for AS

Clinical Criteria

- Low back pain ≥ 3 months, improved by exercise and not relieved by rest
- Limitation of movement of lumbar spine in sagittal and frontal planes
- Limitation of chest expansion (relative to normal values corrected for age and sex)

Radiological criteria

- Bilateral grade 2-4 sacroiliitis OR
- Unilateral 3-4 sacroiliitis

Requirements for definite diagnosis of ankylosing spondylitis: bilateral grade 2-4 or unilateral grade 3-4 sacroiliitis radiologically AND at least one of the clinical criteria.

MRI is the most sensitive techniques in the detection of axial skeletal involvement, permitting earlier diagnosis. Assessment of structural changes in ankylosing spondylitis (AS) is essential for diagnosis, management (disease activity) and outcome. MRI of the sacroiliac joints has been shown to be much superior and sensitive as compared to plain radiography in depicting sacroiliitis and shown to be useful in the early detection of active sacroiliitis.

Spinal changes associated with spondyloarthritis are florid anterior spondylitis (Romanus lesion), florid discitis (Andersson lesion), ankylosis, insufficiency fractures of the ankylosed spine, syndesmophytes, arthritis of the apophyseal and costovertebral joints and enthesitis of the interspinal ligaments. **Aims and objectives** :The purposes of our study were to evaluate MRI of the spine and sacroiliac joints in patients with ankylosing spondylitis and to determine

whether MRI findings of edema, erosion, sclerosis and fatty marrow changes were correlated with clinical features and measures of disease activity. To provide an educational and pictorial review of ankylosing spondylitis (AS) based on MRI features.

MATERIALS AND METHODS: This is a cross sectional prospective case series study. From the period of January 2014 to December 2015, a total of 40 patients (32 males and 8 females) with low back pain with clinical signs and suspicion /radiographic suspicion of sacroilitis were recruited for dedicated MRI evaluation of lumbosacral spine at Deptt of Radiodiagnosis GMC and associated Dr. STH Haldwani, Nainital (U.K.) India. **Inclusion criteria:** All patients who conformed to the modified New York criteria /all patients with HLA B27 positivity and low back pain were included in the study. All patients with seropositivity for RA factor and other established causes of sacroilitis or infective etiology like septic arthritis were excluded from the study. MR imaging protocol useful for evaluating the spinal column comprises of a sagittal T1 and T2 -weighted turbo spin-echo sequence and a coronal short inversion time and recovery (STIR) sequence. Coronal sections short inversion time and recovery (STIR) sequence of the lumbar spine including the sacroiliac joints were particularly useful for early detection and screening of sacroilitis. Additional detailed axial evaluation of the sacroiliac joints both T1w and T2w spin echo sequences were undertaken when the coronal sections showed abnormality of the sacroiliac joints.

OBSERVATIONS AND RESULTS:
In our study total 40 patients with confirmed ankylosing spondylitis (On the basis of modified New York criteria) are included. Out of these 34 were males and 6 were females. The male to female radio was 5.6:1. The youngest patient was 16 years old and oldest patient was 64 with mean age was 32 years. Most of the patients were young adult males between 20-30years. Out of 40 patients 32 patients (80%) had the HLA-B*27 positive. Of these, 28 were male (87.5%) and 4 were female (12.5%), the male-to-female ratio being 7:1, while in those patients who did not have the HLA-B*27 allele the ratio was 3: 1. The main presenting symptom in most patients was chronic back pain which was not relieved by rest and improved by non-steroidal anti-inflammatory drugs, that is inflammatory back pain which was present in 37 patients (92.5%).

Sacroiliac joint involvement
Out of 40 patients , 36(90%) patients had abnormality in sacroiliac (SI) joints. Of these 34 patients had bilateral symmetrical involvement and 2 patients had unilateral sacroilitis. Out of 36 patients ;18 patients had active disease with early stage changes, 10 patients had combination of chronic changes **mixed with signs of disease activity and 8 patients had advanced chronic changes. The sacroiliac joints were predominantly involved in the inferior ileal aspects followed by inferior ileal + inferior sacral regions of the sacroiliac joint. The changes on MRI were deemed to be early and acute if marrow edema ,erosions / joint widening were present. Changes were surmised to be chronic if subchondral sclerosis and fatty marrow replacement of the subarticular regions were present on either side of the sacroiliac joint.**

