Arthritis

11

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Learning Objectives

- To understand the most common arthritides seen in clinical practice and have an overview of their pathophysiology.
- To develop a logical and systematic approach to the assessment of arthritides using conventional radiographs.
- To understand the characteristic features of common arthritides seen on imaging.
- To recognize the role advanced imaging modalities play in the diagnosis and management of common arthritides.

11.1 Overview of Arthritis

A wide variety of conditions affect the joints of the body, but for this chapter we will focus on the most common conditions seen and their imaging features. We will look at arthritides in three main categories: osteoarthritis, inflammatory arthritides (rheumatoid arthritis and spondyloarthritis), and crystal arthritides.

11.1.1 Osteoarthritis

Osteoarthritis (OA) is the most common arthritis encountered and is seen in the majority of people at some stage in their lives. Despite being so common, its etiology isstill poorly understood and the subject of considerable research, much of it involving imaging studies. The disease can be considered to arise primarily from a failureof the normal transmission of forces across a joint. Thismay come about through trauma to bones or ligaments or through altered ability of the tissues of the joint to transmit forces, for instance, alterations in the composition of cartilage in ochronosis or ligaments in some collagen disorders. However, OA has a complex etiology with multiple factors playing a part including genetics, race and ethnicity, obesity, age, and gender.

The term primary generalized OA refers to OA when it occurs without an apparent underlying cause. This is more common in women and carries a genetic predisposition. It most typically affects the hands, thumb bases, hips, knees, and first metatarsophalangeal joints in the feet. In contrast, secondary OA describes cases where an underlying cause exists. A wide variety of causes are recognized, but the radiological features at any joint may be identical to those of primary generalized OA (Table 11.1). It is importantto realize that OA can co-exist with other forms of joint disease.

Table 11.1 Causes of secondary osteoarthritis [1]

Trauma	Acute
	Chronic repetitive
Systemic/metabolic	Hemochromatosis
	Wilson's disease
	Ochronosis
Endocrine	Acromegaly
	Hypothyroidism
	Hyperparathyroidism
	Diabetes mellitus
Other forms of arthritis	Calcium pyrophosphate deposition disease
	Gout
	Rheumatoid arthritis
Other	Paget's disease
	Bone and joint dysplasia

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Erosive OA represents a subset of OA characterized by prominent inflammatory features including destructive joint changes in the form of osseous erosions. While large joint disease may rarely be seen with this form of OA, it typical affects only the distal and proximal interphalangeal joints of the hands. There may be clues to the inflammatory nature of the disease from the clinical assessment, but the diagnosis of erosive OA is based on the imaging findings. Erosive OA primarily occurs in postmenopausal women.

11.1.2 Rheumatoid Arthritis

Rheumatoid arthritis (RA) is an example of an inflammatory arthritis associated with joint inflammation characterized by synovitis. Extra-articular inflammation, including tenosynovitis, soft tissue (rheumatoid) nodules, and multisystem involvement outside the musculoskeletal system (such as rheumatoid lung disease) may also be seen. This autoimmune condition is mediated through inflammatory pathways, and its treatment has changed greatly in recent years with the advent of disease-modifying anti-rheumatic drugs (DMARDs) based on biologic therapies. These can induce remission and prevent the severe joint destruction that was commonly seen prior to their introduction. Toachieve such remission, DMARDs need to be introduced early in the treatment pathway before structural joint damage occurs. This has led to an increased role for advanced imaging modalities such as MRI and ultrasound, both for earlier diagnosis and for monitoring the response totreatment.

Joint damage, including cartilage loss and osseous erosion, is thought to be mediated through synovitis; there is strong evidence that synovitis is a predictor of future joint structural damage [2]. The diagnosis of RA is based on clinical findings, along with laboratory assessment (inflammatory and immunological markers) and radiological assessment. Itis recognized that both ultrasound and MRI are more sensitive than clinical assessment for identifying synovitis [3].

RA is more common in women and typically begins in the small joints in the hands and feet, usually with a fairly symmetrical distribution. Large joint involvement is seen later in the disease.

11.1.3 Spondyloarthritis

The spondyloarthritides are a group of inflammatory arthritides which share certain common features. One of the most characteristic features of these diseases is the presence of inflammatory change at entheses, the sites where tendons and ligaments insert on to the bone. These diseases are also characterized by:

- Axial skeleton and typically sacroiliac joint (SIJ) involvement (sacroiliitis).
- Presence of the human leukocyte antigen B27 (HLA-B27), although the presence of this histocompatibility antigen is not a pre-requisite for diagnosis of these conditions.
- Absence of serum rheumatoid factor.

Like RA, these diseases are increasingly treated aggressively with biological DMARDs to achieve remission and prevent structural joint damage. This means early diagnosis is important, and given the propensity for spinal and SIJ involvement, this frequently includes MRI. While synovitis is a feature of these diseases, osteitis identified as bone edema-like signal is typically the earliest imaging finding. Diagnosis of spondyloarthritis is based on specific criteria, and MRI now forms a component of the diagnostic pathway as outlined in the Assessment of Spondyloarthritis International Society (ASAS) classification criteria for axial spondyloarthritis [4] (Table 11.2).

Four diseases are generally considered under the heading of spondyloarthritis (SpA). However, it is important to recognize that it is often not possible to classify a patient as having a specific type of SpA despite clear clinical criteria for adiagnosis of SpA being present. These patients form a large subgroup referred to as "undifferentiated spondyloarthritis." Some of these patients may go on to develop more specific features allowing them to be reclassified.

11.1.3.1 Ankylosing Spondylitis (AS)

Ankylosing spondylitis is a multisystem disease which characteristically affects the axial skeleton and typically presents with inflammatory back pain. Sacroiliitis is a characteristic feature of the disease and is typically bilateral andsymmetrical. This is frequently seen in association with spinal involvement. Peripheral joint involvement is present in

Table 11.2 Criteria for the diagnosis of spondyloarthritis (SpA) [4]

Imaging pathway	Clinical pathway	SpA features
Sacroiliitis on imaging – MRI or radiograph	HLA B27 positive	– Inflammatory back pain – Dactylitis – Enthesitis
One or more SpA features – From column 3	Two or more other SpA features – From column 3	– Family history of SpA – Good NSAID response – Uveitis – Psoriasis – IBD – HLA B27 positive – Elevated CRP

up to 30% of patients; the hip followed by the shoulder is the most common peripheral joint involved [5]. Unchecked,the disease will progress to joint ankylosis and spinal fusion.

11.1.3.2 Psoriatic Arthritis (PsA)

There is a complicated relationship between cutaneous psoriasis and arthritis, including an increased incidence of seropositive RA in patients with psoriasis. However, the association is strongest if RA is not considered, at which point 20% of patients with seronegative arthritis will be found to have psoriasis [6]. In patients with psoriasis, the presence of nail involvement is a significant risk factor for developing arthritis.

Five typical subgroups of patients with PsA can be identified:

- An erosive arthritis affecting distal interphalangeal (DIP) joints in an asymmetrical distribution often seen with dactylitis
- An arthritis which is similar to RA
- An oligoarthritis involving any of the synovial joints with an asymmetrical distribution
- A pattern of disease involving the axial skeleton and large joints resembling AS
- A severely destructive arthritis typically involving the small joints of the hands and feet (arthritis mutilans)

11.1.3.3 Reactive Arthritis

Reactive arthritis is typically triggered by an extra-articular infection (most commonly gastrointestinal or genitourinary) and usually manifests as an asymmetricalarthritis involving joints of the lower limb and the axial skeleton. Appearances resemble those of PsA, except axial involvement is less common and upper limb involvementis extremely unusual. It is classically associated with soft tissue inflammation in the form of urethritis, conjunctivitis, and mucocutaneous lesions in the oropharynx, tongue, glans penis, and skin.

11.1.3.4 Enteropathy-Associated Arthritis

Arthritis is associated with inflammatory bowel disorders, most commonly Crohn's disease and less frequently ulcerative colitis. It occurs infrequently in other inflammatory gastrointestinal disorders such as celiac disease and primary biliary cirrhosis. Typically, the associated arthritis closely resembles AS, with sacroiliitis and spinal involvement. Peripheral joint disease is uncommon, although patients may experience transient arthritis comprising joint effusion and synovitis in the peripheral joints. These often occur during flare-up of the inflammatory bowel disease.

11.1.4 Metabolic Joint Disease

Gout and calcium pyrophosphate dihydrate-related arthritis are both associated with the deposition of crystals in and around joints.

11.1.4.1 Gout

Gout is a condition associated with the buildup of uric acid in the body (hyperuricemia) that gives rise to intense joint inflammation with the potential to progress to an extremely destructive arthritis. Although any synovial joint can be involved, the disease has a particular propensity for thefirst metatarsophalangeal joints. The sodium urate crystals formed in a state of hyperuricemia characteristically deposit in the synovial membranes, joint fluid, tendon sheaths, bursae, subcutaneous tissues, and kidneys. Asymptomatic hyperuricemia is reported in around 19% of individuals in the USA and UK with only a small percentage of these going on to develop clinical gout [7]. Uric acid is an end product of purine metabolism, and hyperuricemia results from reduced renal excretion of urate or, less commonly, its increased production. A complicated interaction of multiple factors determines a person's propensity for developing gout, including genetic, racial, and dietary characteristics. Comorbidities also predispose to gout, including renal impairment and failure, cardiovascular disease, obesity, and diabetes. Gout is much more common in men than women, although the incidence among women increases following menopause. Gout usually initially presents as an acute intermittent inflammatory arthritis giving rise to severe pain, erythema, and swelling of the affected joint. Similar presentations may be seen in tendon sheaths and bursae. Aspiration of the affected jointwill allow the identification of urate crystals under the microscope. This is frequently undertaken in the workup of this disease as septic arthritis is an important differential diagnosis. Between episodes of acute gout attacks (which may be triggered by trauma or other factors), the patient usually becomes asymptomatic.

