Radiology in Rheumatology

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5.1 Introduction

This chapter addresses different modalities of imaging in approaching the common musculoskeletal diseases (explaining the radiological part of diagnosis), we included: infectious arthritis (septic, tuberculous, and brucellosis), metabolic arthritis (gout and CPPD), rheumatoid arthritis, spondyloarthropathies (ankylosing spondylitis, psoriasis, and reactive arthritis), and degenerative bone diseases like osteoarthritis; it also addresses the role of the musculoskeletal interventional radiologist in the management of rheumatological diseases.

5.2 Learning Objectives

By the end of this chapter, you should be able to:

- Identify the radiological modalities used to diagnose different rheumatological disorders and their appropriate utilization.
- Emphasize on the importance of early radiological detection of infectious arthritis.
- Address the role of the radiologist in the prevention of the long-term rheumatological disabilities.
- Define the proper interpretation of the different musculoskeletal radiological modalities.

5.3 Infectious Arthritis

5.3.1 Septic Arthritis

Septic arthritis is an emergency and a type of destructive infectious arthropathy; it can cause significant mortality and morbidity, if unrecognized and left untreated. Irreversible joint destruction to a joint can be prevented by early diagnosis and prompt and effective treatment [1]. It is well-known that the definite diagnostic method is arthrocentesis by identification of an organism in the synovial fluid. The presence of painful, swollen joint and fever should raise clinical suspicion. Radiological studies play a significant role especially in cases where synovial fluid cannot be retrieved. In these cases, ultrasound- or fluoroscopic-guided joint aspiration demonstrates their importance in reaching the diagnosis. In general, imaging has an adjunct role to arthrocentesis in diagnosing septic arthritis. Effusion and inflammation in some joints like the hip and sacroiliac

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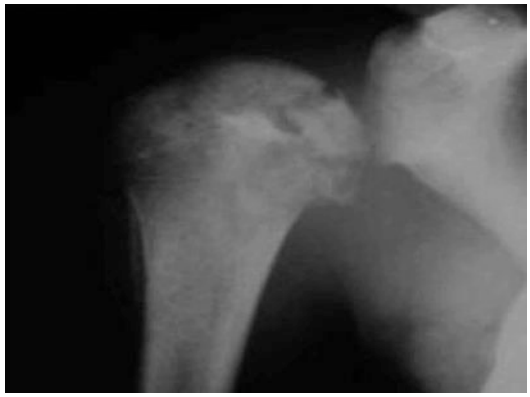

Fig. 5.1 AP view of the right shoulder demonstrates widening of the glenohumeral joint indicative of an effusion with sclerotic changes present on both sides of the sacroiliac joint

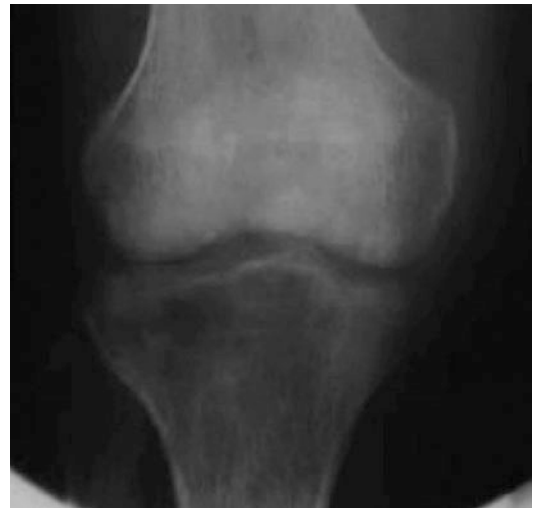

Fig. 5.2 AP view of the right knee demonstrates sclerotic changes present in the distal femur with periarticular osteopenia present in the tibia indicative of hyperemia

joints are difficult to examine clinically but can be detected by scintigraphy, CT scan, or MRI for defining extent of infection. MRI is a useful modality, while CT-guided bone biopsy or aspiration is the test of choice for defining the extent of bone involvement [2]. In rare cases, associated osteomyelitis or concurrent joint disease may be present, so radiographs should be obtained for an infected joint. In addition, it is useful to have a baseline radiograph to follow the response to therapy. In cases of failure to respond to intravenous antibiotics therapy, imaging should not be underestimated as it may change the line of management and guide intervention.

The following demonstrates the imaging modalities used to diagnose septic arthritis and characteristic findings in each one.

5.3.1.1 Radiographs

Conventional radiography should always be the first imaging technique used, although results are usually normal at presentation and generally lack sensitivity and specificity. The radiological findings vary according to the stage of the disease, for example, in the very early stage of the disease, X-ray may be normal, joint effusion may be seen Fig. 5.1, hyperemia may cause juxta-articular osteoporosis (Fig. 5.2), joint space may narrow due cartilage destruction in the acute phase, subchondral bone destruction may be evident on both sides of a joint, reactive juxta-articular sclerosis may develop if left untreated, and, in severe cases, ankylosis may develop (Fig. 5.3). In acute osteomyelitis, the early finding is osteopenia and then cortical destruction and periosteal new bone formation. Subacute and chronic osteomyelitis have different imaging features than marginal sclerosis and osteopenia, which indicate areas of healing. In chronic osteomyelitis, the most specific finding is a sequestrum (a fragment of dead bone surrounded by inflammatory tissue), which radiographically appears as a focal area of sclerotic bone within an area of lucency [1].

5.3.1.2 Ultrasonography

A noninvasive and inexpensive technique, it is considered an improved method for the early diagnosis of septic arthritis, with joint effusion and echoes inside being the characteristic finding of a septic joint. Clearly, it is superior to radiographs in detecting joint effusions as it can detect minor effusions, as small as 1–2 ml, and this allows ultrasound-guided arthrocentesis to be performed in patients with suspected septic arthritis. Furthermore, it is useful for examining inaccessible joints such as the hip. It can also show increased perisynovial vascularity using color Doppler. Echogenic debris may be present; it is very helpful in differentiating between tran-

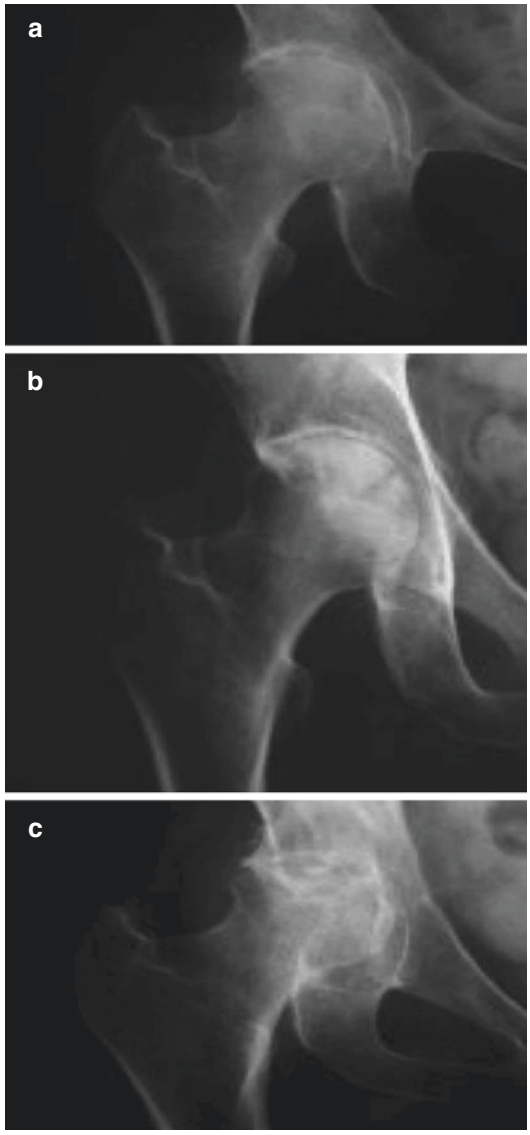

Fig. 5.3 Septic arthritis of the hip, (**a**) moderate osteoarthritic changes with concentric joint space narrowing early, (**b**) demonstrates sclerotic changes in the femoral head indicative of avascular necrosis after 4 months, (**c**) end stage after 8 months demonstrates flattening of the femoral head with osteolysis

sient synovitis and fresh hemorrhagic effusions. Echo-free image is seen in transient synovitis and fresh hemorrhagic effusions, while clotted hemorrhagic collections and septic arthritis do not have an echo-free image. This means that a negative sonogram will exclude fluid collection and the presence of echo-free effusion will virtually rule out septic arthritis [3]. However, for joints with non-distensible capsules (e.g., sacroiliac, sternoclavicular, and acromioclavicular joints), septic arthritis cannot be excluded in the absence of a visible joint effusion, and, if suspected, MR (or CT) imaging together with guided joint aspiration should be undertaken [4]. As mentioned earlier, on ultrasound, the hallmark of septic arthritis is the presence of a joint effusion in a patient with clinical signs and symptoms of joint infection. Ultrasound allows early diagnosis and treatment of septic arthritis, by enabling recognition and guiding the aspiration of joint fluid at an early stage [4]. Joint fluid in septic arthritis may be hypoechoic and clearly demarcated from joint synovium and capsule or hyperechoic and less clearly demarcated from joint synovium or capsule [4].

