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Comparative Study of Imaging of Sacroiliitis by CT and MRI-Scan with Power Doppler Ultrasound in Spondyloarthritis

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Abstract: ***Introduction: Spondyloarthritides are the group of inflammatory disorders of unknown cause and these are often associated with human leukocyte antigen (HLA)-B27. In all these cases, the presence of sacroiliitis is considered as the hallmark of AxSpA and ankylosing spondylitis, but it take longer time to appreciate the radiological features of either sacroiliac or spinal inflammation. As everyone aware, early diagnosis and prompt initiation of non- biological or biological DMARD can arrest or prevent or delay the expected non remediable complications of SpA/AS. Mostly, clinicians are dependent on either MRI or CT scan for the diagnosis of spondyloarthritis, but it has its own merits and demerits. Thus, in our study, we have used low cost, everywhere and easily available power doppler ultrasound in early diagnosis of spondyloarthritis and systematically compared with MRI and CT- pelvis with an age matched healthy controls. Aim of the Study: To diagnose Spondyloarthritis before radiological erosions. To compare Power Doppler imaging of sacroiliitis with conventional CT and MRI scan of Pelvis. Objectives of the Study: Across the world, SpA/ AS is a significant burdens to young, reproductive and the potential earning population. If undiagnosed or inadequately treated, it not only causes continuous pain, stiffness and fatigue and it can lead to erosions, narrowing of joint space and complete ankylosis of spine and pelvic joints with resultant loss of nobilities and functions. To accept the truth that, approximately from the onset of symptoms to diagnosis of SpA/ AS is about 8 to 11 years. Added to that, SI joint is not easily palpated or manipulated and investigations like X-Rays, MRI, CAT Scans, Bone Scans are reported as normal if the observers are not having adequate knowledge in where and what to look for. Thus, miserably, patients may miss early diagnosis and appropriate initiation of treatment for SpA. Conventional x-ray pelvis are not suitable for picking up early synovial inflammation and erosions, hence we depends on the MRI and CT-SCAN, which are not easily available to everyone and expensive and risk of ionizing radiations, respectively. For a decade, power colour Doppler ultrasound is considered as extended hand of Rheumatologists and declared as the "poor man's MRI" and it remarkably help us in early diagnosis of synovitis, enthesitis, tenosynovitis, synovial effusions and proliferation, erosions of cartilage, bone joint margin, enchondral bone erosion, cyst, osteopenia and in crystal deposition diseases. Materials and Methods: In this prospective case control study from January 2007 to February 2009, one hundred and eight patients (84 males, 24 females) were included from those who have presented with signs and symptoms and clinical features suggestive of spondyloarthritis to the Department of Rheumatology, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai. 3. Thirty five age and sex matched asymptomatic controls were selected from patient's attender's who were not a first or second degree relatives. All patients were asked for a detailed history which includes the age of onset of disease, symptoms of disease, duration of the disease and relevant symptoms of secondary AS. A detailed general examination, height and weight assessment was done and usual laboratory tests and all disease activity index scores were calculated. Results: One hundred and eight patients were recruited in this study. Among these, 84 were males and 24 were females (3.5:1). The mean age of patients was 30 ± 11.10 years (range from 16 to 59 years). The average disease duration was 3.46 ± 5.23 years (range from one month to 23 years). There were 35 age and sex matched controls (27 males, 8 females, mean age 30 ± 11). Conclusion : Both MRI and power Doppler ultrasound are 100% sensitive in identifying sacroiliitis. CT-scan is a useful modality of imaging in sacroiliitis but it is not suitable for identifying the early synovial inflammation and erosions and it also has the risk of ionizing radiation. The poor man MRI, the Power Doppler ultrasound becomes the potent choice of tool for the early diagnosis of spondyloarthritis.***

1. Introduction

Spondyloarthritides are the group of chronic inflammatory disorders of unknown cause, often associated with human leukocyte antigen (HLA)-B27 and it usually share common clinical, radiological, and genetic features that are clearly distinct from other inflammatory rheumatic diseases.(1) Wright and Moll introduced the concept initially using the term seronegative polyarthritis (Wright and Moll 1976), which was eventually changed to spondyloarthropathy but in 2002, however, the Assessment in Ankylosing Spondylitis (ASAS) international working group replaced spondyloarthropathy with spondyloarthritis to stress the importance that, these are inflammatory diseases. (2) The term relates not only to the spine and the peripheral joints but also refers to other structures, which are involved in the disease process (the enthesis, the eye, the gut) (Franaois et al. 1995; Braun and Sieper 1996). The adjective, seronegative is useless as the absence of the rheumatoid factor is the primary characteristics of spondyloarthritis and rather the term is confusing, thus, the term sero-negative or sero-positive exclusively are being used in relation to HIV infection.

Sacroiliac joint inflammation is the radiographic hallmark of AxSpA/AS, but by conventional X-rays, usually it take longer time appreciate this radiological manifestations of sacroiliitis. Although, MRI is superior to CT- pelvis in picking up early diagnosis of sacroiliitis, but these are having its own merits and demerits, thus, everywhere and easily available and the low cost modality, the power doppler US (ultrasound) are being tried in our study in identifying sacroiliitis and taken steps to case to case comparisons are being done with MRI and CT- pelvis.

1.1 General Considerations

Axial skeletal involvement predominates in ankylosing spondylitis, which invariably involves the sacroiliac joints and typically presents with the insidious onset of inflammatory low back pain during late adolescence or early adulthood. Onset of symptoms after the age of 40 is uncommon. Although the disease rarely begins after the age of 40 years, it is not uncommon for the diagnosis to be made only years later, well after that age. [3]

Although environmental factors are important in the development of ankylosing spondylitis, the environmental triggers appear to be ubiquitous, and genetic background is the major determinant of susceptibility to ankylosing spondylitis. The only known susceptibility gene, HLA-B27, confers a relative risk of close to 100 but probably accounts for only 10–50% of the overall genetic risk for ankylosing spondylitis.

The disease course varies considerably, ranging from mild disease with little impact on functional status to severe disease that produces substantial disability. The extent of spinal involvement is a major determinant of the impact of the disease on functional status. Unfortunately, there are no reliable predictors of long-term functional outcome early in the disease course. On average, 9 years elapse between the onset of symptoms and the diagnosis of ankylosing spondylitis. Several factors contribute to this delay: (1) The onset of low back symptoms is insidious, and patients may delay seeking medical attention. (2) Mechanical low back pain is prevalent, and patients with ankylosing spondylitis are often misdiagnosed as having that disorder. (3) It can be difficult to diagnose ankylosing spondylitis in its early stages. Radiographic evidence of bilateral sacroiliitis is most definitive finding but, usually takes several years to develop it. (4) There are no diagnostic criteria for the disease. The widely used modified New York Criteria for the classification of ankylosing spondylitis require unequivocal radiographic evidence of sacroiliitis and have limited sensitivity for early disease.

SpA/ AS can be accompanied by extraskeletal manifestations like, acute anterior uveitis, aortic incompetence, cardiac conduction defects, and fibrosis of the upper lobes of the lung, neurologic involvement, or renal (secondary) amyloidosis.

Around the world, SpA/ AS can cause significant pain, disabilities in day to today life, hamper or reduce the psychosexual activities and lead to big social burdens to potential earning group of population. Frankly speaking, few decades ago, these group of AxSpA and AS was considered as non costly disease, but in true sense, now it become costly, because of the availability of various targeted treatment with biological agents like anti–tumor necrosis factor (TNF) and across the world, it has given meaningful life to quite large population Spondyloarthritides cases and redefined the entire therapeutic approaches, based on early diagnosis and probably before complete ankylosis spine and pelvis.

Classification of Spondyloarthropathies

- Ankylosing spondylitis
- Reiter's syndrome or reactive arthritis
- Arthropathy of inflammatory bowel disease (Crohn's, Ulcerative colitis
- Psoriatic arthritis
- Undifferentiated spondyloarthropathies
- Juvenile chronic arthritis and Juvenile onset ankylosing spondylitis

Clinical characteristic of spondyloarthropathies

- Typical pattern of peripheral arthritis –predominantly of lower limb, asymmetric
- Tendency toward radiographic sacroiliitis
- Presence of extra articular features (e.g., anterior uveitis)
- Significant familial aggregation
- Association with HLA-B27
- Absence of rheumatoid factor
- Absence of subcutaneous nodules and other extra articular features of rheumatoid arthritis

Classification Criteria for Spondyloarthropathies [4]

We have the European Spondyloarthropathy Study Group (ESSG) criteria, though clearly not intended for diagnostic purposes, and might be useful to identify atypical and undifferentiated forms of spondyloarthropathies. This set of criteria performed quite well in patients with different sociocultural and geographic characteristics resulted in a sensitivity of 86% and a specificity of 87%.

- Inflammatory spinal pain or
- Synovitis (asymmetric, predominantly in lower limbs) and any one of the following (sensitivity, 77%; specificity, 89):
- Positive family history
- Psoriasis
- Inflammatory bowel disease
- Alternate buttock pain
- Enthesopathy

Adding sacroiliitis, sensitivity, 86%; specificity, 87%

The diagnosis of AS is based on clinical features. The disease is "primary" or "idiopathic" if no associated disorder is present; it is "secondary" if the disease is associated with psoriasis or chronic inflammatory bowel disease.

Modified New York, 1984 criteria [5]

- Low back pain of at least 3 months' duration improved by exercise and not relieved by rest
- Limitation of lumbar spine motion in sagittal and frontal planes
- Chest expansion decreased relative to normal values for age and sex
- Bilateral sacroiliitis grade 2 to 4
- Unilateral sacroiliitis grade 3 or 4

Definite Ankylosing Spondylitis

Unilateral grade 3 or 4, or bilateral grade 2 to 4 sacroiliitis and any clinical criterion

Epidemiology [6]

The prevalence of AS are closely parallels the frequency of HLA-B27. This holds true for those B27 subtypes that are

associated with the disease, but it is not true for populations in which certain subtypes that lack an association with AS occur rather frequently, such as the Indonesian population. [7,8]

Among whites, the estimated prevalence rate of AS as defined by the modified New York criteria ranges from 68 per 100,000 populations older than 20 years in the Netherlands to 197 per 100,000 in the United States.[9,10,11] The prevalence of clinical AS in France is 150 per 100,000 adults, whereas in Norway it is 210 per 100,000 adults.[12,13] The prevalence of the disease in Finland is similar, with a figure of 150 per 100,000 people.[14] Higher prevalence rates have been reported in central Europe.

An epidemiologic study from Berlin reported a prevalence figure of 0.86%.[15] In general population, AS is likely to develop in about 1% to 2% of HLA-B27–positive adults who have a disease-associated B27 subtype, although there may be regional or geographic differences. For example, in northern Norway, AS may develop in 6.7% of HLA-B27–positive people.[16]

The disease is much more common among HLA-B27–positive first-degree relatives of HLA-B27–positive AS patients; roughly 10% to 30% of them have signs or symptoms of AS. Presence of family history of AxSpA/AS, is one of the strong risk factor for the disease.

An Indian study has shown that in South India, HLA-B27 is 83% positive [17] while it is positive in 94% of AS patients in North India.[18] HLA-A locus has been associated with uveitis in North India and HLA A2 has been found increased frequency in Pune study.(19) HLA CW2 has been found in 50.9% of AS patients in South India.[17]

Incidence and Prevalence

There is no adequate evidence that the incidence of AS has changed in the last few decades. Clinical features, age of onset, and survival time have remained stable.[20] One study revealed an overall age and gender-adjusted incidence of 7.3 per 100,000 person-years. This U.S. figure compares quite well with the Finnish study, which revealed a stable incidence of 8.7 (95% confidence interval [CI] 6.4 to 11.0) per 100,000 people aged 16 or older. In aggregate, the spondyloarthropathy have a prevalence estimated rate between 0.5% and 1.9%.

Racial Distribution

AS is presents in all parts of the world. Approximately 90% of white patients with AS possess HLA-B27, whereas AS and HLA-B27 are nearly absent (prevalence of B27 < 1%) in African blacks and Japanese. In African Americans, owing to racial admixture with whites, 2% possess B27, but only about 50% of black patients with AS possess B27. Correspondingly, African Americans are affected far less frequently than American whites.

Gender Issues

Clinically, AS is more common in males, with a reported male-female ratio of about 2:1 to 3:1.[21,22] However, extrapolation of studies employing the genetic marker HLA-B27 suggests that, based on radiographs of the sacroiliac joints, prevalence rates are equal in both sexes. Whereas, case study report from Rheumatic Care Centre, Chennai has shown the ratio of 18.7:1.[23]

Disease expression is thought to be different in males and females. A case-control study comparing 35 female patients to 70 male patients as controls showed no differences in spinal symptoms, chest expansion, peripheral arthritis, extra-articular manifestations, or functional outcome. AxSpA/ AS in male, more often has radiographic spinal changes and hip joint involvement whereas spines are involved in female. There is still some controversy, but overall, there are no significant clinical or radiographic differences between women and men with AS. However, on average, the disease seems to be more severe in men.[21,22]

Burden of Disease

Ankylosing Spondylitis is associated with a considerable burden to the patient and to the society. In addition, large proportion of SpA/ AS cases develop spinal osteoporosis, leading to vertebral fractures and dorsal spinal kyphosis and these are further worsened with increasing duration of disease.[24]

Anatomy of Sacroiliac Joints

The sacroiliac joint is the joint between the sacrum, at the base of the spine and the ilium of the pelvis, which are joined by ligaments. It is strong, weight bearing synovial joint with irregular elevations and depressions that produces interlocking of the two joints.

The sacroiliac joint presents a complex two compartment anatomy (Diarthrodial joints). The synovial portion of the sacroiliac joint is vertically oriented (lower 1/3), while the ligamentous (fibrous) portion presents horizontal-oblique orientation (upper 2/3). The normal joint space of the sacroiliac joint measures 2.5–4.0 mm (mean = 3.0 mm). The stability of the SIJ is maintained mainly through a combination of both bony structure and very strong intrinsic and extrinsic ligaments (anterior, posterior sacroiliac ligaments and strong interosseous ligaments). As we age the characteristics of the sacroiliac joint change. The joint's surface remains flat in early life but as we start walking, the joint surfaces develop distinct angular orientations (lose their planar or flat topography.) They also develop an elevated ridge along the ilial surface and a depression along the sacral surface. The ridge and corresponding depression, along with the very strong ligaments, increase the sacroiliac joints' stability and makes dislocations very rare.