Longer-term gout sufferers may go on to develop a chronic arthritis where the symptoms fail to settle between attacks. There is chronic deposition of sodium urate crystals in the joint and soft tissues (including tendons) leading to joint effusion, synovitis, and destructive changes in the form of erosions. Although small joints of the hands and feetare most commonly affected, large joint involvement is frequently seen, particularly in the knees and ankles. A characteristic feature of chronic gout is the development of soft tissue deposits know as tophi presenting as soft tissue massesmost commonly seen in the hands and feet and on the extensor surfaces of the elbows and knees. Tendon deposition is also seen with the development of tendon nodules.

11.1.4.2 Calcium Pyrophosphate Dihydrate (CPPD) Deposition Disease

CPPD deposition disease is most commonly seen in the middle-aged and elderly. Many people identified as having CPPD crystal deposition in joints will be asymptomatic. Deposition of CPPD crystals occurs in hyaline cartilage, fibrocartilage, synovium, and ligaments. If the crystals are then shed into the joint, an acute attack of inflammatory arthritis which resembles acute gout can develop, known as pseudogout. This is a clinical diagnosis which can be confirmed by iden-tification of the crystals on microscopy in a joint aspirate. A second more chronic pattern of joint disease which resembles OA on imaging is also recognized, although this toocan have inflammatory features [8]. Aging forms the main risk factor for CPPD arthritis, but there are associations with metabolic conditions including hemochromatosis, Wilson's disease, hyperparathyroidism, hypomagnesemia, and hypophosphatasia [8].

It is important to recognize that the presence of chondrocalcinosis itself does not imply a diagnosis of CPPD arthropathy-athy and an absence of chondrocalcinosis does not rule out the diagnosis.

11.2 Imaging in Arthritis

11.2.1 Conventional Radiography

Conventional radiographs remain fundamental to the diagnosis of joint disease, and an understanding of the typical appearances of different arthritides on the radiograph is vital to the diagnosis of these conditions. A review of the radiograph requires attention to be paid to:

- The joint space between bones
- The soft tissues around the joint
- The appearance of the bones forming the articulation
- The alignment of the bones at the joint
- The distribution of the disease

11.2.1.1 Joint Space

Joint space narrowing is an important feature of many arthritides, resulting from loss of the radiolucent cartilage which normally provides the gap seen between the bones on the radiograph. It is helpful to identify the pattern of joint space loss, in particular whether it is even across the whole of the joint (symmetrical) or just involves part of the visualized joint space (asymmetrical). Inflammatory arthritides tend to show joint space loss which is uniform across the joint, while OA shows a more uneven pattern of joint space loss (Fig. 11.1).

Just as valuable is the identification of arthritides such as gout and PsA, where joint space is preserved even where joint damage is significant. In some cases, arthritis will lead to ankylosis of the joint and complete loss of joint space. This is a characteristic feature of the spondyloarthritides.

11.2.1.2 Soft Tissues

Soft tissue swelling is an early feature of disease in the inflammatory arthritides and may be due to synovitis, joint effusion,and/or soft tissue edema. Soft tissue swelling is also a featureof gout as a result of tophus formation around the joint. Theradiographic appearance of tophi is much more irregular and "lumpy" than the swelling associated with synovitis or effusion that causes capsular distention (Fig. 11.2).

In addition to swelling, calcifications may be observed in the soft tissue around the joint (for instance, in cases of CPPD), with or without the presence of chondrocalcinosis.

11.2.1.3 Bones

A variety of changes may be seen in the bones at articulations affected by arthritis. These include change in bone density (sclerosis or osteopenia), cyst formation, and bone erosion. New bone formation can also occur in the form of osteophyte, enthesophyte, and periosteal reaction.

Osteophytes are the hallmark of OA and represent new bone forming around the site of the cartilage degeneration associated with this disease. Osteophytes are most commonly found at the margins of joints, although central osteophytes occurring within the joint space are also recognized (Fig. 11.3). Enthesophytes are a feature of enthesitis and,in contrast to osteophytes, have a finer wispier appearance. Periosteal new bone (periostitis) may be seen in patients with spondyloarthritis, particularly in association with the peripheral joint disease seen in PsA and reactive arthritis.

Subchondral sclerosis and cyst formation are typical features of OA but may also be seen in association with inflammatory and metabolic arthritides. Cysts are often prominent in patients with CPPD arthropathy (Fig. 11.4).

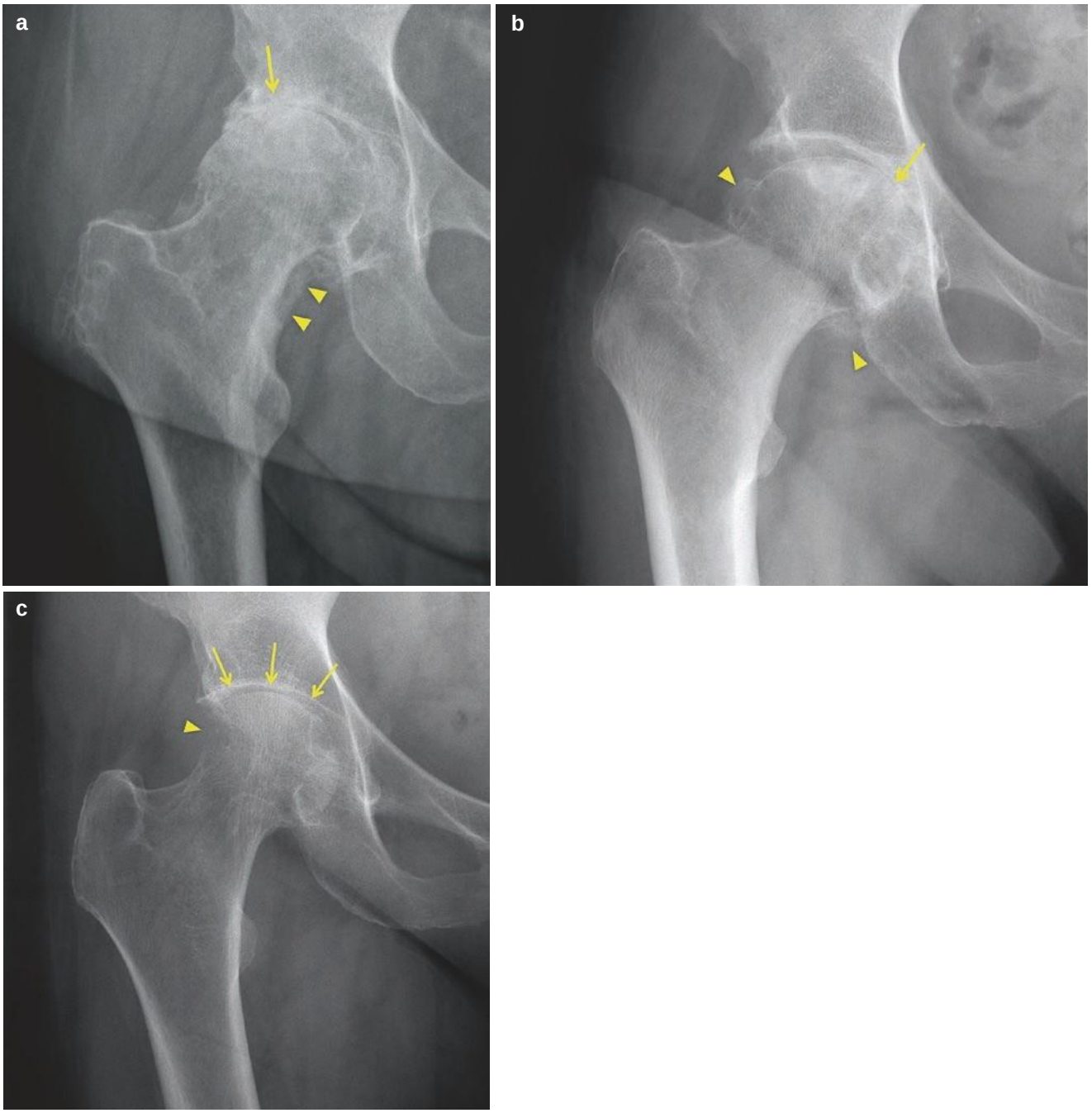

Fig. 11.1 (**a**) Osteoarthritis, showing superior joint space loss associated with subchondral cyst formation and sclerosis (arrow). Note also the bone proliferation along the medial femoral neck, known as buttressing (arrowheads). (**b**) Osteoarthritis, showing medial joint space loss with subchondral sclerosis (arrow). Prominent osteophytes are seen at the margins of the articular cartilage (arrowheads). (**c**) Rheumatoid arthritis, showing more uniform narrowing of joint space (arrows). Note also the absence of subchondral cyst and sclerosis and the large erosion (asterisk)