There are numerous advantages of clinical application of ultrasonography for the diagnosis of septic arthritis. Ultrasound is very sensitive in detecting the joint effusion of septic arthritis. The pathological extent of septic arthritis, in addition to the joint effusion and the joint surrounding subperiosteal abscess and cortical erosion, can be clearly defined and may indicate a concurrent osteomyelitis, which will help clinicians to treat by appropriate surgical debridement. Ultrasound can also help the clinicians avoid unnecessary needle joint aspiration by differentiating soft tissue abscess or tenosynovitis from septic arthritis [5].

5.3.1.3 CT Scan

CT features of septic arthritis are similar to the radiograph features; a fat-fluid level can be a specific sign in the absence of trauma. CT is better for visualizing local edema, bone erosions, osteitis foci, and sclerosis.

CT scan is also an imaging modality which may contribute to the decision of treatment, whether medical or surgical, not in septic arthritis itself but in concurrent osteomyelitis, and is able to detect some radiological features that indicate the need for surgical intervention and cannot be detectable by conventional imaging, for example, sequestra, medullary involvement, and the extent of sinus tracts; from this point, the value of CT

scan in planning medical and surgical treatment of chronic osteomyelitis is appreciated [6].

5.3.1.4 MRI

In general, MRI is the most powerful modality used for the evaluation of musculoskeletal joint infections and provides better resolution than radiography or CT scan for detecting joint effusion and for differentiating between bone and soft tissue infection. When IV gadolinium contrast is used with MRI showing the synovial enhancement, the sensitivity and specificity increase to 100% and 77%, respectively [7].

Joint effusion, cartilage and bone destruction, soft tissue abscesses, bone edema, and cortical interruption all are MRI findings of septic arthritis with or without osteomyelitis; MRI also can differentiate acute from chronic osteomyelitis. In acute infections, there is no sharp zone of transition between normal and abnormal bone marrow, and there is no cortical thickening or sequestrum (Figs. 5.4–5.6).

The presence of bone erosions is a good indicator for an infected joint, but it can also be a finding of non-septic inflamed joint. The same findings can be present in both infected and inflamed joint, so no single sign can be considered as pathognomonic for a septic joint or help

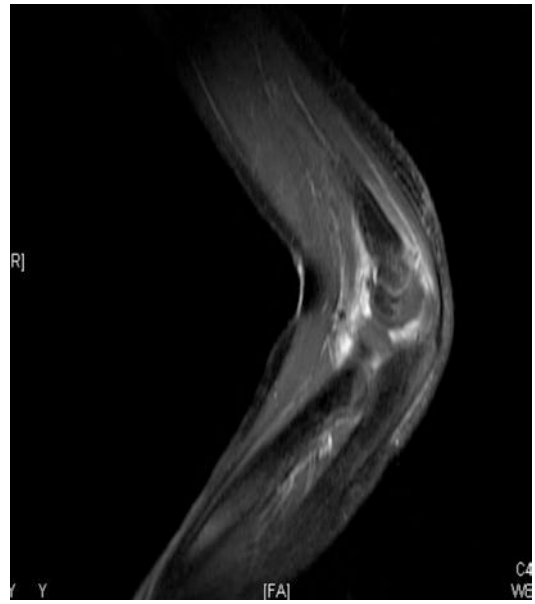

Fig. 5.5 T1-weighted images on your right demonstrate no effusion

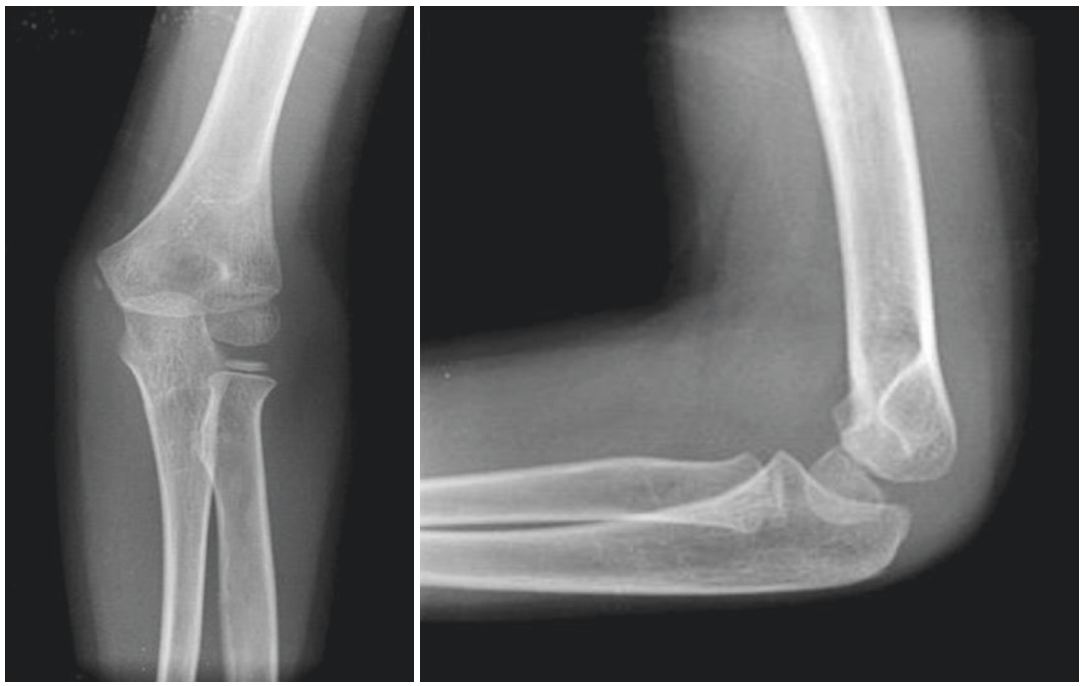

Fig. 5.4 AP and lateral radiographs of the left elbow demonstrate no specific abnormality

exclude its presence. Therefore, MRI is unable to differentiate between infective and other inflammatory arthritis [8].

5.3.1.5 Scintigraphy

This imaging modality can be helpful when evaluating suspected septic arthritis, particularly in the setting of prosthetic joint. Leukocyte-labeled 111-In combined with 99-Tc sulfur colloid studies provides accuracy of 90% in this clinical situation. Uptake of the 111-In in an area that does not show marrow activity with sulfur colloid is considered positive for infection [7].

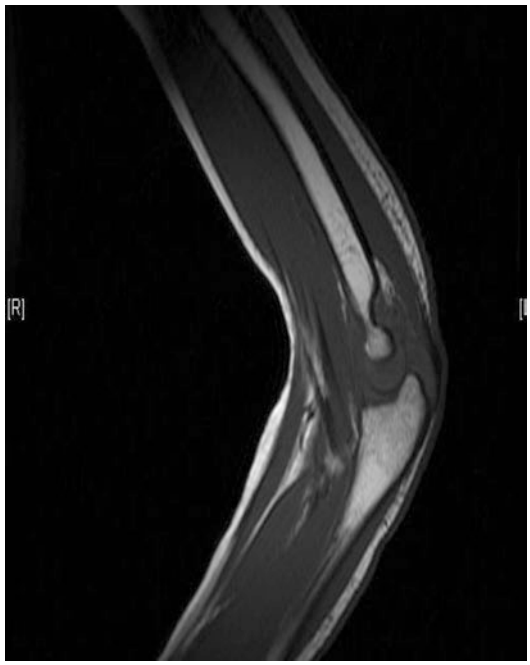

Fig. 5.6 T1 fat-suppressed images with IV gadolinium on your left demonstrate enhancement of the synovial lining of the elbow joint with some fluid present

5.3.2 Tuberculous Arthritis

Tuberculous arthritis is usually monoarticular, like other infectious joint diseases; the large joints, such as the hip and the knee, are most commonly involved, but in general, any other joint can be affected, with lower extremity joints being more affected than upper extremity joints [9]. Tuberculous arthritis is still considered a major concern for clinicians and healthcare workers, especially in developing countries. Advanced stage of the disease may be the first presentation, because of the delay in diagnosis.

In contrast to the old time when the diagnosis was made based on the clinical and basic radiological presentation alone (Table 5.1) [10], nowadays, the radiological investigations improved with more new modalities and new interventional methods, making the diagnosis of an infected joint more easy at any stage. In early stages of the disease, when plain X-rays are negative, it is considered a diagnostic dilemma, so, to avoid missing the diagnosis, the new diagnostic modalities like ultrasonography, CT, MRI, and image-guided aspiration of synovial fluid for PCR and tissue diagnosis should be used [10].