The clinical diagnosis of early sacroiliitis is often difficult because of deep location and lack of motion and also, frequently obscured by the overlying soft tissues. For these features radiographic abnormalities are regarded as the most reliable objective indicator of inflammatory spondyloarthropathies

Pathology

The enthesis, the site of attachment of tendon, ligaments, capsule and fascia to bone, is thought to be the primary site of pathology in AS,[30] particularly in the lesions around the pelvis and spine. Enthesitis is associated with prominent edema of the adjacent bone marrow and is often

characterized by erosive lesions that eventually undergo ossification.

Sacroiliitis is usually one of the earliest manifestations of AS, with features of both enthesitis and synovitis. The early lesions consist of subchondral granulation tissue, infiltrates of lymphocytes and macrophages in ligamentous and periosteal zones, and subchondral bone marrow edema. Synovitis follows and may progress to pannus formation with islands of new bone formation. The eroded joint margins are gradually replaced by fibrocartilage regeneration and then by ossification. Ultimately, the joint space gets totally obliterated.

In the spine, early in the process there is inflammatory granulation tissue at the junction of the annulus fibrosus of the disk cartilage and the margin of vertebral bone. The outer annular fibers are eroded and eventually replaced by bone, forming the beginning of a bony syndesmophyte, which then grows by continued enchondral ossification, ultimately bridging the adjacent vertebral bodies. Ascending progression of this process leads to the "bamboo spine" observed radiographically. Other lesions in the spine include diffuse osteoporosis, erosion of vertebral bodies at the disk margin, "squaring" of vertebrae, and inflammation and destruction of the disk-bone border. Inflammatory arthritis of the apophyseal joints is common, with erosion of cartilage by pannus, often followed by bony ankylosis.

Bone mineral density is significantly diminished in the spine and proximal femur early in the course of the disease, before the advent of significant immobilization.

Peripheral arthritis in AS can show synovial hyperplasia, lymphoid infiltration, and pannus formation, but the process lacks the exuberant synovial villi, fibrin deposits, ulcers, and accumulations of plasma cells as seen in rheumatoid arthritis. Central cartilaginous erosions caused by proliferation of subchondral granulation tissue are common in AS but rare in RA.

1.2 Clinical Manifestations

The symptoms of the disease are usually first noticed in late adolescence or early adulthood; the median age in western countries is 23. In 5% of patients, symptoms begin after age 40. The initial symptom is usually dull pain, insidious in onset, felt deep in the lower lumbar or gluteal region, accompanied by low-back morning stiffness of up to a few hours' duration that improves with activity and returns following periods of inactivity. Within a few months of onset, the pain has usually become persistent and bilateral. Frequently, nocturnal exacerbation of pain that forces the patient to rise and move around and at times, they may sleep in sitting posture.

In some patients, bony tenderness (presumably reflecting enthesitis) may accompany back pain or stiffness, while in others it may be the predominant complaint. Common sites include the costosternal junctions, spinous processes, iliac crests, greater trochanters, ischial tuberosities, tibial tubercles, and heels. Occasionally, bony chest pain is the presenting complaint. Arthritis in the hips and shoulders ("root" joints) occurs in 25 to 35% of patients, in many cases early in the disease course. Arthritis of peripheral joints other than the hips and shoulders, usually asymmetric, occurs in up to 30% of patients and can occur at any stage of the disease.

Neck pain and stiffness from involvement of the cervical spine are usually present as late manifestations. Few patients, particularly in late ages can have constitutional symptoms like fatigue, anorexia, fever, weight loss, or night sweats. Most often juvenile onset SpA/AS are being seen in developing countries and among them, at early stages, peripheral arthritis and enthesitis are usually predominate and the axial symptoms are getting supervened at late adolescence.[25]
Initially, physical findings mirror the inflammatory process. The most specific findings involve loss of spinal mobility, with limitation of anterior and lateral flexion and extension of the lumbar spine and of chest expansion. Limitation of motion is usually out of proportion to the degree of bony ankylosis, reflecting muscle spasm secondary to pain and inflammation. Pain in the sacroiliac joints may be elicited either with direct pressure or with maneuvers that stress the joints. In addition, there is commonly tenderness upon palpation at the sites of symptomatic bony tenderness and paraspinous muscle spasm. The modified Schober test is a useful measure of lumbar spine flexion. The patient stands erect, with heels together, and marks are made directly over the spine 5 cm below and 10 cm above the lumbosacral junction (identified by a horizontal line between the posterosuperior iliac spines.) The patient then bends forward maximally, and the distance between the two marks are measured. The distance between the two marks increases by =5 cm in the case of normal mobility and by <4 cm in the case of decreased mobility. Chest expansion is measured as the difference between maximal inspiration and maximal forced expiration in the fourth intercostal space in males or just below the breasts in females. Normal chest expansion is 5 cm.

Limitation of movements or the pain in hip or shoulders are usually present if either one of these joints are involved but early in the course of mild diseases, symptoms may be subtle and nonspecific, and the physical examination may be completely normal.

The course of the disease is extremely variable, ranging from mild stiffness and radiographically equivocal sacroiliitis to the patient with a totally fused spine and severe bilateral hip arthritis and can be accompanied by severe peripheral arthritis and extra-articular manifestations. Pain tends to be persistent early in the disease and then becomes intermittent, with alternating exacerbations and quiescent periods. In a typical severe untreated case with progression of the spondylitis to syndesmophyte formation, the patient's posture undergoes characteristic changes, with obliterated lumbar lordosis, buttock atrophy, and accentuated thoracic kyphosis. There may be a forward stoop of the neck or flexion contractures at the hips, compensated by flexion at the knees. The progression of the disease may be followed by measuring the patient's height, chest expansion, Schober test, and occiput-to-wall distance. Occasional individuals

are encountered with advanced physical findings who report having never had significant symptoms.

In some but not all studies, onset of the disease in adolescence correlates with a worse prognosis. Early severe hip involvement is an indication of progressive disease. The disease in women tends to progress less frequently to total spinal ankylosis, although there is some evidence for an increased prevalence of isolated cervical ankylosis and peripheral arthritis in women. Overall, in industrialized countries, peripheral arthritis (distal to hips and shoulders) occurs in about 25% of patients, usually as a late manifestation, whereas in developing countries, the prevalence is much higher, with onset typically early in the disease course. Pregnancy has no consistent effect on AS, with symptoms are improving or remain same, or deteriorating in about one-third of pregnant patients, respectively.

The most serious complication of the spinal disease is spinal fracture, it can occur even with minor trauma to the rigid, osteoporotic spine. The cervical spine is most commonly involved. These fractures are often displaced and cause spinal cord injury.

The most common extra-articular manifestation is acute anterior uveitis, which occurs in 30% of patients and can antedate the spondylitis. Attacks are typically unilateral, causing pain, photophobia, and increased lacrimation. These tend to recur, often in the opposite eye. Cataracts and secondary glaucoma are not uncommon sequelae. Up to 60% of patients have inflammation in the colon or ileum. This is usually asymptomatic, but in 5 to 10% of patients with AS, frank IBD can develop.[25] Aortic insufficiency, sometimes producing symptoms of congestive heart failure, occurs in a few percent of patients, occasionally early in the course of the spinal disease but usually after prolonged disease. Third-degree heart block may occur alone or together with aortic insufficiency. Subclinical pulmonary lesions and cardiac dysfunction may be relatively common. Cauda equina syndrome and slowly progressive upper lobe pulmonary fibrosis are rare complications of long-standing AS. Retroperitoneal fibrosis is a rare associated condition. Prostatitis has been reported to have an increased prevalence in men with AS. Amyloidosis is rare.

Several validated measures of disease activity and functional outcome have recently been developed for AS.[25] Despite the persistence of the disease, most patients remain gainfully employed. The effect of AS on survival is controversial. Some, but not all, studies have suggested that AS shortens life span, compared with the general population. Mortality attributable to AS is largely the result of spinal trauma, aortic insufficiency, respiratory failure, amyloid nephropathy, or complications of therapy such as upper gastrointestinal hemorrhage.

Diagnostic Features of Ankylosing Spondylitis

- Inflammatory spinal pain
- Onset before age 40 year
- Insidious onset
- Persistence for at least 3 months
- Morning stiffness of at least 30 min duration
- Improvement with exercise but not with rest
- Awakening because of back pain during second half of night
- Chest pain
- Alternate buttock pain
- Acute anterior uveitis
- Synovitis (predominantly of lower limbs, asymmetric)
- Enthesitis (heel, plantar)
- Radiographic sacroiliitis
- Positive family history of AS, IBD and Psoriasis

The pain is initially felt primarily deep in the gluteal region, is dull in character, is difficult to localize, and is insidious in onset. The pain can be severe at this early phase of the disease; it localizes in the sacroiliac joints but is occasionally referred toward the iliac crest or greater trochanteric region or down the dorsal thigh. Radiation of buttock pain may suggest root compression of the sciatic nerve. The buttock pain typically alternates from side to side. Coughing, sneezing, or other maneuvers that cause a sudden twist of the back can accentuate pain. Although the pain is often unilateral or intermittent at first, within a few months it usually becomes persistent and bilateral, and the lower lumbar area becomes stiff and painful. The pain is associated with a feeling of low back stiffness that is worse in the morning and may awaken the patient from sleep, particularly during the second half of the night. Many patients do not differentiate between low back pain and stiffness. The morning stiffness may last up to 3 hours. Both the stiffness and the pain tend to be eased by a hot shower, an exercise program, or physical activity; they do not improve with rest. Fatigue as a result of chronic back pain and stiffness may be an important problem and can be accentuated by sleep disturbances due to these symptoms.

1.3 Imaging Studies

Conventional Radiography

The typical radiographic changes of AS are seen primarily in the axial skeleton, especially in the sacroiliac, discovertebral, apophyseal, costovertebral, and costotransverse joints. They evolve over many years, with the earliest, most consistent, and most characteristic findings seen in the sacroiliac joints. However, otherwise typical AS has been described in the absence of radiographic evidence of sacroiliitis. The radiographic findings of sacroiliitis are usually symmetric and consist of blurring of the subchondral bone plate, followed by erosions and sclerosis of the adjacent bone. The changes in the synovial portion of the joint (i.e., the lower one thirds of the joint) result from inflammatory synovitis and osteitis of the adjacent subchondral bone.[26] The cartilage covering the iliac side of the joint is much thinner than that covering the sacral side. Therefore, the erosions and subchondral sclerosis are typically seen first and tend to be more prominent on the iliac side.[27] In upper two third of the sacroiliac joint, there strong intra-articular ligaments hold the bones together, the inflammatory process may lead to similar radiographic abnormalities. Progression of the subchondral bone erosions can lead to pseudo-widening of the sacroiliac joint space.

Over time, gradual fibrosis, calcification, interosseous bridging, and ossification occur. Erosions become less obvious, but the subchondral sclerosis persists, becoming the

most prominent radiographic feature. Ultimately, usually after several years, there may be complete bony ankylosis of the sacroiliac joints, with resolution of bony sclerosis.[28,29] It is practical to grade radiographic sacroiliitis according to the New York criteria

Grading of Sacroiliitis: New York Criteria
Grade 0, normal
Grade 1, suspicious
Grade 2, minimal sacroiliitis
Grade 3, moderate sacroiliitis
Grade 4, ankylosis

Bony erosions and osteitis ("whiskering") at sites of osseous attachment of tendons and ligaments are frequently seen, particularly at the calcaneus, ischial tuberosities, iliac crest, femoral trochanters, supraspinatus insertion, and spinous processes of the vertebrae. In the early stages of the evolution of syndesmophytes, there is inflammation of the superficial layers of the annulus fibrosus, with subsequent reactive sclerosis and erosions of the adjacent corners of the vertebral bodies. This combination of destructive osteitis and repair leads to "squaring" of the vertebral bodies. This squaring is associated with gradual ossification of the annulus fibrosus and eventual "bridging" between vertebrae by syndesmophytes.[30] There are often concomitant inflammatory changes, ankylosis in the apophyseal joints, and ossification of the adjacent ligaments. In a number of patients, this may ultimately result in a virtually complete fusion of the vertebral column ("bamboo spine").

Hip involvement may lead to symmetric, concentric joint space narrowing, irregularity of the subchondral bone with subchondral sclerosis, osteophyte formation at the outer margin of the articular surface, and, ultimately, bony ankylosis of these joints.

There are several validated scoring methods available to quantify structural damage in AS: the Bath AS radiology index (BASRI), the Stoke AS spondylitis Score (SASSS), and the modified SASSS. The BASRI includes scores for the cervical and lumbar spine as well as the sacroiliac joints. A similar score for the hips is also available. The SASSS evaluates the lumbar spine only; the modified SASSS assesses the cervical and lumbar spine. These scoring methods are most suited for use in clinical trials and observational studies.[31,32,33]

1.4 Computed Tomography and Magnetic Resonance Imaging

The conventional plain pelvic radiograph is still the initial tool for the evaluation of sacroiliac joints in patients with inflammatory low back pain. This technique, however, lacks sensitivity in the early stages of sacroiliac inflammation. In such cases, dynamic MRI with a T1-weighted sequence after the intravenous injection of gadolinium diethylene triamine penta acetic acid (Gd-DTPA) is able to demonstrate early stages of sacroiliitis.[34,35] Fat-saturation techniques such as short tau inversion recovery (STIR) sequences are very sensitive in the detection of bone marrow edema, which is a frequent finding in AS-related inflammation of the musculoskeletal system. STIR imaging is cheaper than Gd-DTPA sequences and almost as good. Thus, active, early sacroiliitis can best be searched for by STIR or contrast-based sequences.