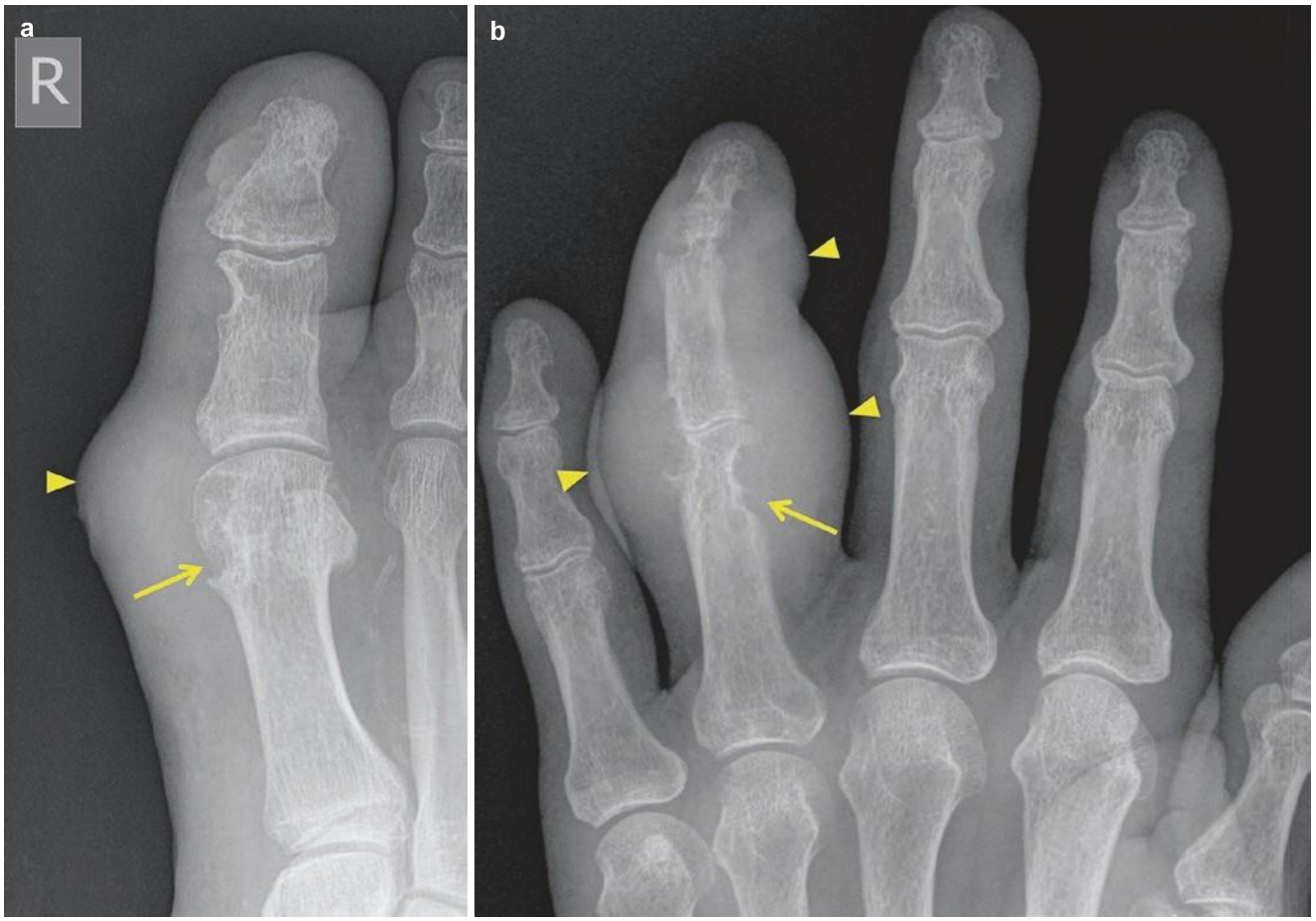

Fig. 11.2 Great toe (**a**) and hand (**b**), showing typical radiographic features of gout. Note the irregular soft tissue swelling (arrowheads) and punched out erosions, some of which occur more remotely from the joint (arrows). Despite the destructive changes, joint spaces are well preserved

Juxta-articular osteopenia is a feature of some arthritides such as RA but can be challenging to identify, particularly if there is extensive joint involvement and if normal joints for comparison are not visible on the radiograph. Gout, spondylarthritis, and OA typically show preservation of bone density.

Bone erosion is a well-recognized feature of the inflammatory arthritides. On conventional radiographs, erosivechange can be subtle, and care must be taken not to miss theearliest features of erosion.

11.2.1.4 Joint Alignment

Joint malalignment resulting from arthritis has a varietyof causes and usually represents a late feature of the disease. Besides resulting from bone and cartilage loss, joint malalignment may also result from tendon and ligament disruption and dysfunction.

11.2.1.5 Distribution of Joint Disease

When reviewing hand and foot radiographs in a patientwith peripheral arthritis, the pattern of joint involvement is an invaluable clue to the underlying nature of the arthritis. Certain arthritides have a predilection for certain joints. Some of the more commonly observed patterns of joint involvement are illustrated in Fig. 11.5.

11.2.2 CT

CT shows similar features in joint disease to conventional radiographs. However, its ability to image bone in fine detail and its cross-sectional and multiplanar capabilities make it more sensitive than radiographs and other cross-sectional imaging techniques for the identification of erosive change. This is particularly true for deep-lying joints with complex 3D anatomy and those joints not aligned to the standard planes viewed in radiography such as the sacroiliac joints (Fig. 11.6). Despite these advantages CT is less commonly used clinically in arthritis imaging, as both MRI and ultrasound are also more sensitive than radiographs for identifying erosive change and offer other advantages in their ability to assess joint disease.

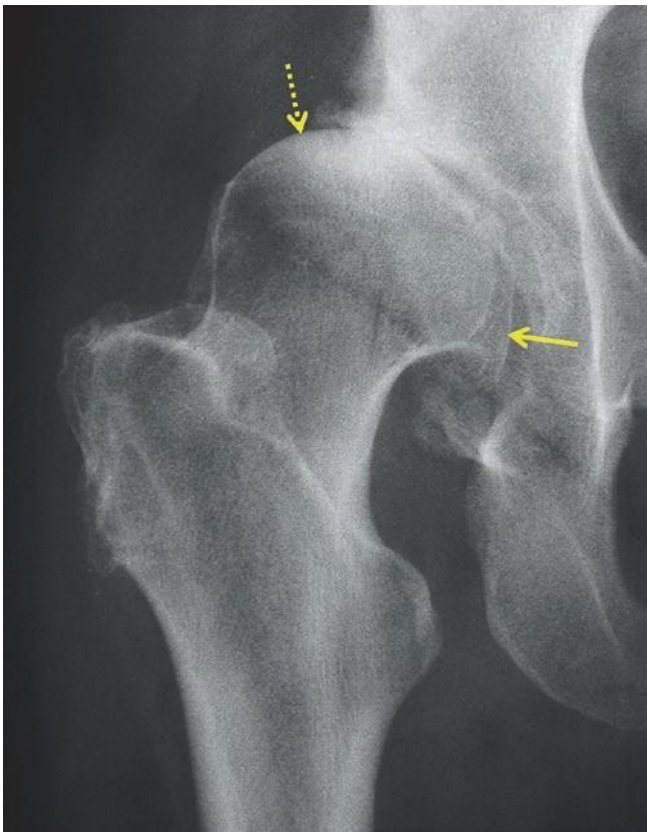

Fig. 11.3 Osteoarthritis of the hip. In addition to the superior joint space loss and subchondral sclerosis, there is central osteophyte (arrow). This is causing lateral subluxation and exposure of the femoral head (dotted arrow)

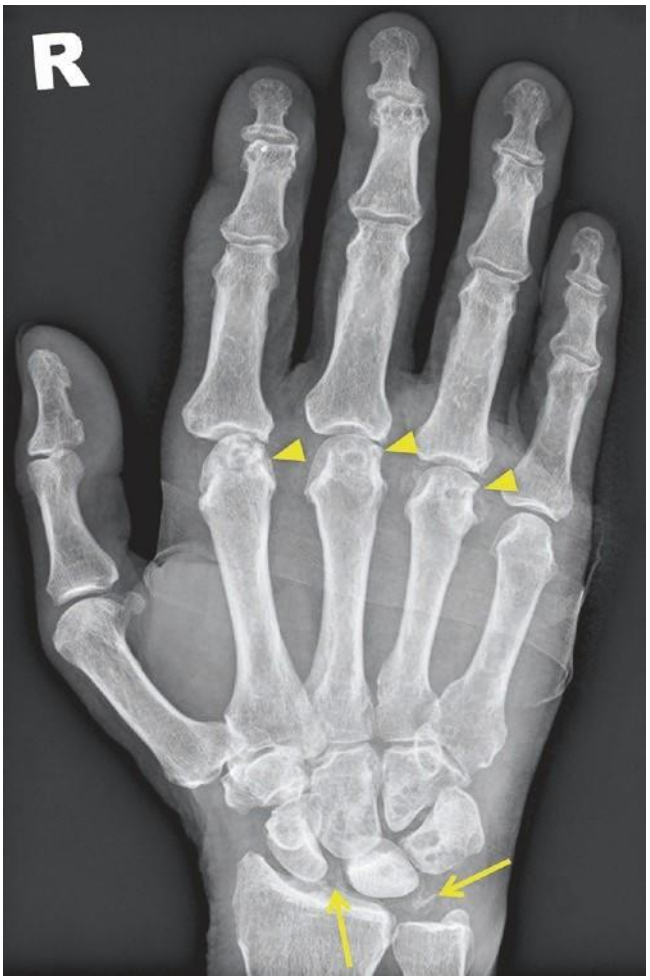

Fig. 11.4 Calcium pyrophosphate crystal arthropathy. In addition to affecting DIP joints, there is MCP (arrowheads) and wrist involvement with prominent cystic change. There is chondrocalcinosis and synovial/ligamentous calcification seen in the proximal wrist joint (arrows). Osteophyte formation is minimal, and the distribution involving MCP joints is typical. Scapholunate dissociation is also evident, a feature of CPPD arthropathy at the wrist

In recent years, dual-energy CT has become increasingly available and has found a particular use in the assessment of patients with gout. The ability of this technique to identify urate deposits in joints and soft tissues with high specificity has made it valuable in clinical practice for diagnosing gout non-invasively [9]. This technique is also able to quantify the volume of urate deposits and therefore shows promise for assessing response to treatment [10].