Usually, tuberculous arthritis is secondary to tuberculous osteomyelitis, in which a primarily tuberculous metaphyseal focus crosses the epiphyseal plate. One of the hallmarks of tuberculous skeletal infection is this transphyseal spread, which is not found in pyogenic arthritis,

Table 5.1 Clinico-radiological classification of tuberculosis of the hip [10]

Stages	Clinical findings	Radiologic features
Synovitis	Flexion, abduction, external rotation, apparent lengthening	Haziness of articular margins and rarefaction
Early arthritis	Flexion, adduction, internal rotation, apparent shortening.	Rarefaction, osteopenia bony erosions in femoral head, acetabulum or both No reduction in joint space
Advanced arthritis	Flexion, adduction, internal rotation, shortening	All of the above and destruction of articular surface, reduction in joint space
Advanced arthritis with subluxation/dislocation	Flexion, adduction, internal rotation with gross shortening	Gross destruction and reduction of joint space, wandering acetabulum

Source: Tuli, Tuberculosis of Skeletal system, fourth ed., 2010. p. 72.

so, without pre-existing osteomyelitis, arthritis less frequently occurs, owing to hematogenous spread of the tubercle bacillus to the synovial membrane [9].

Like any inflammatory joint, reactive hyperemia causing juxta-articular hyperemic osteoporosis, osseous erosions, and cortical and subcortical destruction on both sides of the joint space may be seen. Granulomatous inflammation can cause synovial thickening, and joint effusion may result in expansion of the joint; granulomatous synovial lesions expand inwards from the joint periphery, eroding the articular surface, with patchy cartilage destruction, erosions, and lytic bone lesions [9]. In a tuberculous joint, further extension to adjacent para-articular soft tissue with collection of cold abscess and sinus tracts may occur if not treated and discovered early, so early diagnosis is essential [9]. Radiological investigations play an important role in the diagnosis of tuberculous arthritis.

The following demonstrate the imaging modalities used to diagnose tuberculous arthritis and characteristic findings in each one:

5.3.2.1 Radiograph

Plain X-rays are reliable for detecting and for follow-up of treatment of tubercular joint.

Features are summarized in the Phemister's triad, which consists of juxta-articular osteoporosis, peripheral osseous erosions, and gradual narrowing of the joint space.

In tight or weight-bearing joints like the hip, knee, and ankle, marginal erosions are characteristic features of tuberculous arthritis.

In the early stage of tuberculous arthritis, lack of sclerosis or periostitis is another typical feature. In the end stage of tuberculous arthritis, severe joint destruction and eventually sclerosis and fibrous ankylosis may occur. Bony ankylosis may also occur, but it is less common than in pyogenic arthritis and, when present, is more likely to be secondary to previous surgical intervention [9].

5.3.2.2 Ultrasonography

The only finding is joint effusion, which is nonspecific and can occur in any joint inflammation.

5.3.2.3 CT Scan

CT scan is able to demonstrate bone destruction, sequestration, as well as extension of infection to the surrounding soft tissue or any sinus tract formation (Fig. 5.7) [9].

5.3.2.4 MRI

To detect early changes, MRI is the study of choice. On T2-weighted images, joint effusion appears hyperintense, loose bodies, calcifications and hemosiderin deposits due to bleeding may be hypointense; therefore, tuberculous arthritis should be considered in the differential; when an articular lesion with low- or intermediate-signal intensity on T2-weighted images is seen, marrow changes are of low-signal intensity on T1-weighted images and of high-signal intensity on T2-weighted images.

MRI is better than CT to detect associated soft tissue abnormalities, such as cellulitis, myositis, sinus tract formation, and para-articular collections. With IV gadolinium contrast, sinus

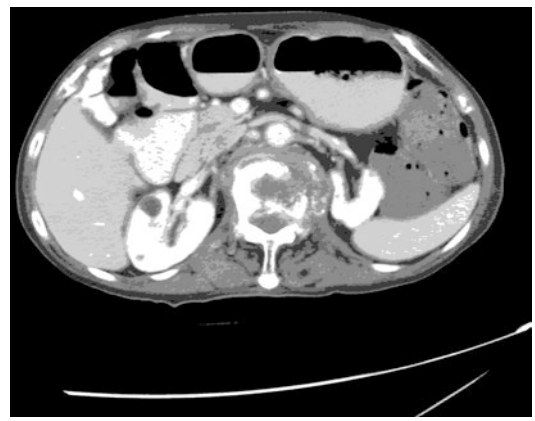

Fig. 5.7 CT scan of the abdomen and the level of the T12 demonstrate a destructive lesion of the body of T12 on the left side extending into the left parapelvic region with some calcification and enhancement peripherally

tracts display a linear high-signal intensity on T2-weighted images with marginal "tram track enhancement" on T1-weighted images. Tuberculous collections may be slightly hyperintense on T1-weighted images, in contrast to collections originating from many other infections (Fig. 5.8).

Precontrast T1-weighted images show a hyperintense rim around these collections, which enhances after administration of gadolinium contrast [9].

For differentiation of tuberculous arthritis and pyogenic arthritis, MR imaging of bone abnormalities, extra-articular lesions, and associated abscesses provides useful information [11].

5.3.3 *Brucella* Arthritis

Brucellosis is still considered a major health and economic issue in many parts of the world, and it can affect different parts of the body. Radiological investigations play an important role in the diagnosis and management of brucellosis [12]. Any joint in the body can be affected by *Brucella*, including sternoclavicular joints and sacroiliac joints, with large joints having more affinity to be involved. In long standing and neglected cases of *Brucella*, avascular necrosis of the femoral head can occur [12]. A favorite location for *Brucella* septic arthritis and osteomyelitis is the sacroiliac joint, and its involvement can extend to bone and muscle involvement in the region [8]. It also affects both joint spaces in the sacroiliac joint and causes erosive and bony destruction of the sacroiliac joint, with enhancement, which is one of the hallmarks of *Brucella* septic arthritis [12]. The radiologic features of the affected joints are indistinguishable from those of tuberculous or pyogenic arthritis; thus, differentiation depends on laboratory findings [13].

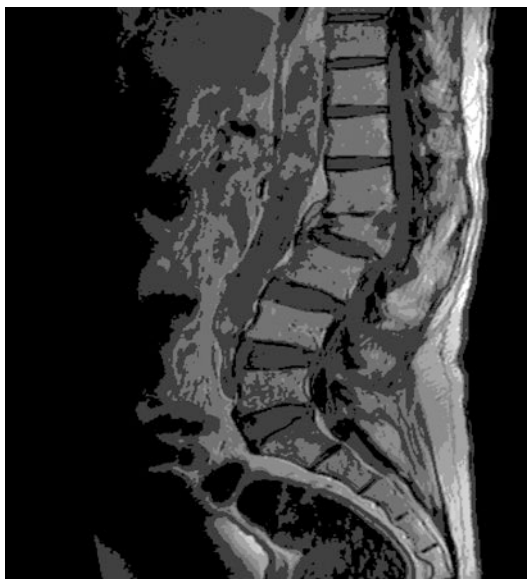

Fig. 5.8 Sagittal MRI T1-weighted of the lumbar spine demonstrates kyphotic deformity of L2 with destructive lytic lesions of the body of L2 and L5 from tuberculous involvement

5.3.3.1 Radiograph

The radiographic findings in a *Brucella* arthritis are not specific and range from poorly defined joints, joint space narrowing or widening, ankylosis, sclerosis, subchondral erosions, to no visible abnormalities [14].

5.3.3.2 Ultrasonography

Like any joint inflammation or infection, ultrasound can detect joint effusion, which is a nonspecific finding, and guide aspiration of synovial fluid to help in the diagnosis.

5.3.3.3 CT Scan

One of the hallmarks of *Brucella* septic arthritis is that it affects both joint spaces in the sacroiliac joint and causes erosive and bony destruction of the sacroiliac joint, with enhancement [12].

5.3.3.4 MRI

In *Brucella* sacroiliitis, bone marrow edema and intra-articular synovial fluids are important clues for early diagnosis. Sclerosis and ankylosis are observed in late phase of the disease.

Peripheral joint involvement can be diagnosed by the presence of bone marrow edema, joint derangement, enhancement of synovium, and periarticular soft tissues after intravenous injection of gadolinium (Figs. 5.9 and 5.10) [15].