Similarly, spinal involvement is first assessed by conventional radiography. Square vertebrae, shiny corners (the Romanus lesion), spondylodiscitis (the Anderson lesion), and syndesmophytes with partial and complete fusion are typical radiographic features of AS.[36,37] Spinal inflammation cannot be assessed by conventional radiography but can be visualized by MRI where it is typically seen in the vertebrae, at both anterior and posterior sites as well as around the intervertebral disk. Posterior elements such as the facet joints, pedicles, and transverse processes can show inflammatory lesions as well. MRI can be very useful to assess enthesitic problems such as Achilles tendonitis and heel pain.[38,39]

For the detection of bone changes, such as erosions and ankylosis, CT is usually considered superior to MRI,[40,41] but MRI is better in the imaging of cartilage and provides the possibility of dynamic measurements.[42] CT is definitely not indicated in the routine evaluation of the sacroiliac joint. CT scanning may be useful in the diagnosis of spinal fractures, spinal stenosis, or thecal diverticula. A major difference between CT and MRI is the radiation exposure associated with the former but not with the latter.

Power Doppler Imaging
Power Doppler imaging has recently gained attention in musculoskeletal ultrasound as an extended arm of rheumatologist or as rheumatologist stethoscope and even to be called as poor man MRI. Additionally, color flow imaging technique that have overcomes some of the limitations of conventional color Doppler ultrasound (US). Limitations of conventional color Doppler US include angle dependence, aliasing, and difficulty in separating background noise from true flow in slow-flow states. Owing to its increased sensitivity to flow, power Doppler Sonography is valuable in low-flow states and when optimal Doppler angles cannot be obtained.[43]

Over the last decade, real-time ultrasound has emerged as one of the leading contenders to be the ideal musculoskeletal imaging modality, capable of combining both morphological and functional imaging in musculoskeletal soft tissues. Increasing numbers of rheumatologists have been using grey-scale, colour and power Doppler ultrasonography not just as a research tool and also in many European countries are doing as daily rheumatological practice. It is now included in the rheumatology curriculum of many different European countries and the European League Against Rheumatism (EULAR) has promoted basic, intermediate, and advanced ultrasound courses in addition to a number of projects under the auspices of the EULAR Working Party on Musculoskeletal Imaging aimed at standardizing both ultrasound training and practice.

High-resolution grayscale ultrasonography improves our ability to detect tiny, hidden erosions and minute amounts of fluid and soft tissue changes in synovial joints at the earliest stages of disease. The resolution of grayscale ultrasonography is now under 300 µm producing one of the

highest levels of definition of musculoskeletal soft tissue morphology.[44] In combination with real-time imaging advances in colour and power Doppler imaging may allow functional depiction and assessment of inflamed joints and vasculitides. Initially, power Doppler was considered far more superior in sensitivity with respect to the detection of slow flow in soft tissues and also promised fewer artifacts, than the forerunner, colour Doppler.

Power Doppler Imaging (PDI) is a promising new sonographic technique for evaluating the vascular system. PDI uses special processing to display the amplitude or strength of the Doppler signal, rather than velocity and directional information as in conventional color Doppler. This allows a much greater sensitivity in detecting small vessels and slow-moving blood. Its increased flow sensitivity and better vascular delineation have been used to document the presence and characteristics of flow in vessels that are poorly imaged with conventional color Doppler.[45,46,47] Unlu et al present some interesting data on the role of color and duplex Doppler ultrasound in detecting SI and spinal inflammation.[48]

Ultrasonography has proved a highly sensitive, noninvasive, and practical tool in assessment of bone and joint pathology, and is gaining increasing attention in many different areas of rheumatology practice. Within the area of SpA, Doppler ultrasonography is currently being used to detect enthesitis and to assess response of enthesitis to therapy.[49]

The presence or absence of sacroiliitis as detected by whatever reliable, reproducible, and affordable method will continue to be a cornerstone for earlier diagnosis of AS. Potentially, Doppler ultrasonography, due to its relative availability and low cost, may be a useful tool in diagnosing patients with AS and assessing response to therapy. Further work is definitely warranted in this area.

Understanding the fundamentals of Ultrasound Imaging
Having a strong grasp of pattern recognition is essential when it comes to interpreting MSU images. All tendons, nerves, muscles and bone have a characteristic quality on MSU imaging. Tendons have a fibrillar pattern or appear as densely packed bright white lines on a dark background. The best example is the Achilles tendon. Nerves have a fascicular pattern. For example, with the median nerve, clinicians will note bright whites lines that are not densely packed on a black background. One can compare a MSU image of muscle to a feather with characteristic bright white lines emanating from the septa. However, Power Doppler is an excellent technique for a quick evaluation of cortical surface but it cannot useful for imaging of internal cortical pathology. Clinicians can easily identify bone by its bright echotexture and it is usually the deepest or lower image one sees on the screen.

It is imperative to have a grasp of what ultrasound is before one can truly appreciate the technology. Simply, ultrasound waves are mechanical sound waves above the hearing frequency of the human ear. Humans hear frequencies between 20 Hz to 20,000 Hz. Sounds below 20 Hz, which can only be heard by animals, are called infrasound. Ultrasound refers to sounds above 20,000 Hz.

1.5 Principles and applications

Today, we have diagnostic ultrasound machines capable of hearing up to 18 MHz. The images are generated by a transducer and a synthetic piezoelectric crystal that vibrates under electric currents. The ultrasound pulses travel through tissues and are reflected at interfaces or boundaries in which tissues with different acoustic properties meet. For example, fluid and bone have different acoustic properties, and one can easily distinguish these under ultrasound. Bone will appear bright white (hyperechoic) and fluid black (hypoechoic). The echoes that return traverse the piezoelectric crystal and create electrical potentials to grey-scale imaging. This leads to the grey and black images we see on the ultrasound monitor. To help detect blood flow and direction, we use color Doppler ultrasound. However, when it comes to MSU, we are more interested in power Doppler ultrasound, which aids in detecting low blood flow states in conditions such as synovitis.[50,51]

The terminology is equally important. The reflected sound waves are either hypoechoic, hyperechoic and anechoic. Anechoic sound waves are structures without internal reflectors. No echoes are returned with these sound waves so clinicians will see black areas of the image (i.e. cartilage, effusions). Hypoechoic sound waves involve structures with low-level echoes that produce weaker reflections or darker grey areas of the image (i.e. muscle, synovial tissue, peripheral nerves). Hyperechoic sound waves are structures with high level echoes that produce bright grey reflections of the image (i.e. bone, calcifications, tendons, foreign bodies.

2. Review of Literature

Spondyloarthritis is a chronic inflammatory disease that primarily involves the axial skeleton. The current standard imaging method in SpA/ AS is sacroiliac (SI) and spinal conventional plain radiography. Radiography reveals the consequences of inflammation, but cannot detect active inflammatory lesions when used alone. [46,47,52] CT- SCAN can detect the end result of inflammation like erosions, sclerosis but acute and active inflammation like marrow edema cannot be made out accurately.[40,41,52] However, CT imaging requires a large radiation dose, (15-20 mGy per examination) to the gonads in particular for patients who are young. However dynamic CT and contrast CT identify active inflammation by additional burden of higher cost.[40]

Magnetic resonance imaging (MRI), on the other hand, can detect SI and spinal, active inflammatory lesions.[38,53,54] Nevertheless, MRI is a relatively expensive and time-consuming method by its own technique and by number joints to be imaged: Hence its routine use in every patient would be difficult in daily practice. Another factor that limits usage of MRI is that an important proportion of AS patients have prostheses. Therefore, an easier and cheaper method is needed to detect the degree of spinal inflammation.

A Closer look at Musculoskeletal Ultrasound
Richard H. Haddad et al offered pertinent pointers about the adjunctive potential of musculoskeletal ultrasound in diagnosing common arthritic conditions ranging from

rheumatoid arthritis, Spondyloarthritis to crystal-induced arthropathies.[55]

Musculoskeletal ultrasound (MSU) is an excellent technique for evaluating soft tissue and cortical involvement in rheumatic diseases. Over the past few years, rheumatology health care professionals have demonstrated an exponentially growing interest in MSU due to its diagnostic potential.[48,49,50,51,55] Indeed; ultrasound provides an adjunctive tool in the assessment of many of the common entities (i.e. shoulder pain, swollen joints) that clinicians encounter in daily practice. In comparison to other imaging modalities, ultrasound is the only imaging tool clinicians can use at the bedside and they can also use the modality to assist with joint injections. The main advantages of MSU are dynamic real-time scanning, absence of radiation, many number of joints can be seen on the same day, low cost, exact localization of symptoms and most importantly, patient acceptance and of course, diagnosis reached on the same day. To aid in diagnosis, the sonographer performing the scan can correlate the clinical findings with the ultrasound images and immediately compare with the contralateral side. Therefore now power Doppler is considered as a rheumatologist extended arm but more appropriately, it's a rheumatologist stethoscope and also being called as poor man's MRI.

With the advancing technology over the years, ultrasound has evolved to a point where it allows exquisite visualizations of anatomy without invasive procedures. Musculoskeletal ultrasound has proven to be valuable in diagnosing common rheumatological conditions including rheumatoid arthritis, crystal-induced arthritis, seronegative spondyloarthropathies and osteoarthritis.

A standard approach is important. First, the technique is an art and having a solid knowledge of anatomy is essential for MSU. Secondly, like learning any other technique, practice is essential. Thirdly, one must learn the limitations of ultrasound. For example, ultrasound has not been useful for imaging internal cortical pathology. Fourthly, to avoid blooming artifacts we would need to adjust Doppler gain to an unacceptably low level, which would lead to non-visualization of true flow. Another alternative to minimizing blooming artifact is to increase the Doppler frequency. Moreover 3 RI measurements per vessel are recommended and the median value should be taken-(normal RI 1-1.5).[43,55]

Therefore, clinicians should consider ultrasound as a complementary modality to magnetic resonance imaging (MRI) and conventional radiography in daily practice.

The Challenge of Early Diagnosis in Ankylosing Spondylitis

Until recently, treatment options for AS were limited. Conventional disease-modifying anti rheumatic drugs, which are effective in other chronic inflammatory diseases such as rheumatoid arthritis, have only a very limited effect on spinal inflammation. Thus, while an early diagnosis has been recognized as important in these patients, this seemed less urgent for many physicians because of the lack of therapeutic options.

This treatment approach has now changed. Non steroidal anti-inflammatory drugs, the mainstay of treatment for control of symptoms, may have a protective effect on structural damage when taken on a regular basis. Anti-tumor necrosis factor (TNF) agents offer an exciting new possibility for effective treatment and possibly arrests disease progression. It has been shown that the anti-TNF agents have a prompt and robust effect on almost all aspects of active disease —most notably not only pain or fatigue, but also function, spinal mobility, peripheral arthritis, enthesitis, bone density, and acute inflammation as reflected by acute phase reactants and magnetic resonance imaging (MRI). It has also been shown that AS patients with shorter disease duration are more likely to respond to anti-TNF agents than patients with longstanding disease.[39,56,]

There are a number of reasons for the long delay in the diagnosis of AS. First, the established classification criteria for AS, which date back over 20 years, rely on the combination of clinical symptoms plus unequivocal radiographic sacroiliitis of at least grade 2 bilaterally or grade 3 unilaterally. The radiographs are often normal when symptoms arise and it usually takes several years for definite radiographic sacroiliitis to evolve.[57,58] Secondly, there is no pathognomonic clinical feature or laboratory test to make the diagnosis of AS. It is a challenge to attempt to identify the estimated 5% of chronic low back pain that represents AS. In this regard, AS presents a distinct diagnostic problem since it occurs in the context of a highly prevalent condition low back pain in which it represents a small subset.[60] This is not true for polyarthritis, in which rheumatoid arthritis represents a large subset.

Choosing clinical characteristics for screening patients for underlying AS is attractive because their determination is not expensive. The clinical symptom of inflammatory back pain (IBP) has been recognized as a cardinal symptom for AS for years, and assessment requires neither laboratory tests nor radiographic studies. It has been estimated that when symptoms of IBP are present in a patient with chronic low back pain, the post-test probability for this patient having the diagnosis of axial SpA is 14%. Recent refinement of these clinical features has identified a candidate core set of criteria for IBP: (1) morning stiffness of > 30 minutes, (2) improvement in back pain with exercise but not with rest, (3) awakening because of back pain during the second half of the night only, and (4) alternating buttock pain. [58,59,60] These features were defined by a study that sought to identify the most sensitive and specific combination of characteristics for IBP using a cohort of patients with established diagnosis of AS and mechanical back pain. If at least 2 of these 4 characteristics were fulfilled, this yielded a sensitivity of 70% and a specificity of 81%, with a positive likelihood ratio of 3.7 for AS. If at least 3 of the 4 characteristics were fulfilled, the positive likelihood ratio increased to 12.4. How these discriminating features perform in a large population with nonspecific back pain remains to be examined.

Currently, imaging is essential for the diagnosis of AS for the purpose of identifying the presence of sacroiliitis. Although plain radiography is always the initial method for evaluating the SI joints, its accuracy is limited by the lack of

sensitivity in early stages of the inflammation and by high intra- and interobserver variability in interpretation. The grade of sacroiliitis is critical for the diagnosis of AS, and plain radiographs of the SI joints are divided into 4 grades, from normal to fully ankylosed. Differentiation of grade 1 (suspicious change) and grade 2 (minimal abnormality — small localized areas with erosions or sclerosis without alteration in joint width) is where most of the diagnostic variability arises. In these cases, different imaging techniques might be helpful.[61]

Quantitative SI joint scintigraphy, computed tomography (CT), and MRI are the currently available imaging modalities to evaluate sacroiliitis. Despite the use of these different modalities, difficulties in diagnosing sacroiliitis remain. By using CT, sclerosis and ankylosis can easily be diagnosed, and for the detection of bony changes, CT can be superior to MRI. However, MRI also identifies abnormalities thought to reflect inflammatory disease activity in the joint and subchondral bone.[62] The sensitivity of quantitative SI joint scintigraphy is reportedly high, but the increased bone turnover in SI joints lowers the specificity of this technique.[63]

MRI has been proposed by many investigators as the best method of detecting sacroiliitis, especially early in the course of the disease. It can demonstrate early pre destructive alterations of sacroiliitis. However, the availability of MRI is often limited and the technique is time-consuming and costly, imposing practical difficulties for its clinical application in all patients with inflammatory back pain and suspected sacroiliitis. MRI is also limited in patients with metal implants or pacemakers, or with claustrophobia.