11.2.3 Ultrasound

The ready availability of ultrasound and its ability to assess multiple joints in a relatively short time frame, along with its dynamic capabilities, ability to guide diagnostic and therapeutic injection/aspiration, and high level of acceptability to patients make it an excellent modality for assessing joint disease [11]. However, ultrasound does have disadvantages:

1. Its assessment of bone is confined to the cortical surface, so while erosions, osteophytes, and enthesophytes are visualized, subchondral cysts and sclerosis and bone inflammation (osteitis) are not demonstrated.
2. Because ultrasound cannot "see" through bone, its ability to assess the interior of a joint is limited to those parts of the joint in the sonographic window, and views of internal joint structures such as articular cartilage and menisci are limited.
3. Deeper joints, such as the sacroiliac joints, allow only very limited assessment, and access to parts of some joints (for instance, parts of some MCP and MTP joints) is limited by the anatomy.

Ultrasound readily identifies features of inflammatory arthritis such as erosion, synovitis, and effusion and can also assess the presence of osteophytes and enthesophytes. It can also be useful for assessing extra-articular disease such as soft tissue rheumatoid nodules, gout tophi, and tendon and tenosynovial disease. While not usually used to assess articu-

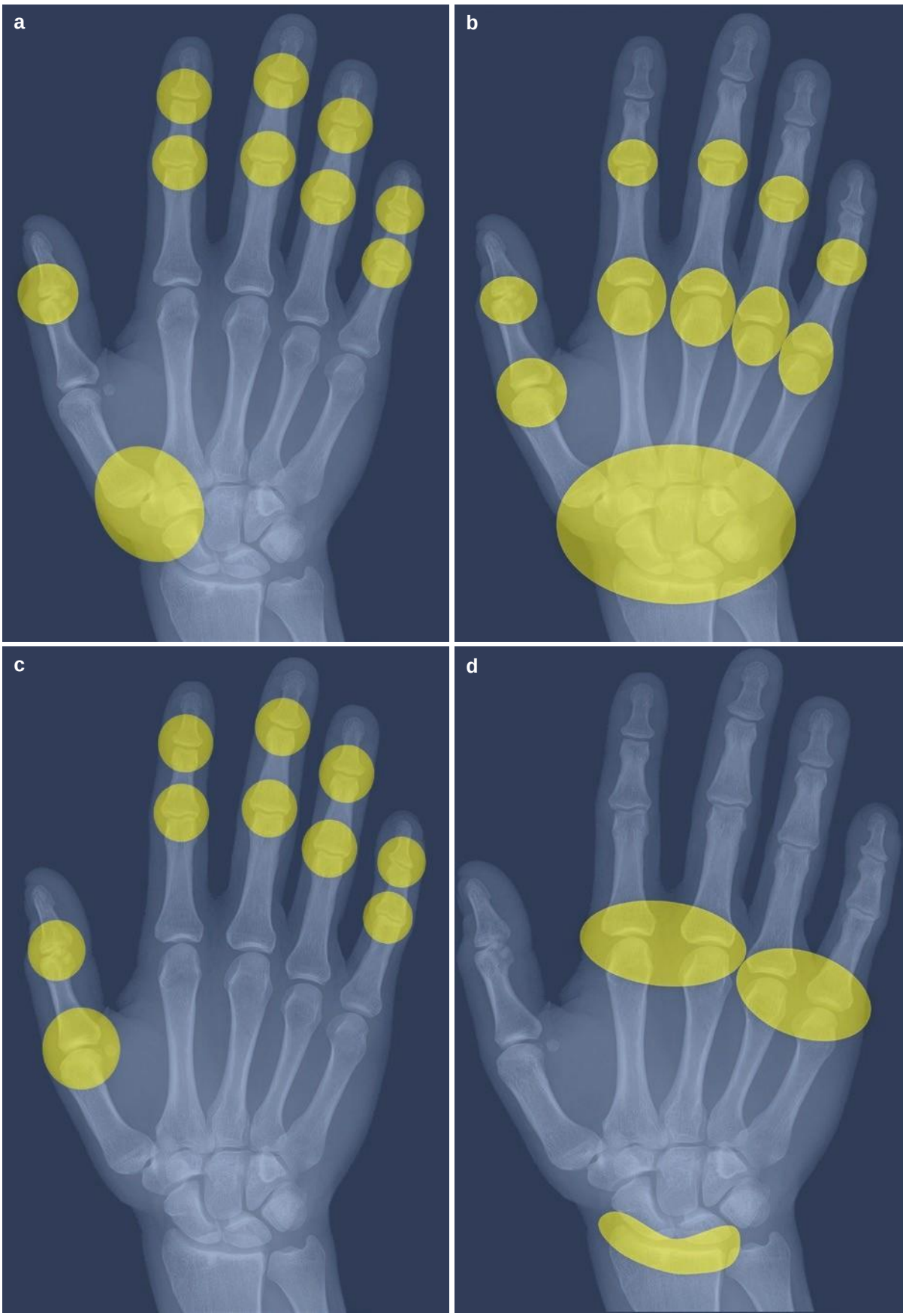

Fig. 11.5 Typical patterns of typical joint involvement in the hand in different arthritides. (**a**) Osteoarthritis, (**b**) rheumatoid arthritis, (**c**) psoriatic arthritis, (**d**) calcium p/yrophosphate deposition arthropathy

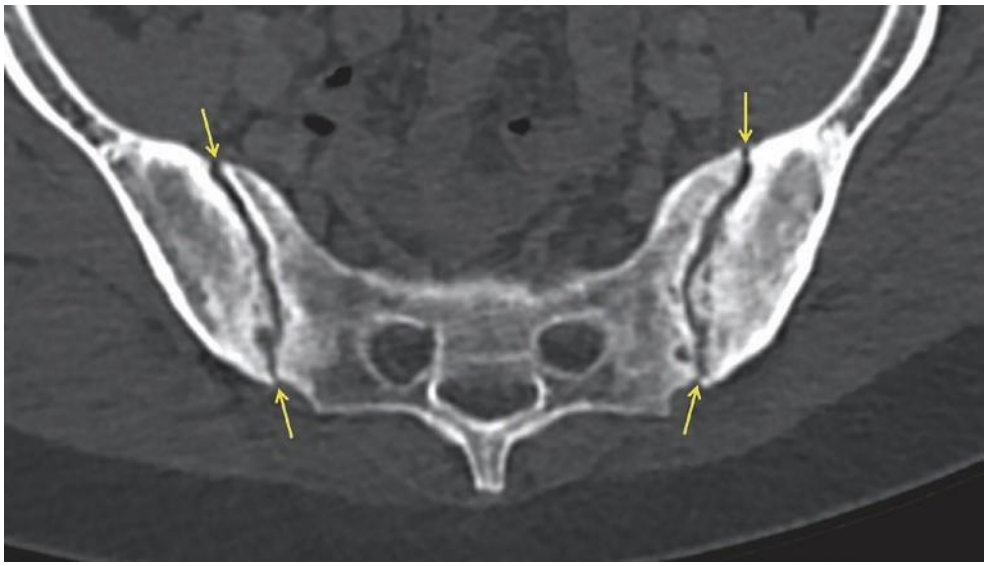

Fig. 11.6 Axial CT. Both sacroiliac joints (arrows) show subchondral erosions and sclerosis typical for chronic sacroiliitis

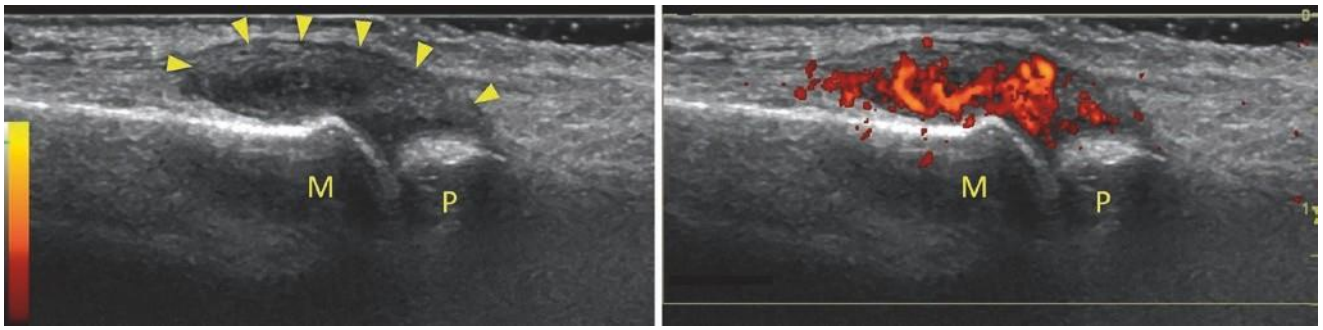

Fig. 11.7 Index metacarpal joint in a patient with synovitis due to rheumatoid arthritis. Longitudinal ultrasound of the dorsum of the joint. M, metacarpal head; P, proximal phalangeal base. The B-mode image on the left demonstrates hypoechoic synovitis in the joint bulging the dorsal joint capsule (arrowheads). The synovitis shows marked vascularity demonstrated on the power Doppler duplex image on the right

lar cartilage in OA and inflammatory arthritides, ultrasound can provide useful information relating to the crystal arthritides, which will be discussed in Sect. 11.3.