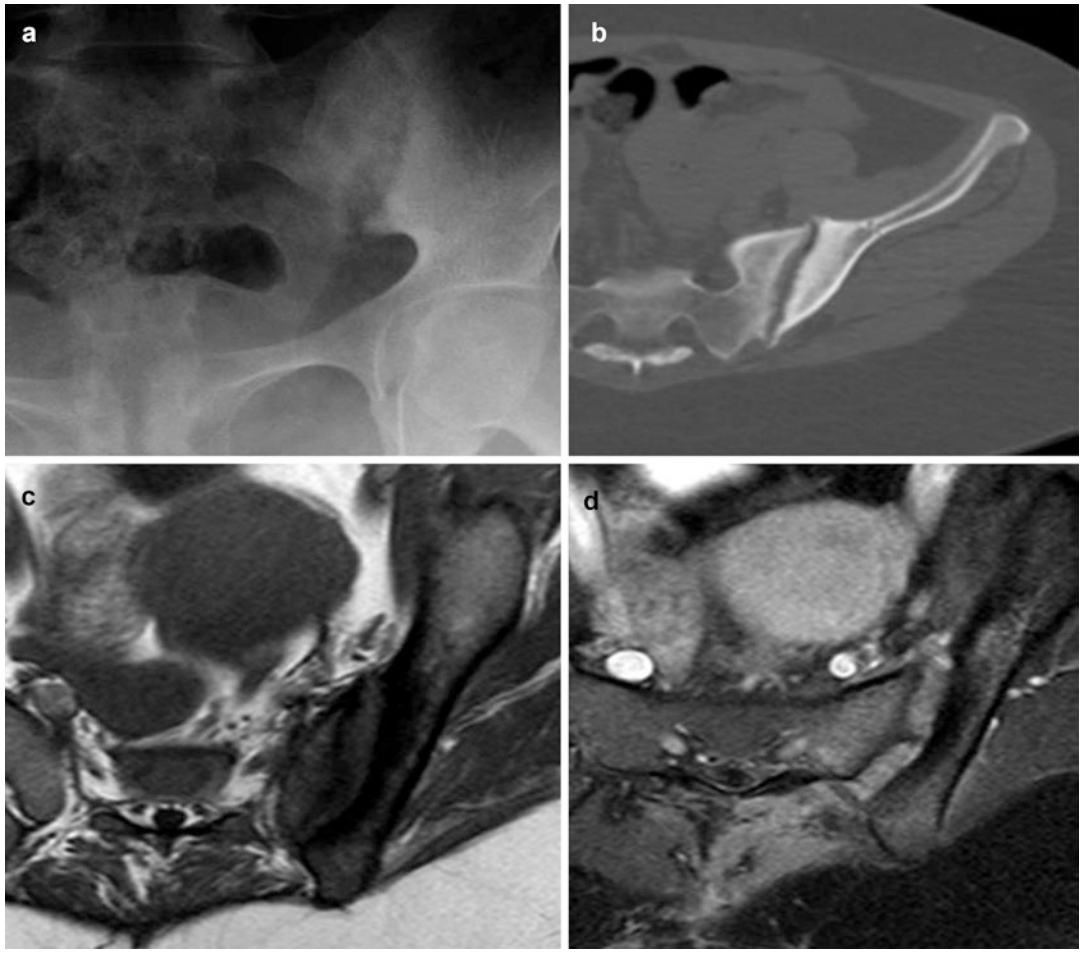

Fig. 5.9 (**a**) Plain radiograph of the left sacroiliac joint demonstrates sclerotic changes on the iliac side of the sacroiliac joint and widening of the sacroiliac joint on the left side. (**b**) demonstrates sclerotic changes of the left sacroiliac joint on the iliac side with widening of the sacroiliac joint. (**c**) Axial T1-weighted image demonstrates sclerotic changes of the sacroiliac joints with some widening. (**d**) demonstrates widening of the left sacroiliac joint with marked enhancement following gadolinium administration that extends into the left paraspinal muscles and subcutaneous tissue

5.3.3.5 Scintigraphy

Joints involved in a vast majority of patients show an increased uptake on bone scans.

5.4 Metabolic Arthritis

5.4.1 Gouty Arthritis

Gout is a common cause of arthritis; it can be diagnosed by expert clinician based on clinical picture and laboratory findings, with little or even no benefit from imaging, but still imaging is needed in cases where deep structures like the spine or sacroiliac joints are affected or when the gouty joint mimics mass lesion or infection. However, many patients with gout visit non-specialized physician, and in such cases, imaging may have an adjunctive role in gout diagnosis and management. Different radiological findings can be found in gout, for example, erosions, synovial proliferation, tophus, bone marrow edema, cartilage involvement, and joint effusion, all these findings need different imaging modalities, with

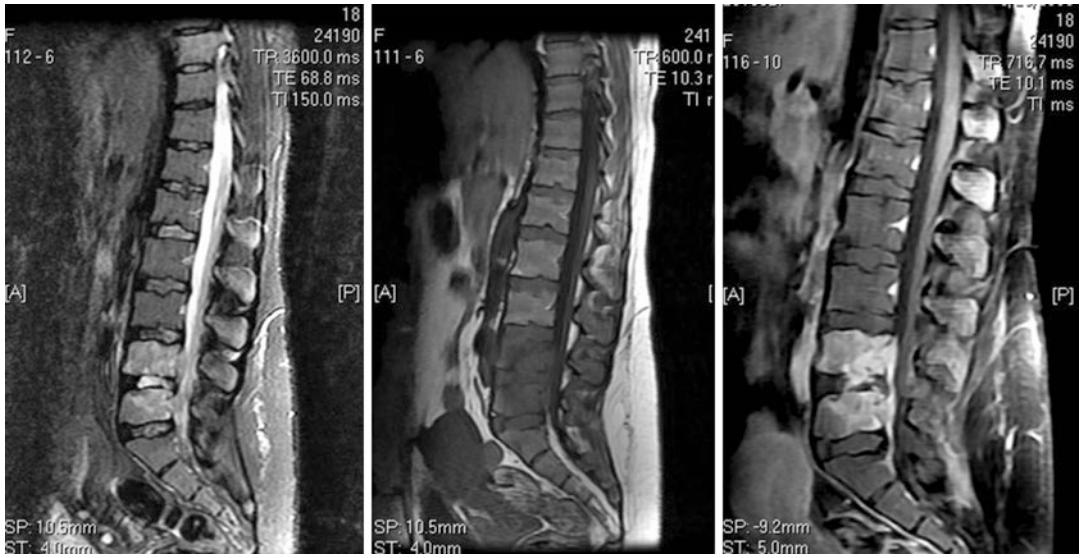

Fig. 5.10 First image on your left demonstrates high signal changes in the L4 and L5 vertebral bodies on this T2-weighted sagittal MRI of the lumbar spine. Middle image is a sagittal T1-weighted image of the lumbar spine with extensive low-signal changes of L4 and L5 with involvement of the disc space. The third image on the right is a sagittal MRI T1-weighted image with gadolinium enhancement and demonstrates marked enhancement of the L4 and L5 vertebral body with enhancement of the L4-L5 disc space

Table 5.2 Comparative utility of X-ray, US, CT, and MRI in the diagnosis of gout [16]

	X-ray	US	CT	MRI
Erosion	+	++	+++	++
Effusion	+	+++	++	+++
Synovial proliferation	–	+++	+	+++
Tophus	+	+++	++	+++
Joint space narrowing	+++	–	+++	+++
Tendon pathology	–	+++	++	+++
Bone marrow edema	–	–	+	+++
Tophus or synovial vascularity	–	+++	–	+++

Source: Review Article, Imaging Appearances in Gout, Volume 2013 (2013), Article ID 673401, 10 pages.

different utilities for each, based on sensitivity (Table 5.2) [16].

5.4.1.1 Radiographs

It is usually a late finding, underestimating the degree of involvement; first MTP involvement is a characteristic finding of gout, juxta-articular erosions with sclerotic margins and overhanging edges, and preservation of joint spaces and periarticular bony density until the disease process is late. The gouty deposits around the joint can be juxta-articular, intra-articular, and subchondral and usually not symmetric (Fig. 5.11). The hallmark of chronic gout is the formation of tophus, which is a soft tissue nodule that represents the granulomatous immune reaction of the body to monosodium urate (MSU) crystals. Tophus calcification is a late finding and may be associated with calcium metabolism disturbance. Erosions are often located next to a tophus (Figs. 5.12 and 5.13) [16].