Where exactly MRI fits in our diagnostic armamentarium is not yet fully resolved. It has recently been shown that conventional radiography can detect structural changes in the SI joint with greater sensitivity than MRI.[42] However, inflammation on MRI can be found in a substantial proportion of patients with IBP but with normal radiographs. Applying only MRI (even if this were practical in the real world) might underestimate structural changes of sacroiliitis. Recent studies have suggested that assessment of structural changes, first by conventional radiography followed by assessment of inflammation on MRI in patients with negative radiographic studies, yields the highest probability of detecting involvement of the SI joints in patients with recent onset IBP, and same can appreciated by Power Doppler ultrasound.

Power Doppler Ultrasound Imaging (PDUS)

Ercument Unlu et al[48,55] valued that ultrasonography has proved a highly sensitive, noninvasive, and practical tool in assessment of bone and joint pathology, and is gaining increasing attention in many different areas of rheumatology practice. Within the area of SpA, Doppler ultrasonography is currently being used to detect enthesitis and sacroiliitis and to assess response of enthesitis to therapy.[45,64]

The presence or absence of sacroiliitis as detected by whatever reliable, reproducible, and affordable method will continue to be a cornerstone for earlier diagnosis of AS. Potentially, Power Doppler ultrasonography, due to its relative availability and low cost, may be a useful tool in diagnosing patients with AS and assessing response to therapy. Further work is definitely warranted in this area.

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Can MSU Aid In The Diagnosis?

The family of spondyloarthropathies is characterized by a number of overlapping features and inflammation at the insertion of tendons to bone, which is referred to as enthesitis. Clinicians can usually detect peripheral enthesitis

by clinical examination; there is a lack of specificity when it comes to generalized pain, swelling and tenderness. The characteristic radiographic diagnosis of sacroiliitis is relatively late.

Recently, clinicians have recognized MSU as a sensitive technique to assess tendon or ligament involvement. Researchers have reported using power Doppler to detect inflammation and low blood flow within the tendon, which is a sensitive indication for tendinitis. Clinicians have also described enthesitis in psoriatic arthritis.

In clinical practice, it can be challenging to diagnose patients who present with generalized arthralgia and without psoriasis. In lower limbs, the most common sites of entheseal involvement are the knee and heel where the Achilles attaches to the calcaneus. For example, one patient was initially diagnosed with osteoarthritis of the knee. After that, author has used MSU, able to diagnose psoriatic arthritis based upon the sonographic findings of his Achilles.

US imaging in SpA and role of three dimensional imaging

Recent review in Current Opinion Rheumatology by Kelly, Stephen A et al opined that ultrasound has developed significantly over the past decade, becoming a potent imaging modality for the assessment of inflammatory arthritis. Ultrasound imaging has been shown to be more sensitive than clinical examination in detecting many features of spondyloarthritis, such as synovitis and enthesitis. The ability to detect subclinical disease and demonstrate a clear response to therapeutic intervention makes this imaging modality a potential tool for both diagnostic and monitoring purposes. Despite this, a number of issues including a lack of standardization of ultrasound assessment of musculoskeletal disorders continue to hamper its progress. New three-dimensional technology is a promising development, which may allow this problem to be addressed. Improving the ability of the rheumatologist to predict prognosis and guide therapeutic intervention is a long-term goal, to which ultrasound may be able to provide a significant contribution. The addition of a novel imaging modality to currently available assessment tools may provide rheumatologists with a more precise working framework, which may be exploited for the benefits of the patients.

Colour and Duplex Doppler Sonography to Detect Sacroiliitis and Spinal
Inflammation in Ankylosing Spondylitis.

Ercüment Unlü et al has demonstrated that signs of active sacroiliitis can be detected by the colour and duplex Doppler ultrasonographic (CDDUS) method, and that anti-inflammatory therapy would lead to improvement in signs of active sacroiliitis.[48]

Klauser A et al in another study, the value of contrast-enhanced colour Doppler ultrasound and MRI were compared in diagnosing SI inflammation and it was shown that ultrasound had a high negative predictive value in the detection of inflamed SI joints.[65] In this study, determined the degree of SI and spinal inflammation in AS patients was determined by CDDUS, and their relationship with clinical activity variables was evaluated in addition to, detecting changes following anti-TNF therapy.

CDDUS detected arterial vascularity for measurement within or around SI joints and in paraspinal areas in all AS patients, including controls. In the AS group, mean RI values of SI joints, LV, and TV areas were significantly lower than in controls ($p = 0.003$, 0.004, and 0.01, respectively).

In patients with AS who had active disease according to BASDAI score, the ratio of men was higher ($p = 0.034$), and higher values were recorded for mean ESR ($p = 0.05$) and CRP ($p < 0.001$).

In their study, AS patients had significantly lower RI values of SI joints and of LV and TV areas when compared to controls. It was suggested that proangiogenic factors lead to increased vascularization in regions of prominent inflammation such as SI joints, which could be associated with disease activity in patients with AS. As a result, RI value is expected to be lower in patients with active inflammation because of hypervascularization.

In the CDDUS study by Arslan, et al [66], RI was similarly significantly decreased in patients with active sacroiliitis, and then increased after anti-inflammatory therapy. However, the study group was heterogenous as against Ercüment Unlü et al study because they used patients with tuberculosis and psoriatic arthritis.

Recently, Klauser, et al[48] reported that, compared with MRI, microbubble contrast-enhanced color Doppler US was a sensitive technique with high negative predictive value for detection of active sacroiliitis. However, their study considered vascularization within the SI joints but not the areas around the joints. Arslan, et al and Ercüment Unlü, et al studied the vascularization around SI joints was examined and measurements were made in all patients. Moreover, the purpose of the study by Klauser, et al was to test the diagnostic usefulness of Doppler US in inflammatory back pain, included 103 patients with inflammatory back pain, 75% of whom turned out to have some form of spondyloarthropathy. The study was also different in that it did not include data such as clinical activity parameters and changes after anti-TNF therapy. Neither of the 2 studies evaluated LV and TV. Whereas Arslan et al was the first study to evaluate LV and TV by CDDUS.

In the study by Arslan, et al, it was demonstrated that SI joint RI increased after anti-inflammatory therapy and reached levels similar to those in the control group. Thus, CDDUS was shown to be useful to demonstrate degree of SI and spinal inflammation as well as regression of inflammatory signs after anti-TNF therapy.

The limitations of this study were that, evaluations was performed by only one radiologist, and no comparison with a more standard method like MRI was made. In addition, it was a disadvantage that no previous data was available on vascularization around LV and TV regions. However, RI values in these areas were lower in patients than in controls and in the active group versus the inactive group; there was

also a significant increase in LV RI after anti-TNF therapy. Together, these findings prove that our methods were correct.

They conclude that CDDUS method might be useful to detect degree of inflammation in SI joints and in LV and TV paraspinal areas in patients with AS. In patients with active disease, a low RI may indicate increased inflammation (RI< 1.5). When evaluating early response to anti-TNF therapy in patients with active disease, CDDUS might be an alternative to MRI because it is inexpensive, easy, can be performed at the bedside, and is less time-consuming. Rather than as a method used for diagnosis, CDDUS might be more suitable to detect disease activity and to obtain more quantitative data about response to therapy. Ours is the first study using CDDUS to evaluate LV and TV vascularization and to interpret response to anti-TNF therapy in light of clinical characteristics. This method merits further study to develop and standardize this use of CDDUS.

The study by Bredella MA et al [(67)] was to evaluate whether MRI findings of the sacroiliac joints are able to distinguish between active and inactive disease in patients with established ankylosing spondylitis and to determine whether these findings correlate with markers of clinical activity, disease duration, severity, and degree of radiographic damage on eighteen patients with symptomatic moderate to severe ankylosing spondylitis were evaluated. MRI of the sacroiliac joint (1.5 T) was performed using fat-saturated T2-weighted, T1-weighted, STIR, and fat-saturated contrast-enhanced T1-weighted sequences. The sacroiliac joints were evaluated by two radiologists for enhancement, subchondral bone marrow edema, erosions, and subchondral fatty marrow infiltration. Findings on MRI were analyzed for correlation with multiple clinical characteristics and measures of disease activity, including radiographic scoring. MRI showed abnormal findings of the sacroiliac joint in 17 patients. Ten patients showed active disease on MRI as measured by abnormal enhancement and subchondral bone marrow edema. Disease activity detected using MRI correlated in a positive fashion with only C-reactive protein (CRP) level. There was no correlation with the other measures of disease activity or with disease duration. In 14 patients, fatty subchondral bone marrow was detected on MRI. These changes were seen in patients with active and chronic disease and correlated with higher radiographic scores but not with disease duration or markers of disease activity. Contrast-enhanced MRI of the sacroiliac joint is sensitive in depicting sacroiliitis in patients with established ankylosing spondylitis. Subchondral edema and enhancement correlated with high CRP levels. Subchondral fatty bone marrow changes were seen in both active and chronic sacroiliitis and correlated with higher radiographic scores. These changes may be a marker of more advanced disease.

Vogler et al [(69)] evaluated the CT appearances of sacroiliac joints in asymptomatic patients, to define the normal joint appearances and differentiate it from early CT signs of sacroiliitis. In their study, they correlated findings in asymptomatic and sacroiliitis groups, and categorized them into two groups. CT findings that were grouped as poor CT indicators of sacroiliitis, by virtue of its frequent occurrence in the asymptomatic population included non uniform iliac sclerosis (83%), focal joint space narrowing in patients over the age of 30 (74%), and ill defined areas of subchondral sclerosis, particularly on the iliac side (67%). Conversely, the good CT indicators of sacroiliitis were those that occurred infrequently in the asymptomatic population, and comprised increased sacral subchondral sclerosis in subjects under the age of 40 (11%), bilateral or unilateral uniform joint space of less than 2 mm (2% or 0%, respectively) and erosions (2%) .

The value of MRI in the diagnosis of sacroiliitis has been well established. MRI accurately delineates the cardinal features of sacroiliitis, like changes in joint space width and symmetry, presence of erosions, subchondral edema, sclerosis, cysts and ankylosis. Furthermore, MRI plays a useful role in patients with early disease, by its superior ability to directly image changes in articular cartilage. Comparative studies between MRI and CT in the evaluation of patients with suspected sacroiliitis have further shown that the sensitivity and specificity of MR for the detection of cortical erosions and subchondral sclerosis when compared to CT images were 100 and 94.3%, respectively. MRI offers valuable information on the lesions affecting the various structures of the sacroiliac joint in sacroiliitis.

Wanders A [(69)] and Finbar o'shea et al [(70)] in their study of the challenge of early diagnosis in ankylosing spondylitis has now changed. Non steroidal anti-inflammatory drugs, the mainstay of treatment for control of symptoms, may have a protective effect on structural damage when taken on a regular basis (86). Anti-tumor necrosis factor (TNF) agents offer an exciting new possibility for effective treatment and possibly arrest of disease progression. It has been shown that the anti-TNF agents have a prompt and robust effect on almost all aspects of active disease most notably not only pain and fatigue, but also function, spinal mobility, peripheral arthritis, enthesitis, bone density, and acute inflammation as reflected by acute phase reactants and magnetic resonance imaging (MRI). It has also been shown that AS patients with shorter disease duration are more likely to respond to anti-TNF agents than patients with longstanding disease.

The role of US in the diagnosis and management of PsA

David Kane et al [(71)] have described in arthritis Rheumatism that psoriatic arthritis (PsA) presents many diagnostic, management and research challenges for rheumatologists who wish to obtain early diagnosis, differentiate synovitis and enthesitis, monitor disease activity accurately and objectively, prevent the development of structural damage, deliver local therapy accurately, and obtain PsA tissue for research purposes. Musculoskeletal ultrasound (MSUS) is widely used by European rheumatologists in their clinical practice to meet these challenges and has the potential to become rheumatologists stethoscope in Europe and North America. This paper examines the evidence that MSUS can improve clinical evaluation of patients with PsA for synovitis and enthesitis, that MSUS is more sensitive than plain radiography in detecting structural damage in joints, that MSUS can improve the success of joint aspiration and guide biopsy of PsA tissues. Recent exciting developments in the management of PsA are detailed including the role of power Doppler in the diagnosis of enthesitis in PsA, the role

of MSUS in objective monitoring of disease activity, the evaluation of MSUS in the diagnosis of sacroiliitis, and the use of MSUS to guide therapeutic injection of the sacroiliac joints.

Aim of the Study

- To diagnose Spondyloarthritis before radiological erosions.
- To compare Power Doppler imaging of sacroiliitis with CT and MRI scan of Pelvis.

3. Objectives of the Study

Across the world, SpA/ AS is a significant burdens to young, reproductive and the potential earning population. If undiagnosed or inadequately treated, it not only causes continuous pain, stiffness and fatigue and it can lead to erosions, narrowing of joint space and complete ankylosis of spine and pelvic joints with resultant loss of nobilities and functions. To accept the truth that, approximately from the onset of symptoms to diagnosis of SpA/ AS is about 8 to 11 years. Added to that, SI joint is not easily palpated or manipulated and investigations like X-Rays, MRI, CAT Scans, Bone Scans are reported as normal if the observers are not having adequate knowledge in where and what to look for. Thus, miserably, patients may miss early diagnosis and appropriate initiation of treatment for SpA. Conventional x-ray pelvis are not suitable for picking up early synovial inflammation and erosions, hence we depends on the MRI and CT-SCAN, which are not easily available to everyone and expensive and risk of ionizing radiations, respectively.