TABLE-1 (sacroiliac joint involvement)

Sacroilitis	36 (bilateral-34, unilateral-2)	90%
Active disease with early changes	18	50%
Combination of chronic changes with active disease	10	27.7%
Chronic disease	8	22.2%

Spinal features:
Spondylitis was seen in 26 (65%) patients mostly in thoracolumbar region (more commonly involving anterosuperior and anteroinferior vertebral end plate, less frequently posterior end plate), followed by upper thoracic and cervical region. Spondylodiscitis was seen in 8 patients (20%). Syndesmophytes and ankylosis was seen in 9 patients (22.5%).

TABLE-2(spinal features and extraspinal joint involvement)

Spondylitis (Romanus lesions)	Present in 26 Thoracolumber-20, upper thoracic-2, cervical-4	65%
Spondylodiscitis(Anderson lesions)	8	20%
Syndesmophytes & ankylosis	9	22.5%
Facet arthopathy	6	15%
Costovertebral joint	7	17.5%
Insufficiency fracture	3	7.5%
Atlanto-occipital joint	1	2.5%
Hip joint	1	2.5%

Discussion
MR Imaging Protocol
MRI provides multiplanar imaging with better soft-tissue contrast and allows assessment of all of the structures involved in musculoskeletal diseases. According to the ASAS classification criteria, active inflammatory lesions are best visualized on fat-suppressed T2-weighted or high-resolution STIR images (512-pixel matrix, 3- to 4-mm slice thickness). T2-weighted fat suppressed (T2wFS) and short tau inversion recovery (STIR) images depict water with a high signal intensity. These are well-suited for detection of oedematous tissue/fluid located in areas e.g. bone marrow oedema. Bone marrow abnormalities in both sacroiliac joints and spine are detected almost equally well with the STIR and contrast-enhanced T1w FS sequences in patients with SpA, so contrast injection is generally not needed [Baraliakos *et al*. 2005; Madsen *et al*. 2010]. Structural damage and chronic lesions, such as fatty degeneration and erosions, are best visualized on T1-weighted images [10]. For assessment of the sacroiliac joints, coronal and axial oblique T1- and T2-weighted sequences with fat suppression or STIR sequences are recommended. An efficient spinal imaging protocol comprises sagittal T1- and fat-suppressed T2-weighted sequences or high-resolution STIR sequences. Axial slices can be useful for assessment of the posterior spinal elements, and coronal slices may be best for assessment of the costovertebral, costotransverse, and facet joints.

Sacroiliac Joint Involvement
Involvement of the sacroiliac joints is a hallmark of ankylosing spondylitis [5]. Sacroiliitis is usually the first manifestation and is characteristically bilateral and symmetrical in AS [Berens, 1971; Resnick *et al*. 1977]. Early radiographic findings predominate on the iliac side of the cartilage compartment with erosion of subchondral bone causing loss of definition of the articular surfaces usually accompanied by variable degrees of adjacent osteoporosis and surrounding reactive sclerosis. The early inflammatory changes of the joint are best detected with MRI. Bone edema is associated with increased signal in fat-saturated fast spin-echo T2-weighted or STIR sequences. The edema is located periarticularly or on subchondral bone surfaces of the sacroiliac joints. Bone marrow edema is typically symmetric and ap-