5.4.1.2 Ultrasonography

Without contrast agent, sonography can detect tophaceous deposits in the soft tissues, joints, cartilage, as well as synovitis, erosions, and

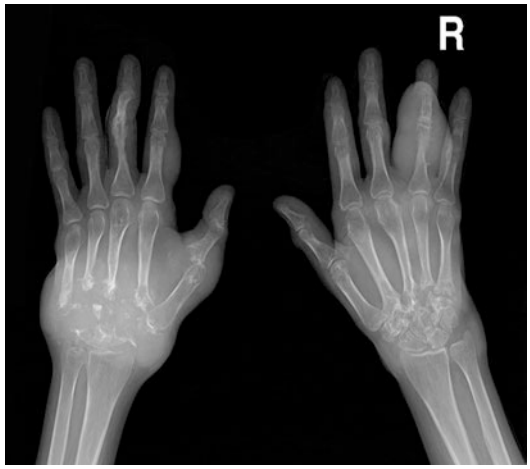

Fig. 5.11 AP view of both hands demonstrates punched out erosions of the left carpal bones along with marked soft tissue swelling at the wrist joint indicative of tophus formation

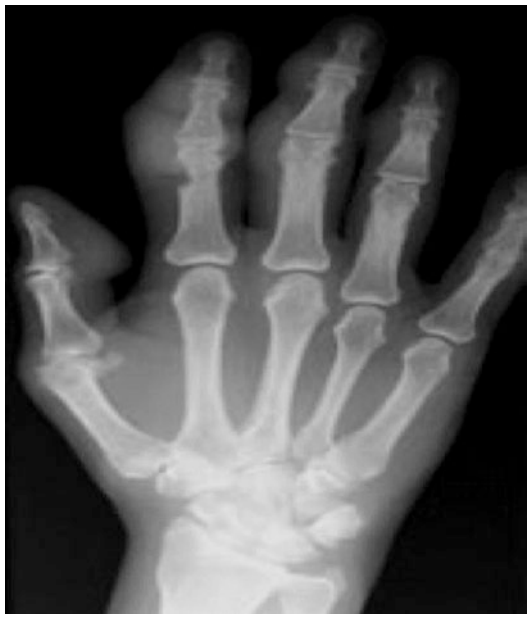

Fig. 5.12 AP view of the right hand demonstrates marked soft tissue swelling at the first metacarpophalangeal joint, second PIP along with punched out erosion of the proximal second phalanx

increased vascularity. It has a good role in the early diagnosis and monitoring the response of the treatment of gouty arthritis. In patients with an acute gout flare, or patients with history of prior gout attacks, or even patients with asymptomatic hyperuricemia, the "double contour sign" is a sign that can be seen by ultrasound, an irregular echogenic line, caused by urate deposition over the most superficial layer of hyaline cartilage, with a sensitivity ranging from 25% to 95% in patients with gout [16].

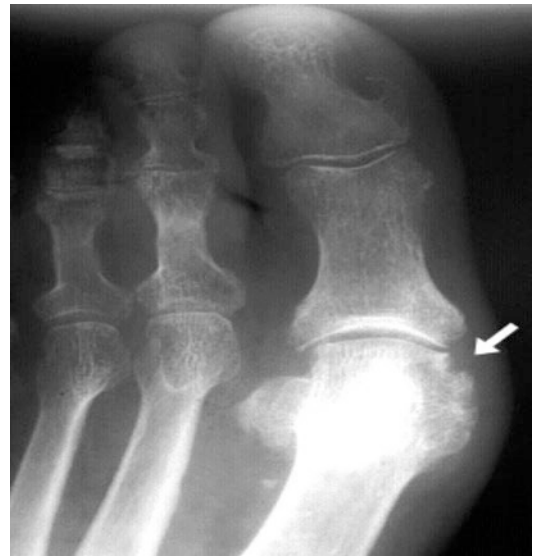

Fig. 5.13 AP radiograph of the left first toe demonstrates punched out erosion of the first metatarsophalangeal joint and first metatarsal head. Notice that the joint space is preserved

The tophus on ultrasonography appears as an anechoic halo and hyperechoic heterogeneous center. Tophi by ultrasound appearance could be either soft or hard tophi, based on sonolucency (soft tophi), and difficulty to image the structure below them (hard tophi), which are usually long-standing tophi [16]. Synovitis in gout by ultrasound shows mixed echogenicity, predominantly hyperechoic with associated increased vascularity. Some cases show hyperechoic foci which represent microtophi, resulting in "snow storm appearance."

Ultrasonography is excellent for identifying bursitis, intratendinous deposition, enthesitis, and subcutaneous nodules seen with gout [16].

5.4.1.3 CT Scan

Dual-energy computed tomography (DECT) has a promising role in diagnosing gout. Based on the spectral dual-energy properties, unique

color-coded aggregates of urate crystal can be seen. This distinguishes gout from other crystal deposition disease, such as hydroxyapatite crystal deposition disease. Characteristic gout erosions and tophi are very sensitive to be detected by conventional CT, but its use is limited by cost. Gouty tophus can be intra-articular or extra-articular, or located in tendons and subcutaneous tissues, with pressure points preponderance. CT and MRI are very accurate in following up response to treatment, as tophi are known to decrease in size, but ultrasonography is more practical for follow-up studies as it is more available at lower cost with less ionizing radiation [16].

5.4.1.4 MRI

When gout affects deep tissues like the spine or locations not amenable to clinical examination like interosseous deposits in the midfoot, MRI is very helpful. It is also accurate in diagnosing the extent of gout involvement of the bursae and tendons and any associated tendon tears. On MRI, tophi appear as low signal on T1-weighted MRI and mostly intermediate signal on T2-weighted MRI [16].

5.4.2 Calcium Pyrophosphate Dehydrate (CPPD) Deposition Disease or Pseudogout

CPPD or pseudogout is a syndrome that manifests as arthritis clinically and as chondrocalcinosis radiographically or as an arthropathy that resembles that of degenerative joint disease. Most likely joints to be involved are the knee, symphysis pubis, and triangular cartilage of the wrist, and they should be examined in suspected patients. CPPD crystals can be found in any cartilage and in the soft tissues where it may mimic calcific tendinitis [17].

5.4.2.1 Radiograph

Arthropathy of CPPD crystal deposition is characterized by sclerosis, joint space narrowing, and osteophyte formation which is difficult to distinguish from degenerative joint disease except by the affected sites which are different than the sites of true degenerative joint disease. For example, pseudogout should be considered if radiocarpal joint, the elbow, or only the patellofemoral compartment of the knee joint is showing degenerative joint disease (Figs. 5.14 and 5.15) [17].

5.4.2.2 Ultrasonography

Based on studies, ultrasonography is more useful in cases of chondrocalcinosis than radiograph which is not sensitive nor specific [18], and it is better than radiograph and CT scan in diagnosing chondrocalcinosis in CPPD cases [19].

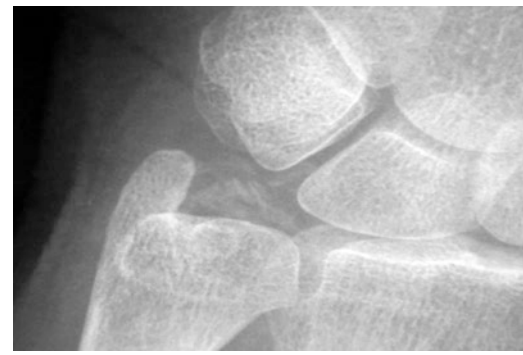

Fig. 5.14 AP oblique view of the right wrist demonstrates chondrocalcinosis of the triangular fibrocartilage complex

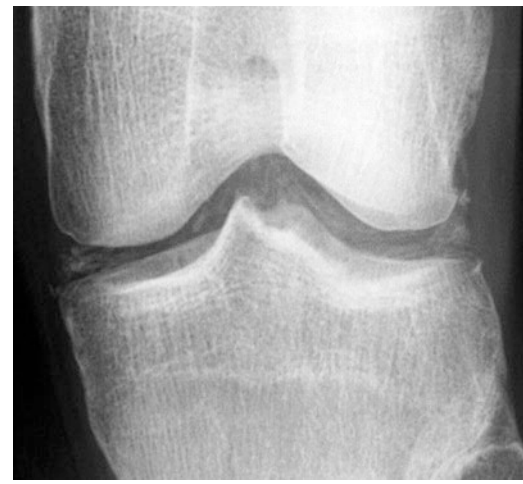

Fig. 5.15 AP view of the right knee demonstrates calcification of the articular lining of the knee. Consistent with chondrocalcinosis and related to calcium pyrophosphate dehydrate deposition disease

5.4.2.3 CT Scan

CT scan and conventional radiography are almost equal in the detection of chondrocalcinosis [19]. The pattern of CPPD on CT scans may show a calcific mass with a lobulated configuration, typically in the ligamentum flavum or within the joint capsule, and within the mass are septum like low-density areas. In addition, pressure erosions may be noted with disruption of adjacent bony cortex. Fine granular calcifications may also be noted. Subchondral cysts or erosions, as well as fractures, may be observed [20].

5.4.2.4 MRI

In detecting the CPPD deposits presence, MRI is not as sensitive as radiography, but 4 T MRI holds better promise in detecting CPPD crystals [21]. Calcifications of chondrocalcinosis are present on MRI as a signal void or decreased signal intensity. High-field MRI is especially effective for visualization of CPPD deposits. Because MRI does not visualize calcific structures well, CT scanning or radiographic confirmation is required; it has low sensitivity for visualization of CPPD deposits but can display massive deposition [20].