For a decade, power colour Doppler ultrasound is considered as extended hand of Rheumatologists and declared as the "poor man's MRI" and it remarkably help us in early diagnosis of synovitis, enthesitis, tenosynovitis, synovial effusions and proliferation, erosions of cartilage, bone joint margin, enchondral bone erosion, cyst, osteopenia and in crystal deposition diseases.

4. Materials and Methods

In this prospective case control study from January 2007 to February 2009, one hundred and eight patients (84 males, 24 females) were included from those who have presented with signs and symptoms and clinical features suggestive of spondyloarthritis to the Department of Rheumatology, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai. 3. Thirty five age and sex matched asymptomatic controls were selected from patient's attender's who were not a first or second degree relatives. All patients were asked for a detailed history which includes the age of onset of disease, symptoms of disease, duration of the disease and relevant symptoms of secondary AS.

Inclusion Criteria

- Age of onset of disease from 16 years to 40 years and
- Patient's with
- Ankylosing spondylitis
- Reactive arthritis
- Psoriatic arthritis
- IBD associated arthritis
- Undifferentiated spondyloarthritis

Exclusion Criteria

- Age of onset of disease < 16 years and > 40 years
- Pregnant females
- Diseases mimicking as AS- such as
- Fluorosis of spine
- Diffuse idiopathic skeletal hyperostosis (DISH)
- Degenerative spinal diseases (spondylosis deformans)

Methods

All patients were asked for a detailed history which includes the age of onset of disease, symptoms of disease, duration of the disease and relevant symptoms of secondary AS. A detailed general examination, height and weight assessment was done.

The musculoskeletal examination and including axial joints and SIJ and other systemic examination was done. Disease activity indices like ESR, CRP levels were determined. Detailed Bath AS Disease Activity Index (BASDAI) scores were calculated. In addition, chest expansion, finger-to-floor distance, occiput-to-wall distance, tragus-to-wall distance, modified Schober (mSchober), lateral spinal flexion, cervical rotation and intermalleolar distance were measured; and Bath AS Metrology Index (BASMI) was calculated using cervical rotation, tragus-to-wall distance, lateral spinal flexion, mSchober, and intermalleolar distance.

Peculiarities of SIJ

Sacroiliac joint is a unique joint in the human body with differences in type and thickness of articular cartilage between different regions of the sacral and iliac articular surfaces.[27,28] Light microscopy and immunohistochemistry has shown significant differences between the iliac and sacral articular cartilages as described in a recent study by Kampen. The sacral cartilage is thick, has low cell density, and rests upon a thin bone end-plate supported by porous, cancellous bone. In comparison, the iliac cartilage is thin, has high cell density, resting on thicker subchondral bone end-plates, supported by twice as dense subchondral cancellous bone. The thickness at sacral side and iliac side in adults is 4 mm and 1-2 mm respectively. The spongiosa trabeculae at sacral subchondral bone are inserted at right angles, implying a perpendicular load on the articular facet, unlike the iliac side where there is no definite alignment of subchondral spongiosa. Moreover, blood vessels penetrate subchondral bone plate at both the iliac and sacral surfaces, coursing closely on the overlying articular cartilage, which causes the high incidence of inflammatory diseases at sacroiliac joint.

Technique of power Doppler examination

First subjects were in the prone position during examination. In order to detect SI joints, the transducer was moved in a transverse direction 3–4 cm to the right and left of the sacral spinous processes in the gray-scale US mode; measurements were performed from the posterior point of the cleft-shaped SI joint that was closest to the transducer. Secondly, US evaluation is performed with the patient in the prone position, starting with a grey-scale US examination to identify the bony spinous processes in the midline and the

posterior part of the SI joints as the hypoechoic cleft and to proceed to examine on both sides. Thirdly with the probe in transverse position, the posterior contour of the sacrum is visualized as an echogenic line, while the sacral spinous process is shown as a concave curve at the midline, with sacral wings, represented by a regular echogenic line laterally. The SI joint is visualized as a hypoechoic cleft between two echogenic lines (sacrum and iliac bone). If possible, care was taken to perform the measurement from the arterial structure within the SI joint. When no arterial recording could be obtained from inside the joint, measurements were taken from the arterial structure closest to the joint.

When performing Power Doppler (performed in two different centres with GE Volusom 4D Experta, USA and with Siemens Acuson Antares, Aloka P 3500), a 12.5-MHz, high-resolution linear transducer was used in subjects with a skin-subcutaneous fat tissue thickness < 3 cm, and a 3.5 MHz, high-resolution convex transducer was used in subjects with skin-subcutaneous fat tissue thickness > 3 cm. For CDDUS, the color box was focused on the area being examined. Standardized machine settings that were applied included color Doppler gain 60–120 dB, wall filter 51–65 Hz, and pulse repetition frequency 300–850 Hz.). Resistive index (RI) [peak systolic velocity – end-diastolic velocity / peak systolic velocity] values obtained from CDDUS performed in SI and are calculated by the program loaded on the machine. Measurements in each examination area were repeated 3 times, mean values of those measurements were used for evaluation, and the results were recorded. In each case CDDUS was completed in about 25–30 minutes. All patients were evaluated by two radiologist, who were experienced in MSK ultrasound, at two different centre's and they were unaware of the subjects' clinical and laboratory data (both patients and controls). To prevent variability in measurements, examination in all subjects was performed by the same radiologist.
MRI Pelvis/ SIJ performed with (GE Sigma H Dx- 3 Tesla MRI, USA and with Siemens 1.5 Tesla, Magnetic Symphony) T1FSE, T2FSE FATSAT by STIR in axial, oblique and coronal planes. CT was done by Toshiba Asteion, Super 4, 120 KB, and 400 MA.

Conventional radiographs of the pelvis were available in all patients. Chronic changes in one SI joint were scored between 0 and 4 on the basis of the modified New York criteria and the total chronicity score for both SI joints varied between 0 and 8.

5. Results

Demographic data
One hundred and eight patients were recruited in this study. Among these, 84 were males and 24 were females (3.5:1). The mean age of patients was 30 ± 11.10 years (range from 16 to 59 years). The average disease duration was 3.46 ± 5.23 years (range from one month to 23 years). There were 35 age and sex matched controls (27 males, 8 females, mean age 30 ± 11).

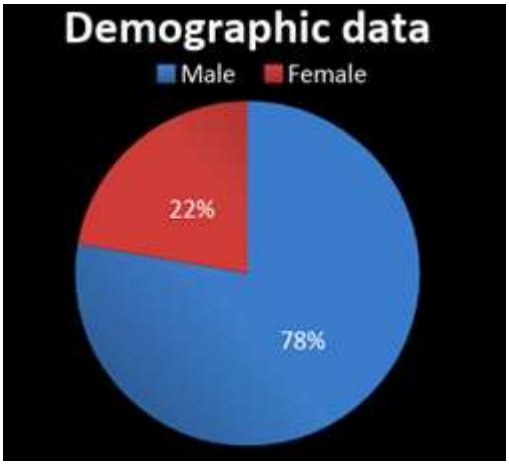


Figure 1: Demographic Data

Categories of patients with Spondyloarthropathies
Undifferentiated spondyloarthritis was seen in 59 cases, of which 45 were males and 14 were females. Among 31 cases of Ankylosing spondylitis, 28 were males and 3 were females.12 cases of Reactive arthritis were found during this study, among which, 8 were males and 4 were females. Only six cases of Psoriatic arthritis were encountered during this study, with equal sex distribution. No cases of IBD related arthropathies were seen during this study.

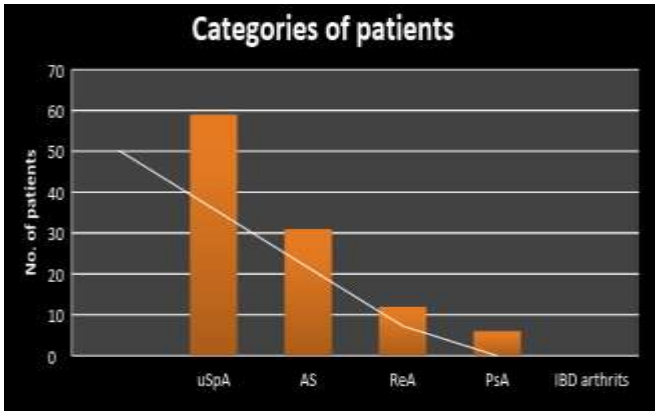


Figure 2: Categories of Patients

Imaging done for all study cases
CT – Scan of Pelvis
CT- Pelvis was done in all patients. Bilateral symmetrical sacroiliitis were seen in 60 patients and asymmetrical bilateral sacroiliitis were noted in 11 patients. Among these, 6 cases showed right more than left side and five cases presented with left more than right side. Unilateral sacroiliitis was seen on the right side in 15 cases and on the left side seen in 10 cases. 12 cases had normal CT- Pelvis.

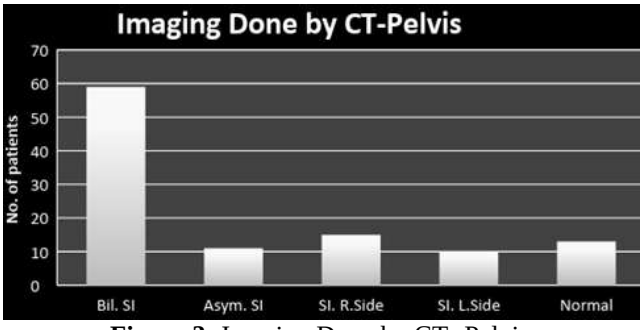


Figure 3: Imaging Done by CT- Pelvis

MRI- Pelvis

MRI Pelvis was done only in 65 cases, due to cost factor. Among these, 43 were found to have bilateral symmetrical sacroiliitis and 6 cases had asymmetrical bilateral sacroiliitis. Right sided sacroiliitis in 8 and left sided in 7 were observed. Normal MRI was seen in one case.

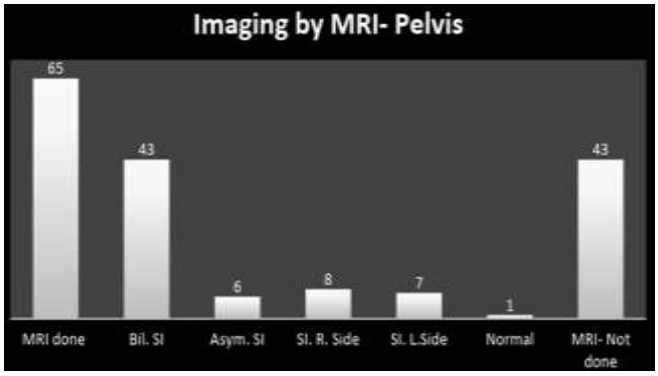


Figure 4: Imaging Done by MRI- Pelvis

Power Doppler Ultrasound of Pelvis

Power Doppler US was done in all cases and with 35 age and sex matched controls (27 males, 8 females, mean age 30 ± 11yrs). Bilateral colour flow with low RI (Resistive Index) was seen in 67 cases. Asymmetrical colour flow with low RI was seen in 12 cases. Right and left sided colour flow with low RI was seen in 13 and 4 cases respectively. No colour flow was seen in 12 cases and none in controls.

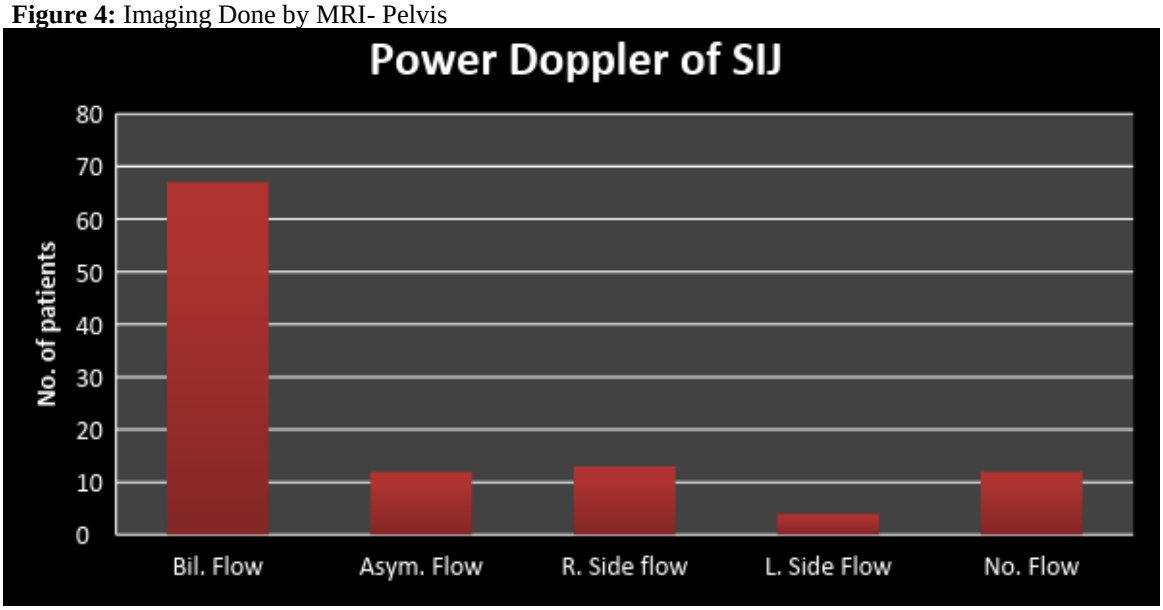


Figure 5: Imaging Done by Power Doppler US of SIJ

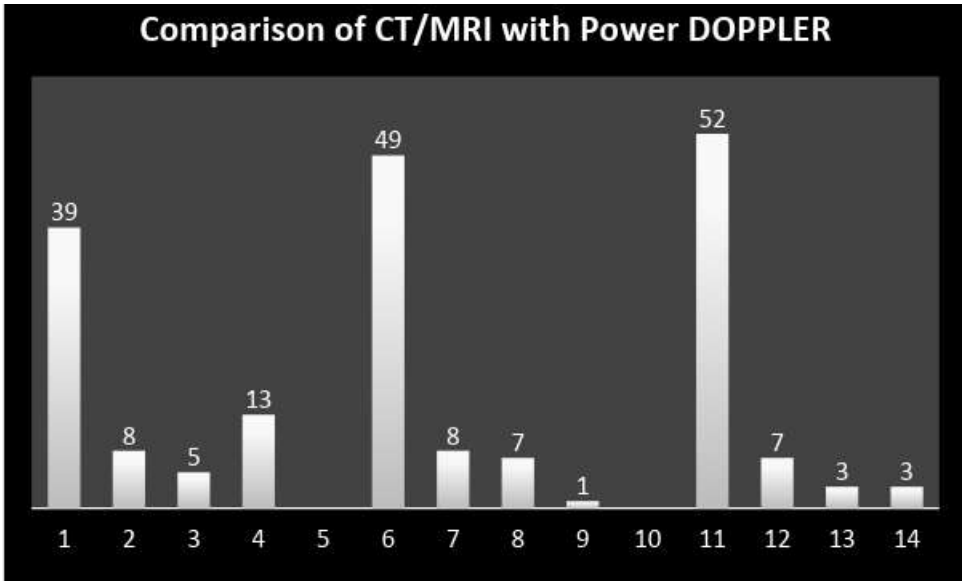


Figure 6: Showing comparison of all cases of our study

Figures-7, 8 & 9 are the normally appearing SIJ by CT, MRI and Power Doppler US.