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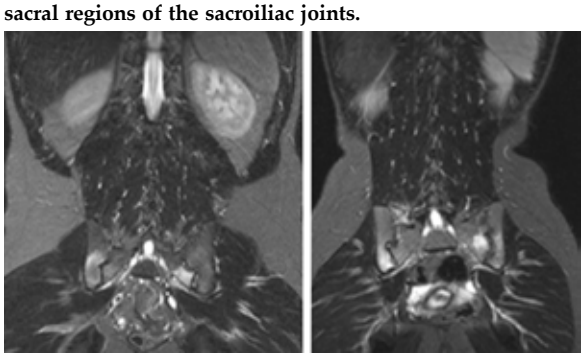
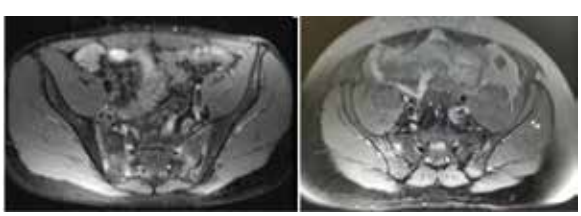
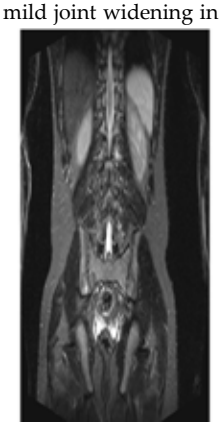
pears most commonly in the lower and posterior thirds of the joints [11]. Among the structural lesions that are well visualized on T1w SE sequence, erosion of the SIJ is highly specific for AS. Erosions are identified on T1w SE MRI image by a break in the cortical bone signal together with a change in the signal for adjacent bone marrow [12]. New bone formation in the SIJ is often easily identified as bright areas on T1SE MRI images, representing bone marrow fat. The final stage of sacroiliac involvement consists of subchondral sclerosis followed by fusion of the joint with ankylosis. At this stage, MRI may show sclerotic changes, hypointense on T1- and T2-weighted sequences, and fusion of the articulation [13]. However, in cases in which radiographs and MRI are equivocal, CT may be the best imaging technique for depicting subchondral sclerosis and sacroiliac ankylosis [14]. In our study 90% patients had abnormalities in the sacroiliac (SI) joints. Of these 85% had bilateral symmetrical involvement and 5% patients had unilateral sacroilitis. **There was predominant inferior ileal followed by inferior ileal + inferior sacral regions of the sacroiliac joints.**



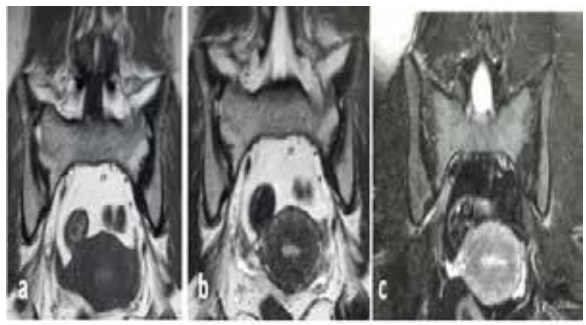
Coronal STIR images showing changes of bilateral acute sacroilitis with subartcular marrow edema (arrows) seen predominantly on the inferior contiguous aspects of the sacro-iliac joints in two different patients of Ankylosing Spondylitis



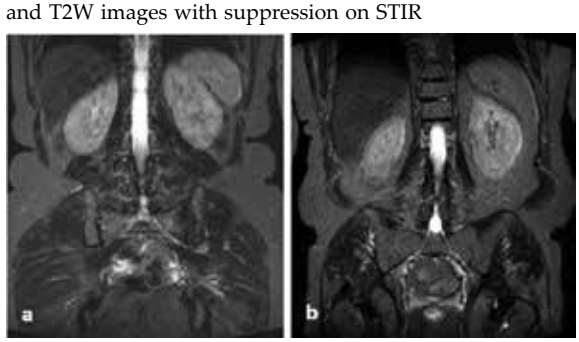
Axial STIR images showing early acute changes of bilateral sacro-ilitis manifested as subarticular bone marrow edema with mild joint widening in two different patients .



Mixed intermediate changes of sacroilitis with admixture of acute and chronic changes manifested as subarticular marrow edema and fatty changes suppressed on the coronal STIR.



Coronal T1W(a), T2W(b) and STIR sequences shows features of chronic sacroilitis seen as hypointensitiy in the subchondral regions (subchondral sclerosis) and fatty marrow reparative changes manifested as hyperintensity on T1W and T2W images with suppression on STIR



Coronal STIR image showing chronic sacroilitis on the left side with pronounced unilateral left sided subchondral sclerosis (a) and advanced bony ankylosis of the bilateral SI joints (b) in known patient of AS.

AXIAL SKELETON

The primary site of pathology in the axial skeletal is the enthesis, where the longitudinal ligaments and the annulus fibrosis collagen merge directly with bone. The osteitis caused by the inflammatory process leads to bone edema and subsequently to ossification of the ligaments. The synovial joints are also affected by inflammation, with erosions followed by bone production and ankylosis.