Rheumatoid arthritis (RA): It is the most common chronic inflammatory joint disease [22]. It is characterized by joint swelling, joint tenderness, and destruction of the synovial joints, leading to severe disability and premature mortality [23]. The hallmark of RA is bilateral symmetric arthritis of more than three joints (polyarthritis) [3]. Over 60% of patients initially present with symmetric arthritis of multiple small hand joints [3]. Typically, the second and third metacarpophalangeal (MCP) and the third proximal interphalangeal (PIP) joints are involved early in the course of the disease; the ulnar and radial aspects of the radiocarpal joint and the intercarpal, carpometacarpal, metacarpophalangeal, and proximal interphalangeal joints are other common sites [3]. Simultaneous synovitis of tendon sheaths of the wrists and hands is another distinct finding [3]. Bilateral and symmetric involvement of foot joints is another typical manifestation of RA [3]. The metatarsophalangeal and the interphalangeal (great toe) joints are favored sites [3]. All midfoot joints may be involved [3]. The talonavicular, subtalar, and tarsometatarsal joints are specific target areas [24].

Later in the course of the disease, large extremity joints and cervical spine joints could be insulted.

The role of radiology in RA is to either diagnose the disease or assess the disease status and progression.

5.4.2.5 Radiographs

Conventional radiography (CR) has been considered the gold standard for imaging in RA, its sensitivity for structural damage in RA diagnosis is low, and disease activity cannot be assessed [25]. When there is diagnostic doubt, CR, ultrasound, or MRI can be used to improve the certainty of a diagnosis of RA above clinical criteria alone [25]. CR of the hands and feet should be used as the initial imaging technique to detect damage. However, ultrasound and/or MRI should be considered if CR do not show damage and may be used to detect damage at an earlier time point (especially in early RA) [25]. The periodic evaluation of joint damage, usually by radiographs of the hands and feet, should be considered [25]. Monitoring of functional instability of the cervical spine by lateral radiograph obtained in flexion and neutral should be performed in patients with clinical suspicion of cervical involvement. When the radiograph is positive or specific neurological symptoms and signs are present, MRI should be performed [25].

Erosion: It is discontinuity of the white cortical line (marginal erosions) and subsequently become projection-like (Figs. 5.16 and 5.17).

Subcortical cysts: These are cystic changes in the subcortical bone which are easily identified as translucent lesions [24].

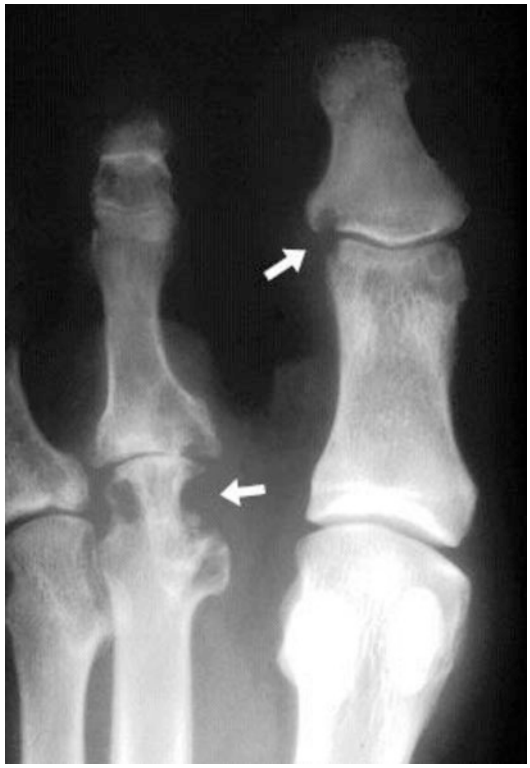

Fig. 5.16 PA view of the forefoot shows erosive changes (arrow)

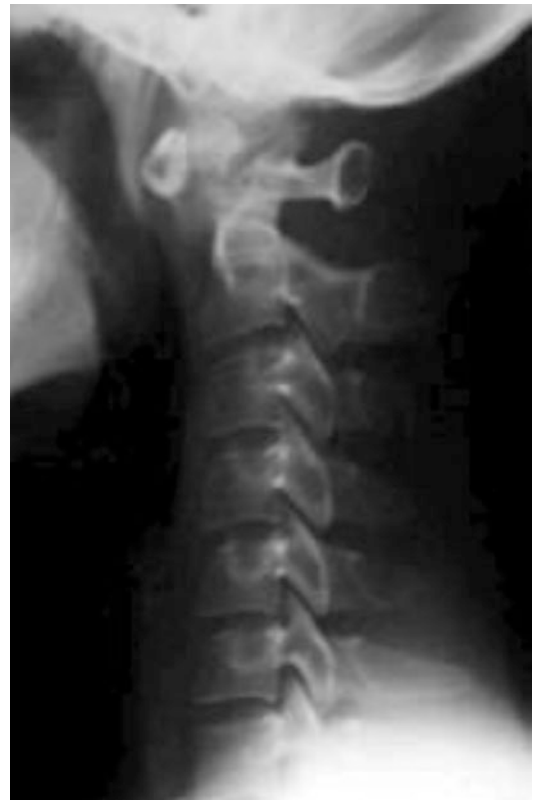

Fig. 5.17 Flexed lateral view of the cervical spine shows straightening of the cervical spine with atlantoaxial subluxation

Joint space narrowing: It is a late finding of RA and can be detected by CR (Fig. 5.18).

Periarticular osteopenia: This refers to non-sharp cortical end plates [3]. This finding is important especially radiographs are used as the first-line imaging tool.

Effusion: Plain radiographs demonstrate indirect signs of effusion such as joint space widening and soft tissue swelling as well as shifting of fat pads [24].

5.4.2.6 Ultrasonography/Magnetic Resonance Imaging (MRI)

Over the past decade, there have been significant advances in the field of musculoskeletal imaging, especially in the application of ultrasound (US) and magnetic resonance imaging (MRI) to the management of rheumatoid arthritis (RA). Both modalities offer significant advantages over the previous standards of clinical examination and radiography and allow direct visualization of both joint inflammation and structural damage. Although measuring similar pathology, each of these imaging tools has its own benefits and limitations, understanding of which can help researchers and clinicians to determine the appropriate role for these tools in RA joint assessment [22].

Ultrasound and/or MRI should be considered if CR do not show damage and may be used to detect damage at an earlier time point (especially in early RA) [25].

Synovitis: Cytokines mediate capillary leakage and edema in the acute phase. This facilitates syno-

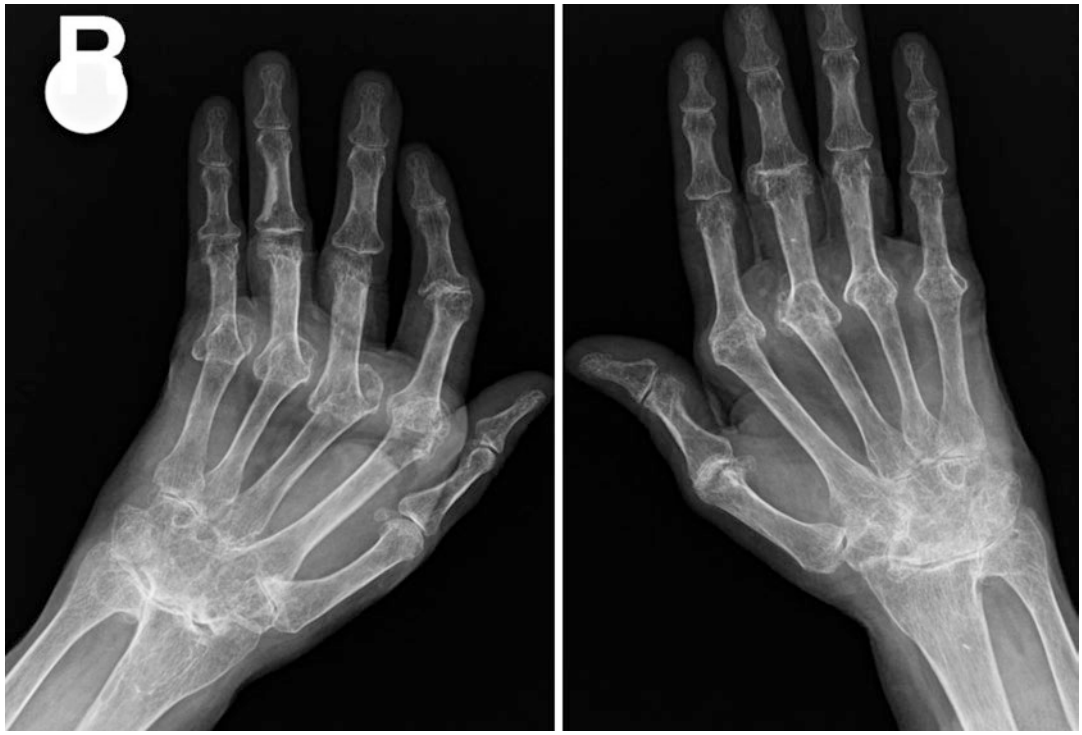

Fig. 5.18 PA view of the hands shows joint space narrowing, erosions, and diffused osteoporosis

vial swelling and leads to widening of the joint space, which may well be exaggerated by effusion [24]. Synovitis initially starts at bare areas.