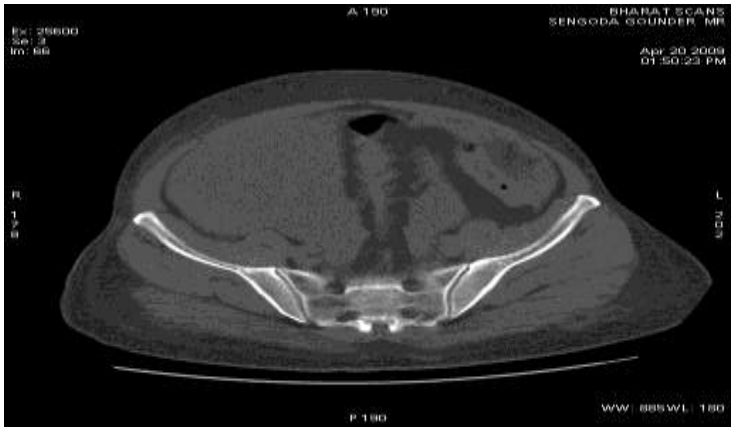


Figure 7: Normal CT- image of SIJ

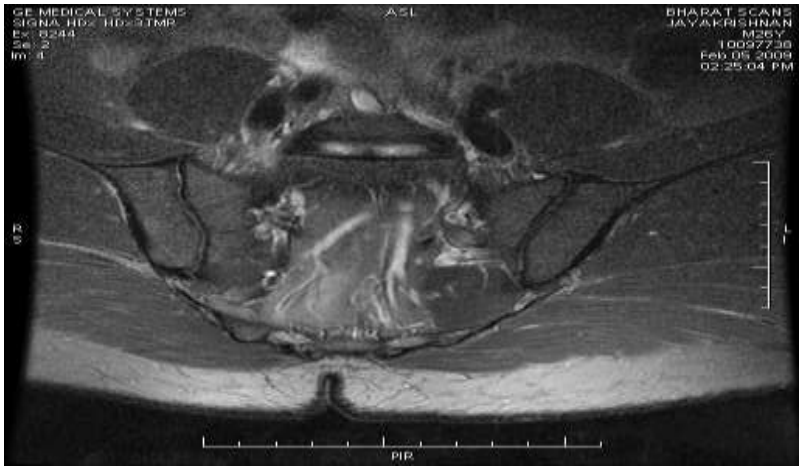


Figure 8: Normal MRI image of SIJ

Figure 9: Normal power Doppler US image of SIJ

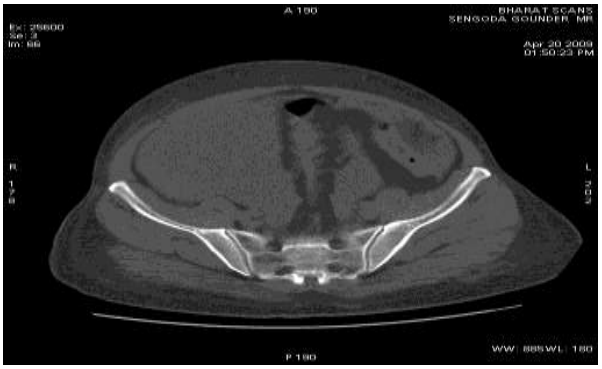


Figure 10: Normal SIJ by CT

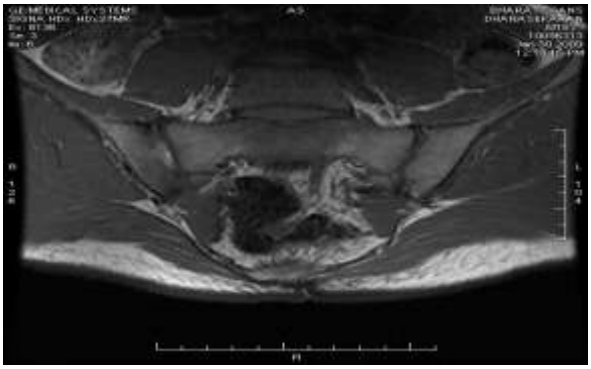


Figure 11: Same case with MRI showing R. Sacroiliitis

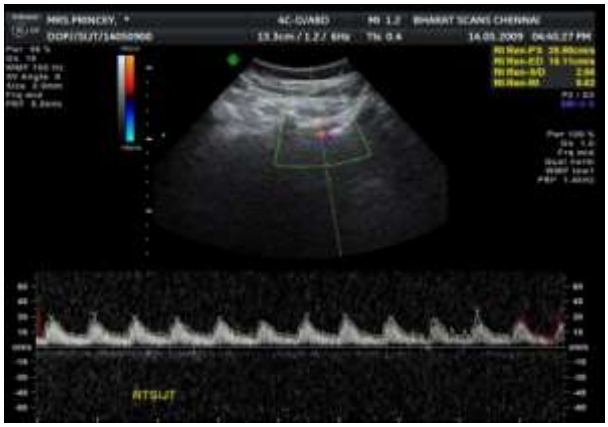


Figure 12: Doppler showing Rt.Colour flow

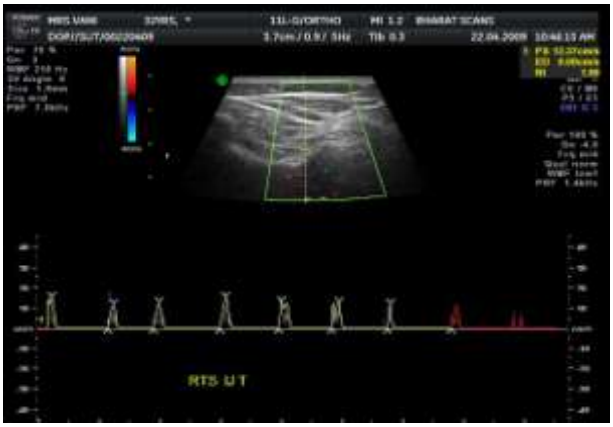


Figure 13: No colour flow signal on left side

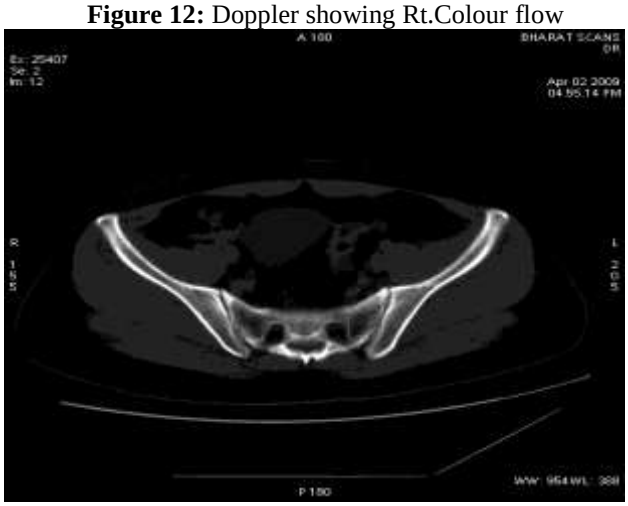


Figure 14: CT with Bil. early sacroiliitis

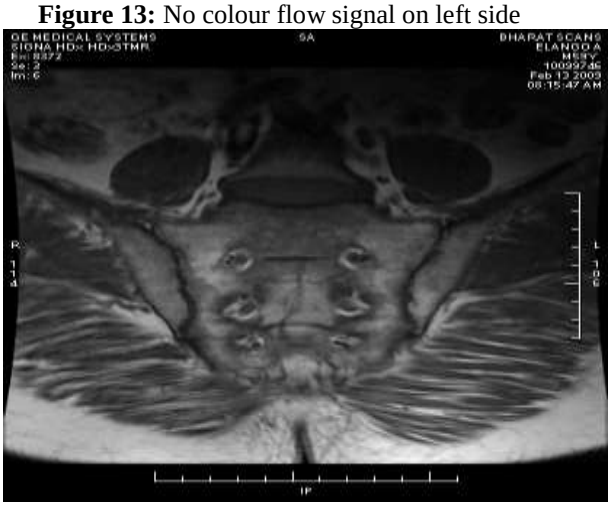
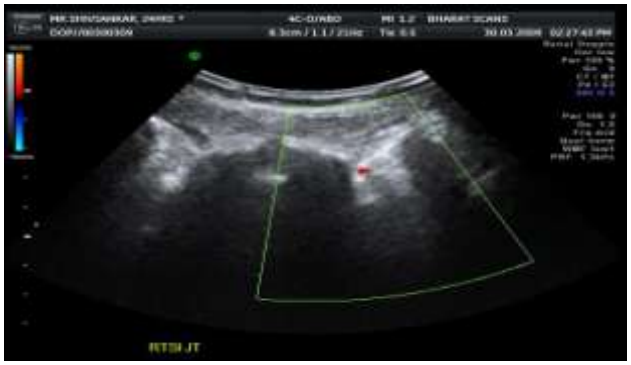


Figure 15: MRI with Bil. sacroiliitis, bone edema, erosions



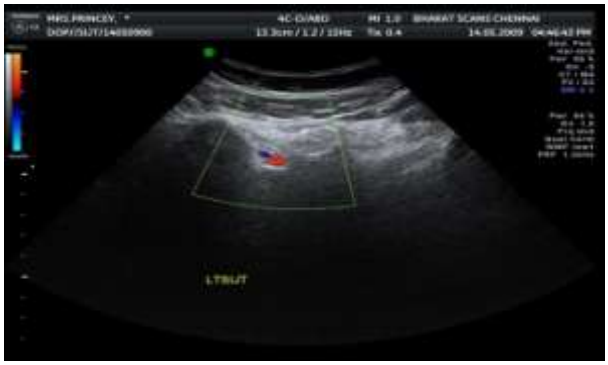


Figure 16 and Figure 17 are showing bil. colour flow signal due to sacroiliitis

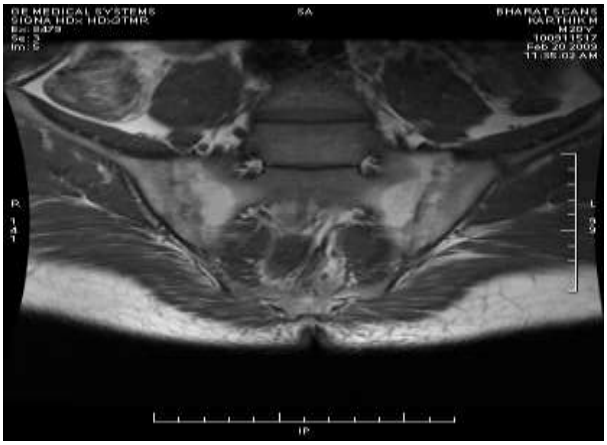



Figure 18 and Figure 19 are showing bil. sacroiliitis by both CT and MRI Pelvis

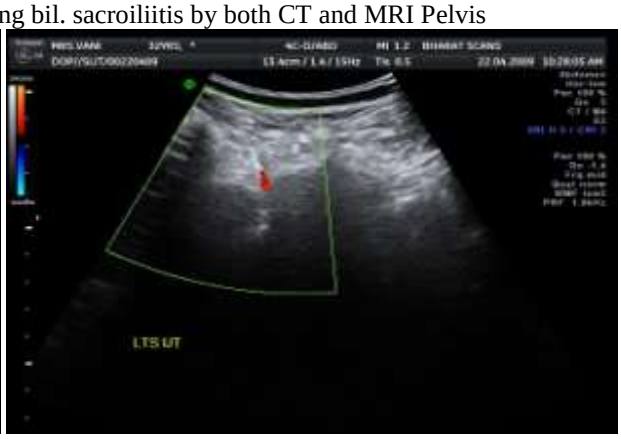


Figure 20 and **Figure 21** are showing bil. colour flow as evidences of SIJ inflammation