Disease involvement of the spine typically starts at the thoracolumbar or lumbosacral junctions. As the disease progresses, the remainder of the thoracic and lumbar spine as well as the cervical spine become involved.

Spondylitis

The changes occur exactly at the site of attachment of the anulus fibrosus to the vertebral endplate. Because such a junction of bone and ligamentous structure is an enthesis by definition, anterior or posterior spondylitis can be regarded as an enthesitis. These changes consist of irregularities and erosions involving the anterior and/ posterior edges of the vertebral endplates and are also known as Romanus lesions. In active disease, these lesions are depicted as reduced signal intensity of the rim of the endplate on T1-weighted MR images and as increased signal intensity on STIR images and represents bone marrow edema or osteitis [15]. Later in the disease course, the epiphyseal ring can appear hyperintense on T1-weighted images. Such hyperintense lesions both on T1W and T2W images represent circumscribed areas of postinflammatory fatty bone marrow degeneration.

Sagittal T2-weighted images (a & b) and Sagittal T1W image (c) shows florid hyperintense foci at various levels along the anterosuperior and anteroinferior end plates representing fatty marrow changes (Romanus lesions).Similar foci are also noted posteriorly at few levels.

Spondylodiscitis

Inflammatory involvement of the intervertebral disks by spondyloarthritis is known as spondylodiskitis or Andersson lesion. Spondylodiskitis is characterized by high signal intensity at the cortical plates adjacent to intervertebral disks on STIR images and fat-suppressed contrast-enhanced T1-weighted images.

Sagittal T2W MR images showing advanced changes of florid discitis (Anderson lesion) in known patients of Ankylosing Spondylitis (a.) .TI W contrast enhanced images (b) show high signal intensity along the end plates suggestive of discitis in a known patient of Ankylosing Spondylitis.

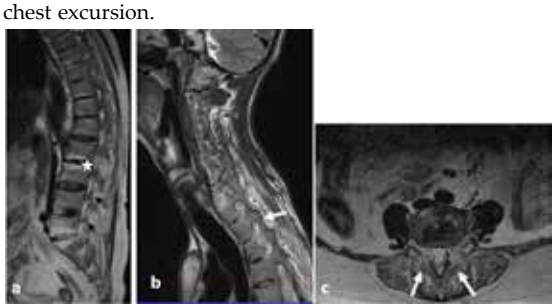
Enthesopahies:

Involvement of ligaments in spondyloarthritis is most extrusively seen when the interspinal ligaments and the supraspinal ligaments are affected. Ligamentous involvement is characterized by increased signal intensity on either STIR or T2W images. Classically, changes are initially noted at the thoraco-lumbar and lumbo-sacral junctions.Spinal extension to the midlumbar, as well as the upper thoracic and cervical vertebrae, occurs with disease progression but may be arrested at any stage (Resnick 2002c).During the course of AS, the spine may present an admixture of destructive changes as well as features due to bone proliferation and ankylosis.

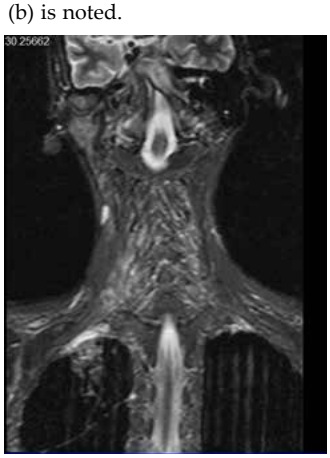
Syndesmophytes

In the spine, the early stages of spondylitis develop as small erosions at the corners of the vertebral bodies. This is followed by the much acclaimed hallmark of Ankylosing Spondylitis that is syndesmophyte formation which is characterized by the ossification of the outer fibers of the annulus fibrosis of the intervertebral disk. This causes the corners of one vertebra to bridge to another which are delicate and fine in nature. The complete fusion of the vertebral bodies by syndesmophytes and other related ossified ligaments produces the so-called bamboo spine.The syndesmophytes typically associated with AS are seen as bony outgrowths of the anterior vertebral edges. MR imaging has its role in depicting florid anterior spondylitis, which is the stage preceding the development of syndesmophytes [19]. Ankylosis involves the vertebral edges or centre with bony extension through the disc. Vertebral ankylosis is clearly depicted by both conventional radiography and MRI as it a late manifestation of advanced changes in ankylosing spondyloarthropathy.