Subcortical cysts: A number of more than three, in an eccentric location, and non-sharp margins increase the likelihood that the subcortical cyst is the result of an inflammatory joint process [3]. On MRI, arthritic cysts usually do not contain fat or trabecular bone [3]. When subcortical cysts are detected by MRI or US, they are considered pre-erosive changes.

Effusion: Both US and MRI can detect small effusion in small joints.

Periarticular osteopenia: This finding is a secondary indirect sign of synovitis.

Bone marrow edema (BME): MRI is the only modality of choice which can detect this finding. BME is a very useful prognostic indicator in RA. Affected marrow will readily show significant uptake of contrast material [24]. It is associated with disease activity.

Erosions: Naturally, erosions arise at the bare areas first due to the lack of the protecting cartilage layer. The diagnosis of erosions is very important as it may well influence therapy. MR imaging demonstrates erosions clearly [24]. US can detect them too.

Computed tomography (CT): It detects all bony changes and pathology; however, its use is limited due to high radiation.

Scintigraphy: Baseline inflammatory disease measured by scintigraphy appears to be associated with radiographic progression. In addition, multiple regression analysis has demonstrated that progression of radiographic joint destruction was primarily predicted by 99mTc-IgG scintigraphy, while joint swelling and erythrocyte sedimentation rate (ESR, IgM rheumatoid factor (RF)) are not predictive. This suggests that scintigraphy may be superior to conventional clinical and laboratory measurements in the prediction of joint destruction [25].

5.5 Summary

The diagnosis of RA is based on history, clinical examination, and laboratory results. If there is a doubt about RA diagnosis, the radiologic modalities take place to improve the diagnosis. CR is the gold standard modality for imaging in RA. MRI and/or US should be considered if the CR does not show any abnormality.

Assessment and follow-up periodic radiographs should be obtained for follow-up. MRI and/or US assesses the disease progression.

Spondyloarthropathies (SpA): They are a group of diseases that have a strong association with human leukocyte antigen B27 (HLA-B27), are characterized by inflammation of sacroiliac joints (sacroiliitis), and affect axial and appendicular skeleton. They include ankylosing spondylitis (AS), psoriatic arthritis (PsA), reactive arthritis known as Reiter's syndrome, and other uncommon arthritic diseases.

Ankylosing Spondylitis (AS): It is a disease that affects young age group, is rarely seen after the age of 40, and is more predominant in male gender. The inflammation affects the axial skeleton in symmetrical way and starts at sacroiliac joint in almost all cases. Spondylitis occurs in 50% of patient with AS and starts at the thoracolumbar and lumbosacral spines. Cervical spine joints are rarely seen affected alone. AS is easy to diagnose as it has a unique pattern of distribution and clear clinical picture.

Radiography: CR is still the first imaging modality and should be obtained for the diagnosis of AS. Anteroposterior (AP) pelvic, AP, and lateral spine X-ray should be ordered when AS is suspected. Other radiologic modalities are used to detect the disease in earlier stage or to determine the prognosis. CR can detect many changes in AS but not at early stage as compared to MRI and CT scan.

Erosions: Small erosions resembling the serrated edges of the postage stamp typically start at iliac side of the joint early in the disease course [26]. In the spine, the earliest change is enthesitis at the insertion of annulus fibrosis fibers. This process is a result of erosions and reactive sclerosis which occur at vertebral corner (Romanus lesions) (shiny corners) and cause vertebral squaring. AS is the least erosive spondyloarthropathy.

Ossification: The ossification of the ligaments at sacroiliac joints may appear as star shape, and complete joint fusion may be seen in advanced stage. As the disease progresses in the spines, the ossification starts developing at annulus fibrosis (s**yndesmophytes**). When the ossification continues through the apophyseal joint, complete spinal fusion occurs (**bamboo spine**). In advance disease, **dagger sign** (Fig. 5.19) appears which is the ossification of supra- and interspinous ligaments and can be detected by radiograph as slim ossified streak. When the ligamentous ossification occurs together with ossification of apophyseal joint capsules, there are three vertical

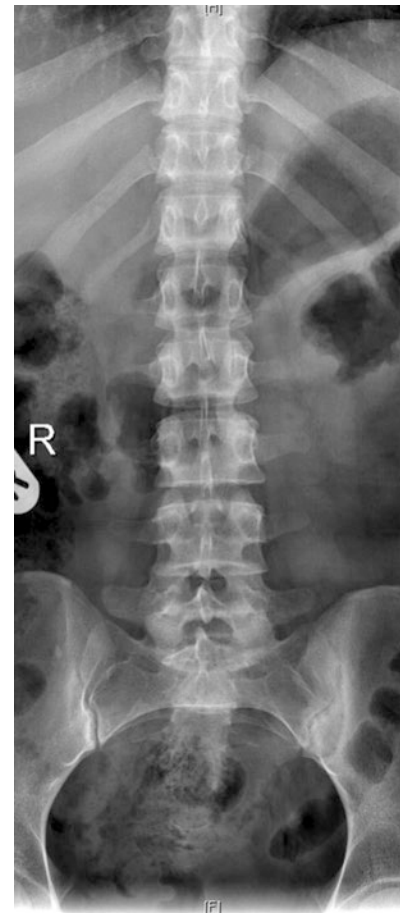

Fig. 5.19 PA view of the pelvis and spines shows bone fusion at sacroiliac joint (ankylosed) and spine fusion (dagger sign)

radiodense lines on frontal radiography (**trolley-track sign**) [27].

Ultrasonography: It has some utility for the evaluation of sacroiliitis when it is very active by using Doppler ultrasonography to assess blood flow and synovitis [26]. It may be useful in some cases in young children as an initial study but is limited to the evaluation of soft tissues surrounding the joint and not the joint itself [26]. Ultrasound may be used for diagnostic and therapeutic injections into the sacroiliac joints as an alternative to fluoroscopy in some cases [26].

Magnetic Resonance Imaging (MRI): MRI has become the gold standard imaging modality for the diagnosis of SpA of sacroiliac joints and spine [26]. It is very sensitive and specific to detect inflammatory changes in and around the sacroiliac joints and spine. Therefore, MRI findings are divided into active and chronic inflammatory findings.

5.5.1 Active Inflammatory Findings

Bone Marrow Edema (BME): It can appear in the sacroiliac joints and spine. It is strongly associated with disease activity and reflects the response to the treatment (Fig. 5.20).

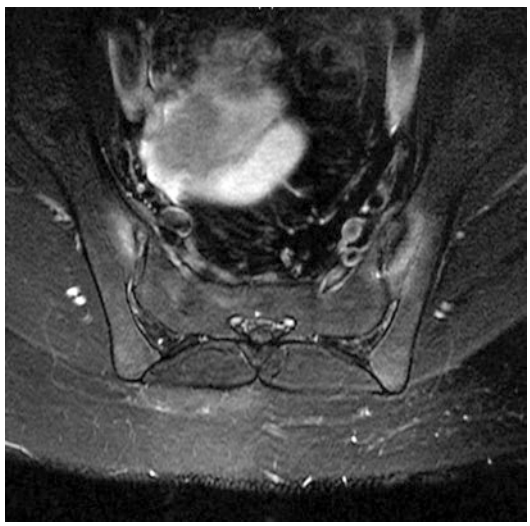

Fig. 5.20 MRI of the sacroiliac joints shows reduced bilateral sacroiliac joint space with symmetrical focal bone marrow edema along the iliac side of both joints

Synovitis/Capsulitis: These findings rarely occur without the occurrence of other findings in AS.

Enthesitis: This finding almost always occurs at muscle insertion and is considered a transient feature.

5.5.2 Chronic Inflammatory Findings

Sclerosis: This appears as low intensity on MRI and mainly develops at joint margins.

Fat deposition: This occurs at bone marrow area in the sacroiliac joint and at vertebral corners in the spine.

Bone bridging: This results from the ossification of ligaments which further lead to the formation of bone bridging and ankylosis as a final result.

Erosions: They are bony defects that can be seen as irregular shapes at joint margins.

Computed tomography (CT): CT is superior to MRI in detecting erosions. It is also used in case of trauma and emergency if fracture is suspected.