11.2.3.1 Synovitis and Effusion

Ultrasound has been shown to be more sensitive than clinical assessment and radiographs for assessing synovitis (soft tissue swelling) and is comparable to MRI [12]. Synovitis appears as hypoechoic intra-articular material that is non-displaceable and may exhibit Doppler signal (Fig. 11.7) [13]. While the degree of Doppler signal detected is variable, its presence, along with the non-compressibility of synovitis, is a useful feature to distinguish synovium from joint fluid on ultrasound. The extent of blood flow in the synovium detected by ultrasound provides a measure of disease activity in the inflammatory arthritides, and several scoring systems have been described [14].

11.2.3.2 Erosion

Erosions are identified on ultrasound as a discontinuity of the bone surface, but it is important that these are identified in two planes to avoid confusion with normal surface contours [13, 14]. While ultrasound has superior ability to conventional radiographs in assessing the presence of erosions [15],it has disadvantages to other cross-sectional techniques as not all parts of a joint necessarily fall within the sonographicwindow (for instance, the radial and ulnar aspects of the mid-dle finger metacarpophalangeal joint). This means that MRIis arguably more sensitive to erosive change.

11.2.3.3 Other Bone Changes

Both osteophytes and enthesophytes appear as bone outgrowths on ultrasound. Enthesophytes appear finer compared to the generally coarse nature of osteophytes. However, the distinction is ultimately dependent on the clinical context along with the location of an enthesophyte relative to an enthesis and the presence of other features of enthesitis, such as thickening and low-reflective change in the inserting tendon or ligament, and associated erosive change [13, 14]. Increased Doppler signal can be seen at sites of active enthesitis. Ultrasound does appear more sensitive than radiographs for the detection of osteophytes in the hands and feet [16, 17].

11.2.3.4 Extra-Articular Soft Tissue Features

Tenosynovitis appears as hypoechoic or anechoic thickened tissue with or without fluid in the tendon sheath and is readily identified on ultrasound [13]. Ultrasound can also demonstrate tendon rupture and may even show an osteophyte orbone prominence causing tendon attrition. Enthesitis is associated with thickening of inserting tendons and ligaments alongwith hypoechogenicity and loss of the normal echotexture.Vascularity may also be identified within and around the inserting soft tissue structure at sites of enthesitis on Doppler imaging.

Rheumatoid nodules appear as hypoechoic mass lesions often with a well-defined hypo- to anechoic center representing necrosis [18]. Gout tophi can appear very poorly definedon ultrasound but are usually hyperechoic, often with a hypoechoic rim (Fig. 11.8). Depending on their composition, especially the presence or absence of calcification, they may also show posterior acoustic shadowing.

11.2.4 MRI

The role of MRI has been increasing in recent years as evidence has grown for its role in the diagnosis and assessment of arthritides, particularly the inflammatory arthritides. As highlighted in Sect. 11.1.3, MRI now plays a fundamental role in the diagnosis and management of patients with suspected axial spondyloarthritis. Like ultrasound, MRI is sensitive to the assessment of synovitis and erosions and can identify osteophytes and extra-articular disease manifestations. However, MRI also enables an assessment of articular cartilage and the subchondral and medullary bone. MRI techniques have been integral to research that has provided a much greater understanding of the pathophysiology of many arthritides. Despite the many advantages of MRI, there are disadvantages such as cost, and MRI may be contraindicatedin some patients, for instance, patients with some types of implantable devices. Other recognized weaknesses include:

1. It is very time-consuming to image multiple joints. While multiple joints can be scanned in a single examination with whole-body MRI, this necessitates an acceptance of decreased resolution.
2. To reliably assess synovitis, the administration of intravenous gadolinium contrast is normally required.
3. Patient tolerance can be poor.

The identification of both synovitis and erosions usually requires assessment in two planes, both to confirm location and to ensure that the abnormality is not due to partial volume averaging or a normal anatomical feature. It is often helpful, particularly with small joint disease, to employ 3D sequences with isotropic resolution to permit multiplanar reconstruction. When serial imaging over time is employed, the added ability to reconstruct also makes it easier to compare timepoints if imaging has not been acquired in preciselythe same plane.

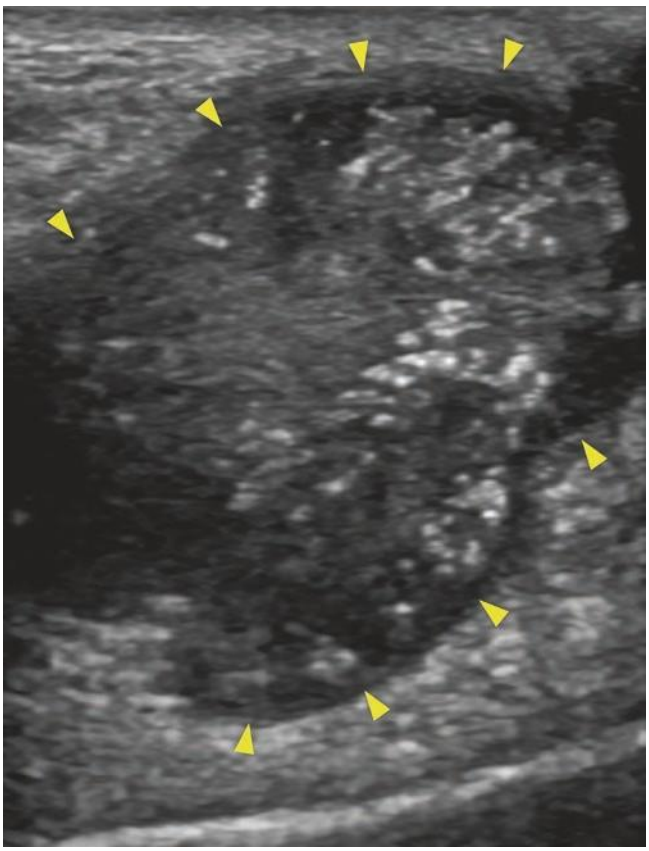

Fig. 11.8 Longitudinal ultrasound showing gout tophus with typical hyperechogenicity and a lower reflective rim. Bright echogenic foci representing crystal aggregates are seen within the tophus

11.2.4.1 Synovitis

Synovitis on MRI is defined by the Outcome Measuresin Rheumatology (OMERACT) as an area in the synovial compartment that shows above normal post-gadolinium enhancement of a thickness greater than the width of normal synovium [19]. This recognizes that normal synovium may show some enhancement and indeed implies that synovium may be seen in a normal joint, but in practice the distinction between synovium and synovitis is rarely difficult [20]. While the use of gadolinium complicates the examination, current thinking is that gadolinium contrast is required, particularly for distinguishing synovitis from effusion. In addition, the rate of gadolinium uptake by the synovium can alsoprovide useful information as it relates to disease activity inboth inflammatory arthritides and OA and may even play a role in distinguishing between different types of arthritis [21–24]. However, research into imaging techniques which allow accurate assessment of synovitis without the use of contrast medium is still ongoing.

11.2.4.2 Erosion and Structural Bone Changes

Erosions are readily shown on MRI as sharply marginated bone lesions visible in at least two planes with a cortical break seen in at least one plane [19]. The OMERACT definition also specifies that the erosion shows "typical signalcharacteristics," which in practice usually means a loss ofthe normal high signal from the marrow on T1-weightedimaging. Enhancing synovium will be frequently seen in theerosion on post-gadolinium imaging. MRI is sensitive to erosion detection but may identify erosion-like lesions in normalcontrol subjects, especially in older patients.

Osteophytes are generally well demonstrated on MRI, and in the hand MRI has been shown to be more sensitive to their detection than conventional radiographs [25]. Unlike ultrasound, MRI is also able to detect osteophytes which occur in the central portions of the articular space and are associated with severe cartilage damage (central osteophyte).

The thin and delicate nature of enthesophytes and syndesmophytes, frequently occurring without the presence of high T1 signal bone marrow, can make MRI relatively insensitive to their presence, particularly because they are usually seen in association with tendon and ligament and cortical bone, all of which also appear low signal on conventional MRI sequences.

11.2.4.3 Bone Marrow Changes

Edema-like signal in the bone marrow is a feature of OA and inflammatory arthritis and typically appears as high T2 signal on fat-suppressed imaging (Fig. 11.9). In RA and spondyloarthritis, this appearance represents an inflammatory process within the bone (osteitis). However, it is evident that the nature of these lesions in OA is not the same, although the actual underlying pathophysiology remains poorly understood and a topic of ongoing research. Subchondral cysts are also demonstrated by MRI in OA (Fig. 11.9), corresponding to the cysts described on conventional radiographs.However, even these may not be all that they seem since studies show they frequently demonstrate full or partial contrast enhancement, which would not be expected with pure fluid-filled cysts [26].