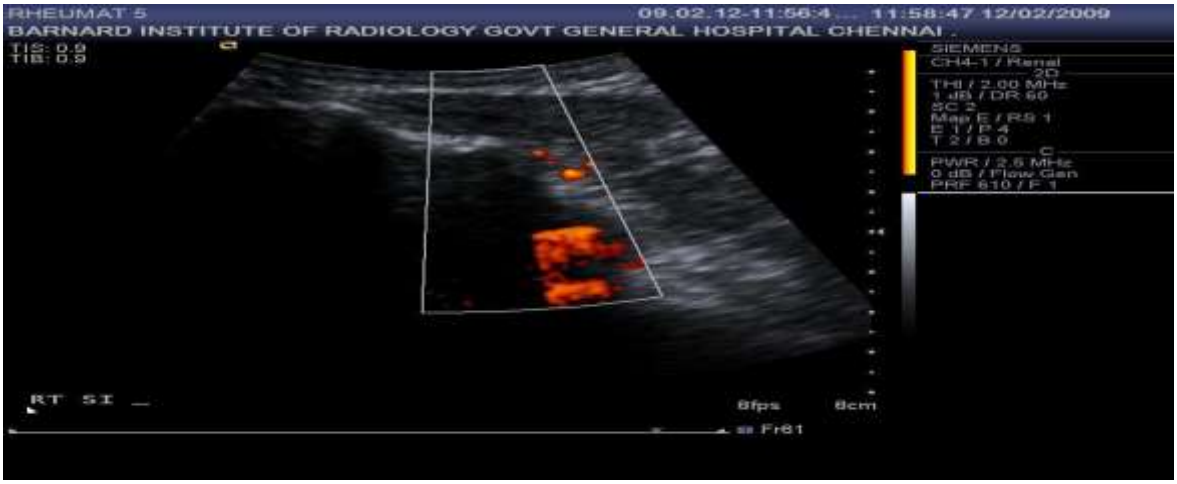


Figure 22: Rt. SIJ showing joint space widening, iliac cartilage erosions and Doppler flow

Figure 23: Lt. SIJ showing joint space widening, echogenic iliac cartilage and Doppler flow

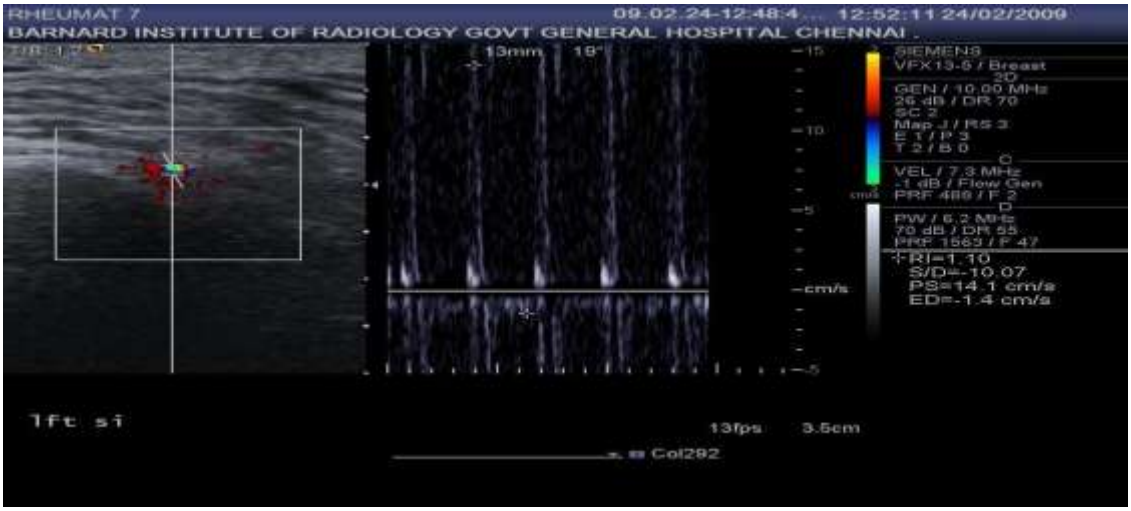


Figure 24: Left SIJ Power Doppler showing inflammatory flow signal with RI= 1.10 (Resistive Index)

Imaging of Reactive arthritis and Psoriatic arthritis

In this study, imaging of ReA and PsA, revealed bilateral sacroiliitis in 2 and one case respectively. Unilateral sacroiliitis was noted in 10 cases in ReA and 5 cases in PsA.

Statistical analysis

Statistical analysis was done only for 65 cases, for whom all three imaging studies was done. Among these, sacroiliitis was detected in 53 cases by imaging by CT-scan, 64 cases by MRI- scan and 62 cases by Power Doppler Ultrasound.(Figure-3, 4, 5 and 8) In this study, the images were compared as follows, CT scan versus MRI (table-1), CT scan versus Power Doppler Ultrasound (table-2) and MRI scan versus Power Doppler Ultrasound (table-3). Imaged patients were again, divided into two groups. Group-1 is with disease duration of less than 1 year and Group-2 is with disease duration more than 1 year.

Table 1: Comparison of imaging by CT- scan versus MRI-scan

CT vs MRI scan	All	< 1 yr	>1 yr
Both CT & MRI abnormal	53	23	30
CT abnormal & MRI normal	0	0	0
CT normal & MRI abnormal	11	9	2
Both normal	1	1	0
Total	65	33	32

Table-1 shows that CT- scan fails to detect sacroiliitis in 12 cases (10 in group-1, 2 in group-2) whereas MRI scan was able to identify, sacroiliitis in 11 cases (group-1) and misses to identify sacroiliitis in one case. (group-1).

Table 2: Comparison of imaging by CT- scans versus Power Doppler US

CT scan vs PD US	All	< 1 yr	>1 yr
Both CT & PD abnormal	50	23	27
CT abnormal & PD normal	3	0	3
CT normal & PD abnormal	12	10	2
Both normal	0	0	0
Total	65	33	32

Table-2. Shows that, CT- scan as in table-1, was unable pick up sacroiliitis in 12 cases (10 in group-1, 2 in group-2) whereas Power Doppler was normal (e.g. No flow is detected) only in three cases.(group-2)

Table 3: Comparison of imaging of MRI scans with Power Doppler US

MRI vs Power Doppler	All	< 1 yr	>1 yr
Both MRI & PD abnormal	61	32	29
MRI abnormal & PD normal	3	0	3
MRI normal & PD abnormal	1	1	0
Both normal	0	0	0
Total	65	33	32

Table-3 shows that, MRI scan was unable to demonstrate sacroiliitis in one case and which was identified by the Power Doppler US. Whereas in group-2, Power Doppler was unable to show the inflammatory flow in 3 cases, due to disease duration more than 1 year.

Statistical analysis was done using CHI- SQUARE test, to see the validity of imaging methods in spondyloarthritides and to identify the most useful imaging methods, according to disease duration.

Table 4: Chi-square kappa statistics

CHI-Square kappa statistics analysis for CT and MRI scan with Power Doppler US						
Validity and clinical agreement (%)						
Images	Sensitivity	Specificity	PPV	NPV	Accuracy	Ƙ
CT vs MRI	100	83	8	100	83	0.11
CT vs PD	100	85	25	100	86	0.35
MRI vs PD	100	95	25	100	95	0.38

PPV: positive predictive value; NPV: negative predictive value; κ : kappa statistics.
Kappa statistics incorporation:
0 -- 0.2 poor correlation
0.2 – 0.4 fair correlation
0.4 – 0.6 moderate correlation
0.6 – 0.8 good correlation
0.8 – 1.0 very good correlation

In our study, statistical analysis ($\chi 2$, κ statistics) was done only for 65 cases for whom all three imaging investigations were done and with 35 controls. (Controls enrolled only for Power Doppler US). Statistically when CT- scan was compared with MRI, the sensitivity of MRI was 100% and specificity 83%, positive predictive value 8% (PPV), negative predictive value 100% (NPV), accuracy 83% (Ac), kappa 0.11 (κ), false positive rate 17% (FPR) and false negative rate 0% (FNR). When we compared CT scan with Power Doppler US, the Power Doppler scan has shown sensitivity of 100% and specificity 85%, PPV25%, NPV100%, Ac 86%, κ 0.35%, FPR 15% and NPR 0%. When MRI was compared with Power Doppler US, the sensitivity was 100%, but specificity rises to 95%, PPV25%, NPV 100%, Ac 95%, κ 0.38%, FPR 5% and NPV was 0%. (vide chi-square table-4)

Statistically analyzed cases (65 cases) were again divided into two groups. Group 1: Disease duration ≤ 1 year (33 cases) and group 2: > 1 year (32 cases) and these two groups were again statistically analyzed and compared for MRI versus Power Doppler US. In group: 1, both MRI and Power Doppler US was 100% (sensitivity & specificity) whereas in group: 2, although MRI/ Power Doppler US was 100 % sensitive, the specificity decreases to 70%. (table- 1 to 3)

In addition, group: 1, patients and their 3 images were statistically analyzed with OR (Odds Ratio). CT- scan OR 1.00, MRI- scan, OR 2.09 and Power Doppler US, OR 2.20. Therefore, Power Doppler US was 2.20 times better than CT and MRI scan in spondyloarthritis with disease duration less than 1 year.

The following tables- 5 to 7 are presented here to see the importance of imaging in ≤ 3 months but it was not analyzed statistically.

Table 5: CT SCAN vs MRI in disease duration <3 months

Both CT & MRI abnormal	7
CT abnormal & MRI normal	0
CT normal & MRI abnormal	3
Both normal	1
Total	11

Table 6: CT scan vs Power Doppler in disease duration< 3 months

Both CT & PD abnormal	7
CT abnormal & PD normal	0
CT normal & PD abnormal	4
Both normal	0
Total	11

Table 7: MRI vs Power Doppler in disease duration < 3 months

Both MRI & PD abnormal	10
MRI abnormal & PD normal	0
MRI normal & PD abnormal	1
Both normal	0
Total	11

Table 8: Impact of duration of disease and the validity of imaging

Impact of duration of disease and the validity of imaging						
	Normal in 108 cases (all study cases)			Normal in 65 cases (statistically analyzed cases)		
Duration of disease & Imaging	<3 mo	3mo-1yr	>1yr	<3 mo	3mo-1 yr	>1 yr
CT- scan	3	9	0	3	9	0
MRI- scan	1	0	0	1	0	0
PD Ultrasound	0	0	12	0	0	3

Table-8 shows that, if the duration of the disease was less, the validity of imaging by MRI and Power Doppler increased, whereas it was vice versa for the CT scan. Likewise Power Doppler US also ceased to be useful if the disease duration was more.

Table 9: ESR / CRP and BASDAI analyzed with Student- t test

ESR / CRP and BASDAI analyzed with Student- t test					
Duration	< 1 yr	>1 yr	Analyzed value		
	Mean	Mean	t- test	P-value	Result
ESR	58.70	69.56	2.40	0.0183	*
CRP	13.84	19.11	2.87	0.005	**
BASDAI	4.74	3.74	5.50	0.0000	***

In this study, acute phase reactants like, ESR and CRP were compared with the disease durations like less than 1 year and more than one year. Mean ESR was 58.70 and 69.56 in group-1 and group-2 respectively. Range of ESR was 10 mm to 110mm. Mean CRP was 13.84 and 19.11 in group-1 and group-2. Range of CRP was from negative to 36. Both increased ESR and increased CRP were independently statistically significant in group-1. (P-0.01 & P-0.005)

Disease activity measure was done by BASDAI. The mean BASDAI was 4.74 and 3.74 in group-1 & 2 respectively. If BASDAI was more than 4.2, the disease activities are more. BASDAI score was high in group-1 compared to group- 2, and it was statistically significant. (P-0.0000).

6. Discussion

Across the world, spondyloarthritides is one of the most common connective tissue diseases affecting males more than females in their late adolescence, early adulthood and before the 4th decade's life, during the most crucial period of earning and reproductive stage of life. The M: F sex ratio varies from 18.7:1 (27) to 2:1 [21,22] in various published studies. In our study, the sex ratio was 3.5:1(males-84, females-24). The mean age was 30 ± 11.10 years (range from 16 to 59 years). 35 (27 males, 8 females) age and sex matched controls were enrolled for Power Doppler ultrasound (the mean age was 30 ± 11 years and range from 16 to 54 years). The average duration of the disease was 3.46 ± 5.23 years (range from 1 month to 23years). SpA results in a significant reduction in health and wreckage of quality of life and leads to economic burden if not diagnosed early and or adequately treated.

In particular, in the early phase of AS, conventional sacroiliac radiographs may be normal, and it has been proposed to diagnose the disease with predominantly axial clinical manifestations before the presence of radiographic sacroiliitis. In addition, earlier symptoms often are mild, often ignored, or not recognized as being part of SpA by the treating primary care physician. This ultimately results in complete anatomical damage and radiological erosions, syndesmophytes formation and ankylosis of the axial skeleton and sacroiliac joints. Although, different modalities of imaging investigations like CT, MRI SCAN and SCINTIGRAPHY are available to demonstrate the spinal inflammation and sacroiliitis, each one has its own merits and demerits, hence other imaging modalities are being warranted in early diagnosis of SpA.

By using CT scan,[40,41] sclerosis, erosions and ankylosis can easily be diagnosed, and for the detection of bony changes, CT scan is superior to MRI. In addition, to cartilage erosions, MRI also identifies abnormalities, thought to reflect inflammatory disease activity in the joint, cortical bone marrow and subchondral bone.[34,35] The sensitivity of quantitative SI joint scintigraphy is reportedly high, but the increased bone turnover in SI joints lowers the specificity of this technique.[54,63]

MRI has been proposed by many investigators as the best method of detecting sacroiliitis, especially early in the course of the disease. Wittram Conrad et al [35] did the Comparative study of MR and CT in Suspected Sacroiliitis in 39 cases with 9 controls. He found that, MRI (T1WFS and fast STIR) can replace CT in cases with a strong clinical suspicion of sacroiliitis and equivocal or normal plain radiographs. The sensitivity and specificity of MR images for the detection of cortical erosions and subchondral sclerosis when compared to CT images were 100 and 94.3%, respectively. The interobserver variation was low (k = 0.80) with MR and T1WFS and fast STIR images were superior to T1 and T2 images. In our study, when CT scan compared with MRI, the sensitivity of MRI was 100% and specificity 83% and CT scan was unable to pick up sacroiliitis in 12 cases in group-1. Whereas in group- 2, both CT scan and MRI have shown equal 94% sensitivity and specificity.