Psoriatic arthritis (PsA): PsA is a chronic systemic disease characterized by inflammatory joint changes and is accompanied with skin psoriasis. PsA affects joints asymmetrically. It involves the hands (no sparing joint), feet, and axial skeleton and rarely affects large joints. PsA develops in 7% of patients with skin psoriasis [26]. Axial psoriatic arthritis occurs in approximately 40% of patients with peripheral PsA [26].

Radiography: Radiographs are the first radiologic modality that should be obtained. The radiographic hallmark of PsA is the combination of destructive changes and bone proliferation.

Erosion: It is discontinuity of the white cortical line. Marginal erosion is an early PsA sign which then becomes irregular and ill-defined because of bone formation adjacent to erosions. This sign is also called "pencil in cup" (Fig. 5.21).

Joint space narrowing: Dramatic joint space narrowing may lead to serious disability.

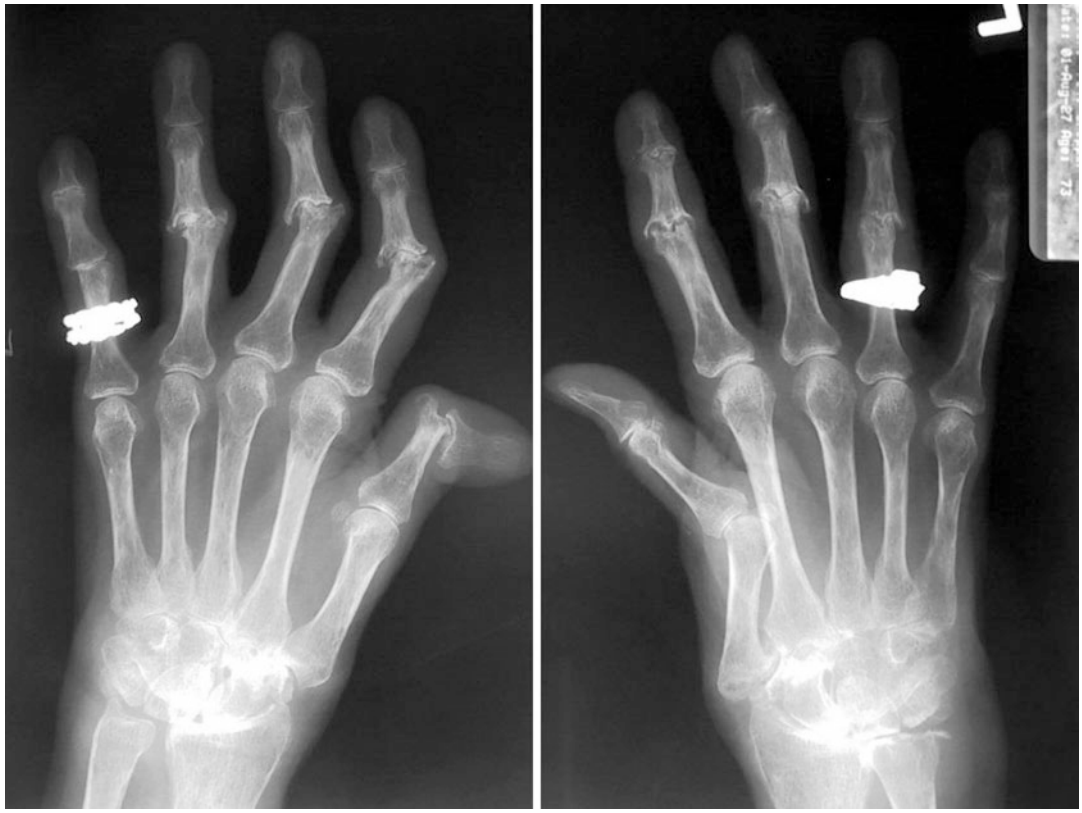

Fig. 5.21 AP view of the hand shows aggressive erosions (pencil in cup) which appear in all PIP joint of both hands; bone proliferation appears at distal part of metacarpal bones. Pan-carpal bone involvement. MCP joints are spared

Bone proliferation: This is a feature of PsA involving particularly metaphysis and diaphysis of the hands and feet.

Ultrasonography: Ultrasound (US) in conjunction with power Doppler (PD) indicative of degree of inflammatory activity has an increasing important role in the evaluation of PsA. In fact, US is useful mainly for its ability to assess musculoskeletal (joints, tendons, entheses) and cutaneous (skin and nails) involvement, to monitor efficacy of therapy and to guide steroid injections at the level of inflamed joints, tendon sheaths, and entheses [28].

Synovitis: Asymptomatic US synovitis and enthesopathy may indicate subclinical musculoskeletal involvement [28].

Erosions: These can also be detected by US.

Tenosynovitis: US findings indicative of tendon involvement include fusiform swelling and focal derangement of tendon echotexture [28]. Achilles tendon, plantar fascia, patellar tendon, and tenosynovial sheaths of the hand and ankle are frequently affected in patients with PsA [28].

Enthesitis: US signs of enthesitis include hypoechoic swelling of the tendon insertion, enthesophytes, and possible bursal enlargement [28].

Magnetic resonance imaging (MRI): This modality is mainly used when the axial skeleton is affected. MRI is the most sensitive imaging for the detection of subtle bilateral changes, which can be important in distinguishing PsA from septic sacroiliitis. The spondylitic changes in PsA and reactive arthritis appear more randomly than those in AS. Large chunky-appearing paravertebral ossification is commonly seen in the thoracolumbar junction. These ossifications do not bridge the intervertebral discs as seen in AS. Ankylosis, squaring of vertebral bodies, and spinal fusion are very rare in PsA.

Computed tomography (CT): CT has little role in the assessment of peripheral joints but may be useful in assessing elements of spine disease [28]. The accuracy of CT is similar to MRI in the assessment of erosions in sacroiliac joints; however, CT has radiation and is not effective in detecting synovial inflammation [28].

Reactive Arthritis (ReA): It is previously known as Reiter's syndrome. It is usually accompanied by conjunctivitis and urethritis. It affects males between the ages of 15 and 35 years. Arthritis might be the only clinical manifestation of ReA. The radiographic features are identical to those in PsA, but the difference is in the pattern of distribution which begins in the feet and then hand. History and clinical examination are helpful in differentiating ReA from PsA.

Osteoarthritis (OA): OA is the most common arthropathy in elderly. It impacts the quality of life, and it has a major implication on public healthcare. OA asymmetrically affects joints of the hands (sparing MCP joints), shoulders, feet, knees, hip, and spine.

Radiography: CR is the gold standard radiologic modality in detecting OA. It detects many OA features. Radiographic progression appears specific (91%) but not sensitive (23%) for cartilage loss [29].

Joint space narrowing: Non-uniform narrowing of the joint spaces occurs in OA.

Osteophytes: These are joint spurs that occur along joint margins. Osteophytes can also be observed on the joint line (Fig. 5.22). The definition of OA relies on the presence of osteophytes on anteroposterior weight-bearing radiographs [29].

Sclerosis: It is seen as an increased density on radiograph [30].

Cyst formation: This is seen as a loss of trabecular structure [30].

Ultrasonography: US is widely used in RA and has been accepted to be used in OA too. US has the advantage of assessing and visualizing many OA features without exposing the patient to radiation. One limitation of US is that it cannot penetrate the bony parts to visualize the structures beyond them. The use of US is more common for hand and knee OA and has very limited usage in the assessment of other joints.

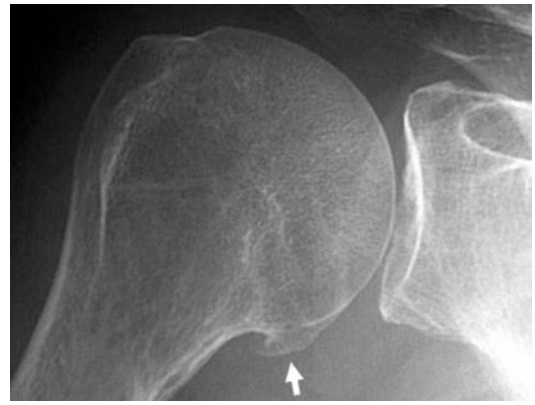

Fig. 5.22 AP view of the shoulder joint shows osteophyte formation (arrow)

Osteophyte: They can be seen as a disturbed acoustic window.

Synovitis: This appears as thickening of synovial membrane.

Erosions: They can be detected in erosive OA.

Magnetic resonance imaging (MRI): MRI is widely used in knee OA and spondylolisthesis as it has the ability of providing a multiplanar image of all compartments. MRI can assess all features of OA, osteophytes, synovitis, effusion, joint spaces, bone marrow lesions, ligaments, cartilage, and vertebral height, as it decreases with degenerative diseases.

Computed tomography (CT): This test is of limited use as it exposes the patient to radiation. It still has its main role emergencies and in cases of suspected fracture.

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