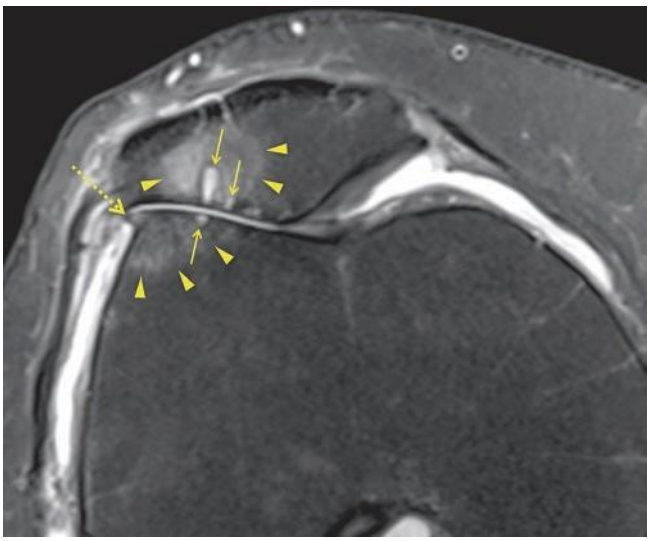

Fig. 11.9 Patellofemoral osteoarthritis. Axial intermediate weighted MRI with fat suppression. There is full-thickness cartilage loss on both sides of the lateral patellofemoral joint associated with subchondral bone marrow lesions, showing an edema pattern (arrowheads) surrounding subchondral cyst-like lesions (arrows). A small osteophyte is also seen (dotted arrow)

11.2.4.4 Articular Cartilage

The ability of MRI to directly image articular cartilage and demonstrate cartilage loss and cartilage defects is one of the great advantages of this modality over other imaging techniques. Cartilage visualization requires visual contrast between the cartilage and underlying bone and between the cartilage and overlying joint fluid. A variety of sequences may be employed to achieve this, including both gradient echo and fast spin-echo techniques. An early advantage of gradient echo (GRE) imaging for articular cartilage visualization was the ability to undertake 3D sequences with high-resolution thin slices. In recent years, the advent of 3D fast spin-echo (FSE) sequences has allowed optimized visual contrast from spin-echo sequences in addition to thin slices similar to GRE imaging. In clinical practice, FSE proton-density-weighted images with fat suppression provide accurate depiction of the articular cartilage. Imaging techniques which provide information about cartilage composition have now become available and continue to be an area of research. The object of these sequences is to identify compositional changes in cartilage at a stage before cartilage damage becomes apparent in the form of morphological change.These techniques, which include T2 mapping, T1 rho imaging, delayed gadolinium-enhanced imaging (DGEMRIC), sodium imaging, and magnetization transfer contrast-based techniques, are currently primarily used in the research environment and are beyond the scope of this chapter.

11.2.4.5 Soft Tissue Features

Like ultrasound, MRI is able to identify tendon and ligament abnormalities associated with arthropathy, including tendon rupture, tenosynovitis, and changes within tendons and ligaments in association with enthesitis. In cases of enthesitis, thickening of the inserting tendon with increased intrasubstancesignal on short and long TE sequences becomes apparent.

Tophaceous gout deposits are also shown with MRI, although their signal characteristics are dependent on their composition, including the degree of calcification. The majority of tophi are isointense to muscle on T1 imaging and intermediate to low signal on proton density and T2 imaging. Rheumatoid nodules are seen on MRI with variable and non-specific signal characteristics.

Key Point

- Conventional radiographs remain fundamental to the imaging workup of patients with arthritis and provide valuable information relating to the assessment of joint space, periarticular soft tissues, bone (including erosions and osteophytes), joint alignment, and the distribution of the arthritis. However, these changes often represent late and irreversible features of the disease. Because of this, more advanced imaging modalities are increasingly used in the investigation of joint disease. In particular, ultrasound and MRI allow sensitive assessment of synovitis and erosions, with MRI also able to identify bone marrow changes including osteitis along with articular cartilage changes.

11.3 Imaging Findings in Specific Arthritides

11.3.1 Osteoarthritis

11.3.1.1 Radiographic Appearances

OA shows very characteristic features on conventional radiographs regardless of the joint affected. However, it should be remembered that the severity of the patient's symptoms correlates poorly with the extent of radiographic change in the joint. Also, OA frequently coexists with other arthritides,and features of more than one type of arthritis may be seen. In cases of OA occurring secondary to trauma, features of the injury may be apparent.

- *Joint space*: Cartilage thinning and therefore joint space loss are a feature of OA. Typically, this occurs in an asymmetric pattern across the joint leading to uneven areas of joint space loss. This is a helpful discriminator from other causes of arthropathy. For instance, in the knee, loss of joint space in one compartment, most commonly the medial femorotibial, will often predominate, and in the hip, joint space loss will often be limited to the superior or superolateral portion (Fig. 11.1a). Generally, the degree of joint space loss relates to the severity of other changes seen.
- *Soft tissues*: Synovitis, giving rise to soft tissue swelling, is variably seen in OA. In the finger joints, clinically apparent nodules may be due solely to prominent osteophytes, but focal synovial/capsular hyperplasia may accentuate the soft tissue prominence.
- *Bones*: Osteophytes are a key feature of OA and represent new bone generally formed at the joint margins at the edge of the cartilage. Central osteophytes developing in the subchondral bone are a less common feature of the disease. When present, central osteophytes can contribute to joint malalignment (Fig. 11.3). In the hip, a particularly characteristic feature of OA is the development of osseous hypertrophy along the inferomedial femoral neck, known as buttressing (Fig. 11.1a).

  Additional features of OA are subchondral cyst formation and sclerosis. These changes may progress to sub-chondral collapse and remodeling.
- *Alignment*: Malalignment of joints is typical in OA, arising from focal cartilage loss, subchondral collapse, and ligamentous dysfunction. In the elderly, reduced proprioception and muscle tone are also thought to be important factors. At the knee, joint space narrowing predominating in the medial femorotibial compartment may lead to varus deformity.
- *Joint distribution*: In primary OA of the hands, a distal pattern involving DIP and PIP joints is typical. In the wrist, OA is usually confined to a "trapeziocentric" distribution involving the scaphotrapeziotrapezoid (STT) joint and thumb carpometacarpal joint. Large joint involvement typically involves the hips and knees, while in the feet, the first MTP joint is typically affected. Bilateral OA may be symmetrical or asymmetrical.

Erosive OA

Erosive OA is usually confined to the hands with a similar distribution to the pattern of disease seen in generalized primary OA. While marginal erosions may occur, central erosions in the subchondral bone are characteristic, giving rise to a "seagull wing" pattern of erosion (Fig. 11.10). Ankylosis may eventually occur, a distinguishing feature from non-erosive OA.

Osteoarthritis in the Spine

OA (degenerative disease) of the spine typically occurs in the cervical and lumbar regions and is associated with disk degeneration (evident as loss of disk height) and prominent osteophyte formation. The vertebral endplate will show irregularity and sclerosis with advancing disease. Typically, the facet joints (synovial joints) are also involved. OA changes in the spine lead to ligamentous laxity and intervertebral subluxation in the form of anterior or posterior subluxation of a vertebra on its more caudal neighbor (antero- and retrolisthesis).

11.3.1.2 Advanced Imaging

In clinical practice, imaging of OA is usually confined to conventional radiography. However, osteophytes, synovitis, and joint effusion are readily seen on ultrasound and MRI. MRI also offers additional advantages in being able to directly assess the articular cartilage and visualize the subchondral bone (Fig. 11.9). In addition to subchondral cysts, MRI frequently identifies edema-like signal in the subchondral bone. This does not represent true edema, and such fociare often referred to simply as bone marrow lesions.

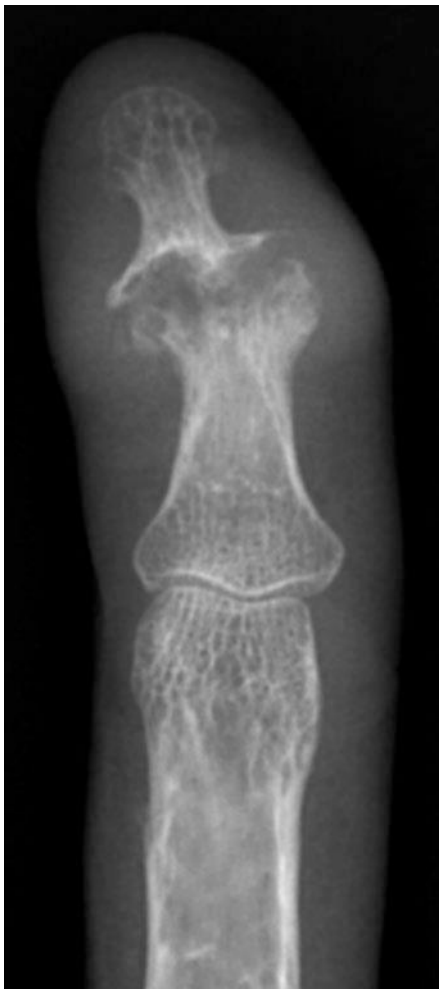

Fig. 11.10 Typical central erosive change with seagull configuration to the distal phalangeal base in a patient with erosive osteoarthritis

Key Point

- Key radiographic features of OA are uneven (asymmetric) joint space loss, osteophytes, and subchondral bone changes. Involvement in the hands and wrists is typically seen at DIP and PIP joints and at the thumb base. Erosive OA is associated with central joint erosion.