The zygapophyseal joints (facet joints), costovertebral joints, and costotransverse joints are also involved in ankylosing spondylitis. In facet joint arthritis any facet joint from C2 to S1 can be affected. Any costovertebral joint from T1 to T12 can be affected. Arthritis involving the above-mentioned joints is characterized by joint effusion, synovitis, erosions, and bone marrow edema. Affected joints may undergo ankylosis at late stages and thus impair chest excursion.



Sagittal (a and b) and axial T2W images (c) showing facet joint arthritis and fusion (arrows).Additionally Andersons lesions are seen (Image a asterix) and vertebral body fusion (b) is noted.



Costovertebral arthritis manifested as marrow edema(white arrow) on the STIR sequence with upper lobe fibrosis (asterix) in a known case of Ankylosing Spondylitis .

Insufficiency fractures : The non-inflammatory lesion corresponds to an insufficiency fracture in an ankylosed spine. Insufficiency fracture occurs at the level of the disc (transdiscal) or at the level of the vertebral body (transvertebral). Older insufficiency fractures appear hyperintense on T1-weighted images, whereas fresh fractures have a low signal intensity.

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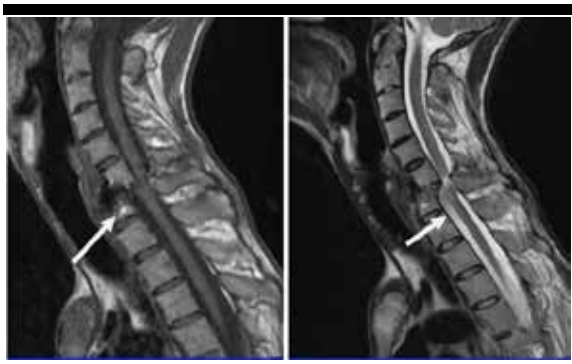

Sagital T1W and T2W MR images showing an insufficiency fracture at C6-C7 level associated with squaring of vertebrae in a known patient of Ankylosing Spondylitis.Associated compressive changes on the spinal cord noted secondary to retropulsion of the vertebral body.

APPENDICULAR SKELETON

In the appendicular skeleton the hips, shoulders, and knees are the most common sites of involvement, typically bilateral and symmetric. When the hips are involved, there is axial migration, concentric joint space narrowing, cuff like femoral osteophytes, acetabular protrusion, and eventually ankylosis .At the shoulder, in addition to typical joint space narrowing of the acromioclavicular and glenohumeral joints, a hatchet deformity can form on the humeral head. This defect is a large erosion at the greater tuberosity. At the knee, the radiographic manifestations of involvement are tricompartmental joint space narrowing and erosions. The small joints of the hands and feet as well as the wrists are affected less frequently than large joints. The findings include asymmetric involvement, small erosions, and osseous proliferative changes.

Coronal STIR sequence shows left sided hip joint involvement in a patient with ankylosing spondylitis. Marked concentric joint space narrowing with femoral osteophytes and enthesitis manifested as hyperintense foci are noted.

Complications

The osteoporotic rigid, fused spine of chronic AS is susceptible to fracture from even minimal trauma. Sometimes fractures may occur without known injury [17]. Such fractures are typically horizontal, through the disc or vertebral body, and involve all 3 columns. Spinal stenosis is another potential complication caused by ossification of the posterior longitudinal ligament and ligamentum flavum. Dural ectasia with arachnoiditis and cauda equina syndrome have been reported in patients with longstanding disease [18].

CONCLUSION : The early diagnosis of Ankylosing Spondylitis is of unsurmountable importance .We conclude that MRI is the most sensitive imaging modality to detect the earliest changes of this chronic progressively disabling spondyloarthropathy. This is especially important in the light of the fact that early detection of this chronic spondyloarthropathy greatly aids in assessing the disease activity and treatment stategy and may halt the progression of the disease activity by aggressive treatment alternatives.

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