Another study by Battafarano DF et al [72] by the Quantitative bone scan (QBS), computed tomography (CT), and magnetic resonance imaging (MRI) have each been used to confirm the diagnosis of active sacroiliitis (SI) in patients with low back pain (LBP). The authors prospectively evaluated 19 patients referred for symptoms of possible inflammatory LBP (group I), 26 seronegative spondyloarthropathy (SNSP) patients with LBP (group II, inflammatory or mechanical), and 5 SNSP patients without LBP (group III) to determine which radiological scan is helpful in sacroiliitis. He found MRI, which had 100% predictability, was the best single test for confirming active inflammatory SI. It can demonstrate early pre-destructive alterations (Bone marrow oedema) of sacroiliitis. He also found that, ESR and CRP did not significantly correlate with sacroiliitis. In our study, as mentioned in previous paragraph, MRI was 100% predictability in detecting active sacroiliitis. As against the Battafarano DF et al study, in ours, ESR and CRP were statistically significant in disease duration less than 1 year (group-1), P-0.01 & P-0.005 respectively.

Murat Fani BOZKURT et al [63] studied the combined use of bone and bone marrow scintigraphy for the diagnosis of active sacroiliitis. Thirty-one patients who were clinically suspected to have SI were included in the study. Bone and bone marrow scintigraphy were done after injections of 740 MBq of 99mTc-MDP (MDP) and 370 MBq of 99mTc-sulfur colloid (SC) respectively with a 2-day interval. Both visual and quantitative assessment of MDP uptake and visual assessment of SC uptake in sacroiliac joints were performed. Also sacroiliac joint radiographic findings for each patient was evaluated and graded from O to 4 according to the New York grading system. Patients were divided into 2 groups according to their x-ray findings (Group A: grade 0-2, Group B: grade 3-4). A total of 14 patients (10 bilateral, 4 unilateral) had increased MDP uptake with decreased/normal SC uptake. Twelve of 14 patients had grade 0-2 radiographic changes while only 2 patients had

grade 3-4 radiographic changes. Increased MDP uptake with decreased/normal SC uptake is the most common scintigraphic pattern seen in the acute phase of SI in which radiographic findings are generally found to be normal or slightly changed. In at least in 8 patients decreased bone marrow uptake of SC was demonstrated, supporting the diagnosis. Although his results did not reveal any significant superiority of bone marrow scintigraphy over bone scan for the detection of active sacroiliitis, combined use of bone and bone marrow scintigraphy was presented as an alternative method to characterize patients with active sacroiliitis.

The study by Bredella MA et al [(67)]was to evaluate whether MRI findings of the sacroiliac joints are able to distinguish between active and inactive disease in patients with established ankylosing spondylitis and to determine whether these findings correlate with markers of clinical activity, disease duration, severity, and degree of radiographic damage on eighteen patients with symptomatic moderate to severe ankylosing spondylitis. MRI of the sacroiliac joint (1.5 T) was performed using fat-saturated T2-weighted, T1-weighted, STIR, and fat-saturated contrast-enhanced T1-weighted sequences. The sacroiliac joints were evaluated by two radiologists for enhancement, subchondral bone marrow edema, erosions, and subchondral fatty marrow infiltration. Findings on MRI were analyzed for correlation with multiple clinical characteristics and measures of disease activity, including radiographic scoring. MRI showed abnormal findings of the sacroiliac joint in 17 patients. Ten patients showed active disease on MRI as measured by abnormal enhancement and subchondral bone marrow edema. Disease activity detected using MRI correlated in a positive fashion with only C-reactive protein (CRP) level. There was no correlation with the other measures of disease activity or with disease duration. In 14 patients, fatty subchondral bone marrow was detected on MRI. These changes were seen in patients with active and chronic disease and correlated with higher radiographic scores but not with disease duration or markers of disease activity. Contrast-enhanced MRI of the sacroiliac joint is sensitive in depicting sacroiliitis in patients with established ankylosing spondylitis. Subchondral edema and enhancement correlated with high CRP levels. Subchondral fatty bone marrow changes were seen in both active and chronic sacroiliitis and correlated with higher radiographic scores. These changes may be a marker of more advanced disease.

Similar study by Finbar o'shea et al, observed that acute inflammation is better reflected by MRI.[(70)]The value of MRI in the diagnosis of sacroiliitis has been well established. MRI accurately delineates the cardinal features of sacroiliitis, like changes in joint space width and symmetry, presence of erosions, subchondral edema, sclerosis, cysts and ankylosis. Furthermore, MRI plays a useful role in patients with early disease, by its superior ability to directly image changes in articular cartilage. Comparative studies between MRI and CT in the evaluation of patients with suspected sacroiliitis have further shown that the sensitivity and specificity of MRI for the detection of cortical erosions and subchondral sclerosis when compared to CT images was 100 and 94.3%, respectively. MRI offers valuable information about the lesions affecting the various structures of the sacroiliac joint in sacroiliitis.

Though, the MRI was the major tool of imaging investigations in sacroiliitis, the availability of MRI is often limited and the technique is time-consuming and costly, imposing practical difficulties for its clinical application in all patients with inflammatory back pain and suspected sacroiliitis. MRI is also limited in patients with metal implants or pacemakers, or with claustrophobia. Despite the use of all these different modalities, difficulties in diagnosing sacroiliitis remain.

Power Doppler US, has recently have taken a big stride in the field of rheumatology, being called as rheumatologist extended arm, rheumatologist stethoscope and more appropriately as poor man's MRI. Various authors have done studies on sacroiliitis with Colour Doppler Ultrasound and with Power Doppler US and inferred that Power Doppler US was found to be a useful tool of investigation in spondyloarthritis, enthesitis, in diagnosing and in assessing the response to treatment. Patients with SpA, need to do scanning at multiple entheseal sites, joints and dactylitis scanning and also after treatment. Power Doppler US is useful, convenient and most appropriately, bed side scan than MRI scan.

Ercument Unlu et al[(48)] have demonstrated that signs of active sacroiliitis and the response to anti- TNF therapy with CDDUS. He included 39 consecutive patients with AS (24 men, 15 women, mean age 37.3 ± 10.8 yrs) and with 14 age and sex matched controls (8 men, 6 women, mean age 37.2 ± 10.7 yrs) and with 11 AS patients after anti- TNF therapy (Infliximab in 7 patients and Etanercept in 4 cases). CDDUS measurements were done before therapy and during the 12th week of therapy. RI values are low in sacroiliitis and found to have higher RI values after anti- TNF treatment. He suggested that, CDDUS may be an alternative, less expensive, and easier method for detecting inflammation secondary to increased SI and spinal vascularization and in evaluating response to anti-TNF therapy in AS. In our study, we have included 108 consecutive patients SpA (84 men, 24 women, mean age 30 ± 11.10 yrs) and with 35 age and sex matched controls (27 men, 8 women, mean age 30 ± 11 yrs) and did only diagnostic Power Doppler US and found to have low RI all patients between 0.60 – 1.2 (in both group-1 & 2). None of our patients were received anti-TNF treatment.

Arslan et al [(51)] study with CDDUS has shown that, RI was similarly significantly decreased in patients with active sacroiliitis, and then increased after antiinflammatory therapy. However, he has done this study on heterogeneous patients groups as he included psoriatic arthritis and tuberculosis and he has not compared with clinical disease activity parameters and has not used anti – TNF.

Unlike this study, Ercument Unlu et al study groups are homogenous as he selected only AS patients. In their study, results of CDDUS in patients with inactive disease were nearly similar to controls. Limitation of these two studies is that no comparison was made with MRI. In our study, we have selected only spondyloarthritis patients and we have compared images of CT scan and MRI with Power Doppler US and we have systematically analyzed with BASDAI and acute phase reactants- ESR and CRP. We have found that

MRI and Power Doppler US was 100% sensitive and 95% specific in diagnosing the early spondyloarthritis. No Power Doppler flow was noted in our controls. We have not repeated the imaging after NSAID. (figure-6, table-4)

Andrea Klausar et al [50] compared with MRI, microbubble contrast-enhanced and non enhanced colour Doppler US in 103 (206 SI joints) patients with inflammatory back pain and with 30 (60 SI joints) controls without inflammatory back pain. He found that CDDUS was a sensitive technique with negative predictive value for detection of active sacroiliitis. None of the controls have shown colour flow state by CDDUS. In our study too has similarly shown that Power Doppler US was sensitive with 100% negative predictive value. Likewise, none of our controls have shown Doppler flow state. (Figure-6, table-4)

In our study, statistical analysis ($\chi 2$, κ statistics) was done only for 65 cases for whom all three imaging investigations were done and 35 controls were enrolled only for Power Doppler US. Statistically when CT- scan was compared with MRI, the sensitivity of MRI was 100% and specificity 83%, positive predictive value 8% (PPV), negative predictive value 100% (NPV), accuracy 83% (Ac), kappa 0.11 (κ), false positive rate 17% (FPR) and false negative rate 0% (FNR). When CT scan was compared with Power Doppler US, the Power Doppler sensitivity was 100% and specificity is 85%, PPV25%, NPV 100%, Ac 86%, κ 0.35%, FPR 15% and NPR 0%. When MRI was compared with Power Doppler US, the sensitivity was 100%, but specificity rises to 95%, PPV25%, NPV 100%, Ac 95%, κ 0.38%, FPR 5% and NPV was 0%. (table-4)

Here again, the inflammatory component may come down as the disease advances, indicating that MRI and Power Doppler may not identify the true inflammatory lesions. Therefore, to assess the importance of doing imaging in early spondyloarthritis, study cases (65 cases) were again divided into two groups. Group 1: Disease duration $\leq$ 1 year (33 cases) and group 2: > 1 year (32 cases) and these two groups were again statistically analyzed and compared for MRI versus Power Doppler US. In group: 1, both MRI and Power Doppler US was 100% (sensitivity & specificity) whereas in group: 2, although MRI/ Power Doppler US was 100 % sensitive, the specificity decreases to 70%.

In addition, group: 1, patients and their 3 imaging were statistically analyzed with OR (Odds Ratio). CT- scan OR, 1.00, MRI- scan, OR, 2.09 and Power Doppler US, OR, 2.20. Therefore, Power Doppler US was 2.20 times better than CT and MRI scan in spondyloarthritis with disease duration less than 1 year.

In this study, inflammatory markers like ESR and CRP and the clinical assessment BASDAI score were correlated and statistically analyzed by single sample student's t- test. The mean ESR was 61.80 ± 24.51(minimum 10, maximum 110 mm) and mean CRP was 16.51± 9.11. The statistical significance of ESR and CRP when compared with MRI scan was P-0.01 and P-0.05 respectively. The mean BASDAI was 4.47 ± 1.20 but it was not statistically significant. (P-0.57). whereas in another published study of patients with AS who had active disease according to BASDAI score, the ratio of men was higher ($p = 0.034$), and higher values were recorded for mean ESR ($p = 0.05$) and CRP ($p < 0.001$). In various studies, it was demonstrated that anti-TNF therapy led to regression of SI and spinal inflammation findings on MRI. Conventional radiography might show chronic spinal changes; however, it does not give immediate information about response to therapy.

Screening of patients with MRI scan was costly and it has some limitations in certain patients. Presence or absence of sacroiliitis as detected by whatever reliable, reproducible, and affordable method will continue to be a cornerstone for the diagnosis of SpA/ AS. Potentially, Power Doppler Ultrasonography may take over as one of the alternative investigations in patients with spondyloarthritis due to its relative availability and low cost, and surely may then be a useful tool in diagnosing and assessing response to therapy. Literature has proved that if diagnosis of Spondyloarthritis is made early and if treatment is initiated at the appropriate time with NSAIDs, DMARDs and THE BIOLOGICALS and by early initiation and maintenance of supervised group physiotherapy, near normal life can be restored.

7. Conclusions

1) Both MRI and Power Doppler Ultrasound are 100% sensitive in the diagnosis of sacroiliitis.
2) Though MRI scan is a time tested and the best method of detecting sacroiliitis, the availability of MRI is often limited and the technique is time consuming and costly, imposing practical difficulties in patients with metal implants, pacemakers and claustrophobia.
3) Occasionally closed MRI may not be suitable for obese patients and in severe inflammatory back pain with limitation of movements of spine.
4) CT scan, a useful modality of imaging in sacroiliitis, may not be suitable for early spondyloarthritis (less than 1 yr) and in addition, it is associated with radiation hazards.
5) Power Doppler Ultrasound can be used instead of MRI scan in spondyloarthritis, preferably with disease duration of less than 1 year.
6) Power Doppler Ultrasound is a dynamic real time scanning with absence of radiation; multiple joints can be seen on the same day with exact localization of symptoms and more importantly is patient's acceptance due to lesser cost. Thus, Power Doppler ultrasound is "Poor Man's MRI."
7) Power Doppler Ultrasound has become a potent imaging modality in diagnosing subclinical inflammatory arthritis and you can compare with the contralateral side. Therefore, Power Doppler is considered as an "extended arm of rheumatologists and rheumatologists stethoscope."
8) Power Doppler Ultrasound has proved to be a less time consuming, non invasive tool for assessing and monitoring the response to therapy at multiple joints and entheses in a single sitting at the bedside.
9) Though, Power Doppler Ultrasound is preferable but cannot replace MRI, because internal cortical bone pathology cannot be made out by Power Doppler US.

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Appendices

Abbreviations

SpA	Spondyloarthropathies
AxSpA	Axial spondyloarthritis
AS	Ankylosing spondylitis
uSpA	Undifferentiated spondyloarthropathies
ReA	Reactive arthritis
PsA	Psoriatic arthritis
IBD arthropathy	Inflammatory bowel disease related arthropathy
anti- TNF	Anti- tumor necrosis factor
HLA	Human leukocyte antigen
ESSG	European Spondyloarthropathy Study Group
CT scan	Computerized Tomography scan
MRI scan	Magnetic Resonance Imaging scan
STIR	Short Tau Inversion Recovery
T1FSE, T2FSE	T 1& T 2 Fast Spin Echo
ESR	Erythrocyte Sedimentation Rate
CRP	C - Reactive Protein
BASDAI	Bath Ankylosing Spondylitis Disease Activity Index
PDUS	Power Doppler UltraSound
CDDUS	Color Duplex and Doppler UltraSound
MSU	Musculoskeletal Ultrasound
SIJ	Sacroiliac joints
SI	Sacroiliitis
TV	Thoraco Vertebral
LV	Lumbar Vertebral
RI	Resistive Index