11.3.2 Rheumatoid Arthritis

11.3.2.1 Radiographic Appearances

- *Joint space*: Joint space narrowing in RA tends to be more uniform than in OA as cartilage loss is evenly spread across the joint (Fig. 11.1c). It should be noted that joint space loss does not always precede bone erosion.
- *Soft tissues*: Soft tissue swelling at joints is an early feature of rheumatoid arthritis. At MCP and PIP joints in the hands, this is seen as smooth fusiform swelling about the joints. Swelling as a result of effusion and/or synovitis may produce a thickened suprapatellar stripe at the knee or displaced fat pads at the elbow.
- *Bones*: Another early feature of RA is the development of periarticular osteopenia (Fig. 11.11). However, its detection can be very subjective, particularly where multiple joints are involved and there are no normal joints for comparison.

  The erosions seen in RA are typically marginal in location, occurring at the edge of the joint where intracapsularbone is unprotected by overlying cartilage, the so-called bare area. Erosions are more commonly seen in the smalljoints of the hands, wrists, and feet rather than large joints,and early sites of erosion are the radial side of the metacarpal heads in the hands (especially on the index and middle metacarpals) and the ulnar aspect of the wrists, characteristically the ulnar styloid process (Fig. 11.11). Involvement in the foot is often seen first on the lateral aspect of the fifth metatarsal head. The earliest evidence of erosion is seen as subtle discontinuities in the cortex of the bone with underlying osteopenia, before larger areas of bone destruction become apparent.

  Osteophytes and enthesophytes are not features of RA.
- *Alignment*: Joint malalignment occurs as a result of tendon and ligament dysfunction and erosive change. Ulnar deviation of the fingers at the MCP joints and radial deviation at the wrist are characteristic. In the fingers, swan neck (flexion at the DIP and extension at the PIP) and boutonnière (extension at the DIP and flexion at the PIP)deformities are also characteristic.
- *Joint distribution*: RA typically begins in the peripheral joints, usually the MCP and PIP joints, the wrists, and the MTP joints, with a predominantly symmetrical left/right distribution. This more proximal distribution in the hands and wrists with sparing of the DIP joints (Fig. 11.5b) is a useful distinguishing feature compared to OA and PsA. Large joint involvement is a later feature of RA.

11.3.2.2 Advanced Imaging

Many of the radiographic features of RA, such as erosion and joint space loss, constitute structural changes to the joint which are largely irreversible. Effective therapy needs to be commenced prior to these occurring, and the use of advanced imaging modalities to detect disease earlier is now commonplace.

Both ultrasound and MRI are routinely used to detect subclinical synovitis in the early stages of RA and to monitor its response to therapy (Figs. 11.7 and 11.12). Both modalities also detect erosive changes and extra-articular features of the disease, such as tenosynovitis and rheumatoid nodules (Fig. 11.12). Unique to MRI is its ability to assess the bone marrow and identify osteitis. The presence of osteitis isstrongly predictive of the development of erosions [27].

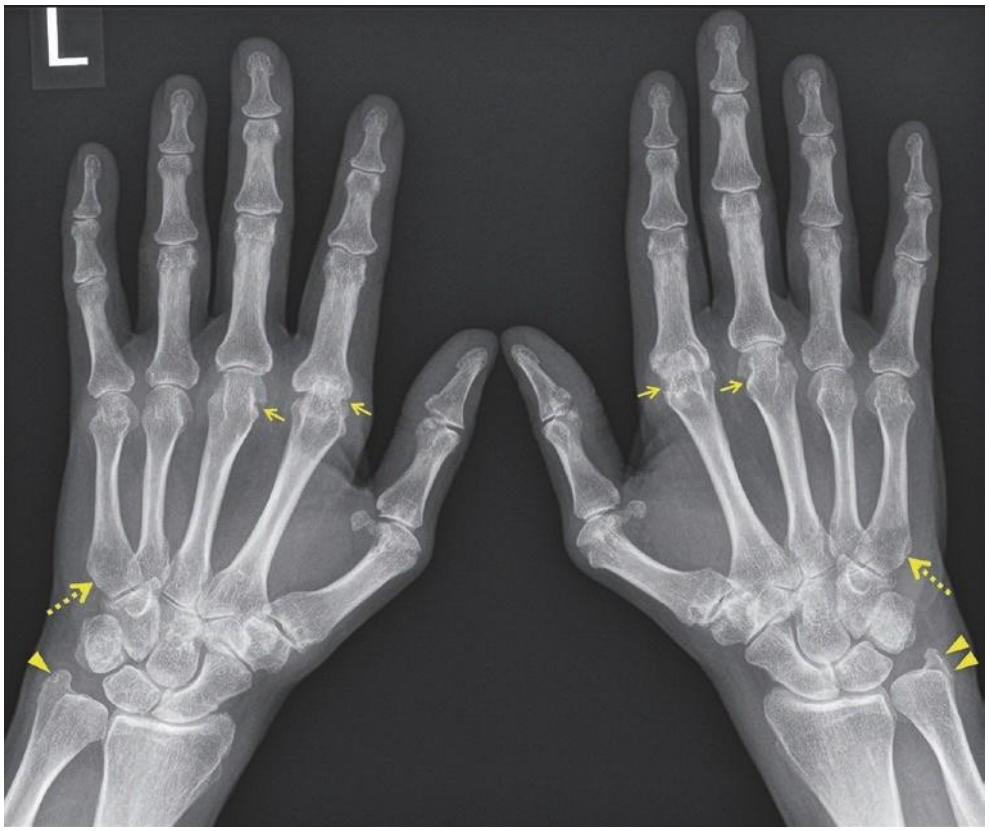

Fig. 11.11 Dorsopalmar radiograph of both hands in a patient with rheumatoid arthritis. There is typical involvement of the MCP joints with joint space narrowing and marginal erosions, most markedly seen on the radial side of the metacarpal heads (arrows). Subluxation is evident at the index MCP joints. Note erosions also seen at the ulnar styloid processes (arrowheads). Periarticular osteopenia is seen at several sites, for instance, at the fifth metacarpal bases (dotted arrows)

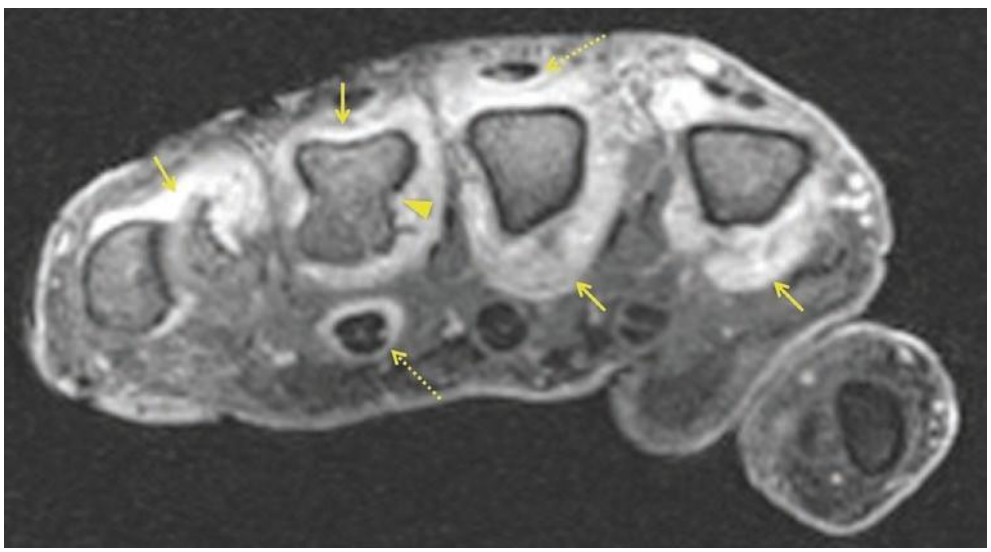

Fig. 11.12 Axial MPR of 3D fat-suppressed spoiled gradient echo (SPGR) MRI post-gadolinium, just proximal to MCP joints in a patient with rheumatoid arthritis. There is extensive enhancing synovitis seen around the metacarpal heads (arrows) associated with erosion in the ring finger metacarpal head (arrowhead). Note also enhancing tenosynovitis around the ring finger flexor and middle finger extensor tendons (dashed arrows)

Key Point

- The radiographic features of RA are characterized by marginal erosions and joint space narrowing, with involvement typically seen at the PIP, MCP, and wrist joints. These features are relatively late findings in the disease process, and increasingly MRI and ultrasound are used to detect early abnormalities, including synovitis and osteitis. Both modalities detect erosions with higher sensitivity than radiographs.

11.3.3 Spondyloarthritides

While PsA and reactive arthritis typically involve the small joints of the hands and feet, AS more usually involves the large peripheral joints. However, all of the spondyloarthritides are characterized by frequent axial involvement of the spine and sacroiliac joints. These conditions also involve enthesis sites throughout the body.

11.3.3.1 Radiographic Appearances

- *Joint space*: Joint space loss is a common feature of SpA and is characteristically pan-articular as with RA. However, a feature of SpA is apparent preservation of or even increase in joint space due to the formationof fibrous tissue within the joint. For instance, interphalangeal joint involvement in PsA can lead to large spaces between bone ends despite extensive osseous destruction.In later stages of SpA, joints may progress to ankylosis.
- *Soft tissues*: Soft tissue swelling is a feature of inflamed joints in SpA. A particular characteristic of PsA is inflammation of all joints in entire digits in the hands and feet, with diffuse soft tissue swelling, known as "sausage digit." Bursitis at sites of enthesitis, such as the retrocalcaneal bursa at the Achilles enthesis, along with tendon thickening may be seen as radiographic soft tissue swelling.
- *Bones*: Periarticular osteopenia is not a feature of peripheral SpA. However, bone erosion seen in the hands and feet is typically closely related to ligamentous and capsular enthesis sites and is associated with fluffy new bone formation (enthesophyte) (Fig. 11.13). At sites remote from joints, such as the Achilles tendon and plantar fascial insertions, enthesitis gives rise to similar patterns of erosion along with fluffy enthesophyte formation. A char-characteristic finding in the hands and feet of patients with PsA is the so-called "pencil in cup" appearance, with both extensive bone destruction and maintenance or even widening of apparent joint space. Bone loss may also be seento involve the terminal phalangeal tufts, which can be useful in discriminating PsA from erosive OA.
- *Alignment*: Involvement of the hands and feet in PsA can result in "arthritis mutilans" with severe resorption of bone from the digits leading to telescoping of the overlying soft tissues and resulting alignment deformity.
- *Joint distribution*: Involvement of the small joints of the hands and feet is typical in PsA. This tends to be distally distributed with relative sparing of the wrist and MCP joints until later in the disease (Fig. 11.5c). The absence of trapeziocentric thumb base involvement is helpful in distinguishing PsA from OA, which otherwise shows similar joint distribution. In PsA and reactive arthritis, involvement of the MTP and interphalangeal joints of the foot is typical. Conversely, hip and shoulder involvement is relatively common in AS. In all types of SpA, a careful review of visualized enthesis sites is helpful to look for signs of enthesitis (soft tissue swelling, erosion, and fluffy enthesophytes) remote from the joints themselves.

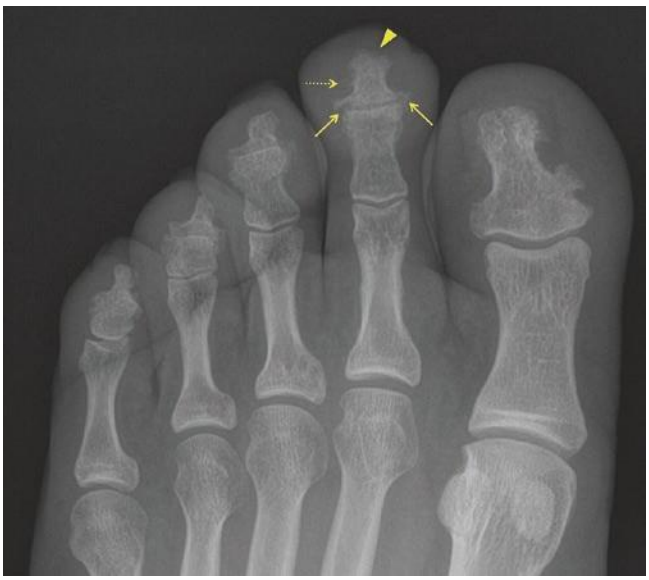

Fig. 11.13 Dorsoplantar radiograph showing the toes in a patient with psoriatic arthritis. There is erosive change at the base of the distal phalanx of the second toe, associated with fluffy new bone formation (enthesophyte). Further new bone formation is evident on the lateral aspect of the phalanx (dashed arrow). There is also early resorption of the phalangeal tuft (arrowhead)

11.3.3.2 Advanced Imaging

Both ultrasound and MRI have roles in imaging peripheral SpA with their ability to demonstrate synovitis, tenosynovitis, and articular cartilage. Dactylitis is associated with flexor tenosynovitis and thickening of the soft tissues, joint effusion, and synovitis on ultrasound, while MRI will also showbone and soft tissue edema.

The two modalities have a valuable role in the detection of enthesitis. Both techniques will identify erosive change and enthesophyte formation at enthesis sites with soft tissue changes of tendon/ligament thickening and signal/echogenicity change. Ultrasound may show increased vascularity, while MRI may show osteitis (bone edema) at enthesis sites. In large joints, the presence of bone edema at characteristic enthesis sites on MRI may point to the underlying etiology of the inflammatory joint changes.

11.3.3.3 Sacroiliitis

Sacroiliitis is evident on conventional radiographs as subchondral sclerosis and erosive change. Erosion may lead to apparent widening of the joint, but ultimately the natural history of the disease is progression to ankylosis. CTis more sensitive to the detection of sacroiliitis than conventional radiographs, but the features seen are similar (Fig. 11.6). In AS and enteropathic SpA, involvement of the sacroiliac joints is usually bilateral and fairly symmetrical; this contrasts with sacroiliitis-associated with PsA and reactive arthritis where involvement is often more asymmetrical. MRI has become fundamental in the diagnosisand assessment of sacroiliitis. While the erosive findings

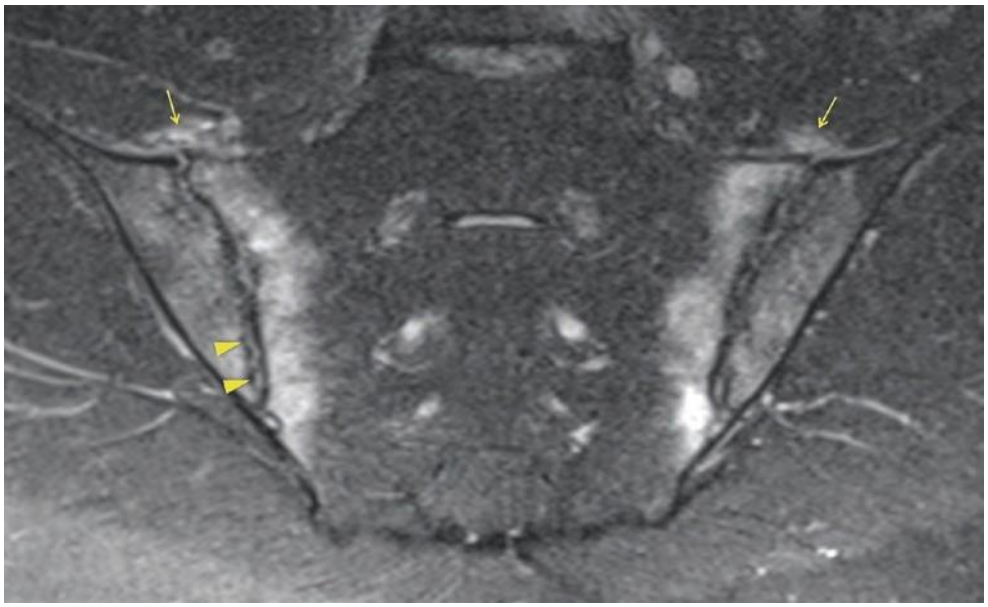

Fig. 11.14 Coronal oblique STIR image through the sacroiliac joints in a patient with acute on chronic sacroiliitis. In addition to the subchondral bone edema (osteitis) seen bilaterally on both sides of the joint, there is periarticular soft tissue/ligamentous edema (arrows). Erosive change is also evident (arrowheads)

and subchondral changes seen with radiographs and CTare evident on MRI, these represent later changes. The earliest feature of sacroiliitis seen on MRI is osteitis in the subchondral bone, which has become an important feature in the classification of SpA (Table 11.2) (Fig. 11.14). However, sacroiliac subchondral bone edema is not specific to the diagnosis of SpA and is well-recognized in healthy subjects, especially those participating in sports such as running; it is a prominent feature of infective arthritis. In chronic sacroiliitis, sites of subchondral bone edema eventually become replaced with high T1 signal fat.

11.3.3.4 Spinal Involvement in Spondyloarthritis

Involvement of the discovertebral unit and the posterior elements of the vertebral column in patients with SpA may precede sacroiliac involvement. The early features of spinal spondyloarthritis are the result of enthesitis, in particular at the attachment sites of the annulus fibrosus and ligaments. On conventional radiographs sclerosis becomes evident at these insertion points, classically seen at the corners of vertebral endplates, known as Romanus lesions. Erosive change at these sites is hard to detect on conventional radiographs, but associated ossification of the anterior longitudinal ligament results in a squared-off appearance to the anterior vertebral body. Although these constitute the earliest features seen onconventional radiographs, they are late features of the disease. MRI will show bone edema at these same enthesis sites much earlier, giving rise to a characteristic appearance of high T2 signal corners to the vertebral bodies on water-sensitive sagittal imaging (Fig. 11.15). Edema at other sites of ligamentous insertion may also be apparent, for instance,at the costovertebral joints and at ligamentous attachments to the spinous processes (Fig. 11.15). Later in the disease, fat marrow signal may develop at these enthesis sites similar to the sacroiliac joints.

Proliferative new bone formation that develops later can be hard to appreciate on MRI, especially early in its development, as the low-signal syndesmophytes contrast poorly against adjacent bone cortex and ligaments. However, syndesmophytes become progressively coarser as the disease advances and are readily seen on CT and radiographs. Ultimately, vertebral fusion involving anterior and posterior elements may result in the characteristic appearanceof a "bamboo spine." While the syndesmophyte formation seen in AS and enteropathic spondylitis typically has a fine appearance and involves the spine at each level in a symmetrical distribution, the bone proliferation in PsA and reactive arthritis tends to appear more coarse, with a more asymmetrical distribution.

It should be remembered that a fused inflexible spine is particularly susceptible to fracture and a transverse fracture through a fused spine is highly unstable and a potentially catastrophic event.

Key Point

- As with rheumatoid arthritis, the radiographic features of axial and peripheral spondyloarthritis are late findings of the disease. A characteristic finding of spondyloarthritis is enthesitis including erosive change and enthesophytes. On MRI this is associated with osteitis in the subchondral bone at the sacroiliac joints and in characteristic entheseal locations in the spine.

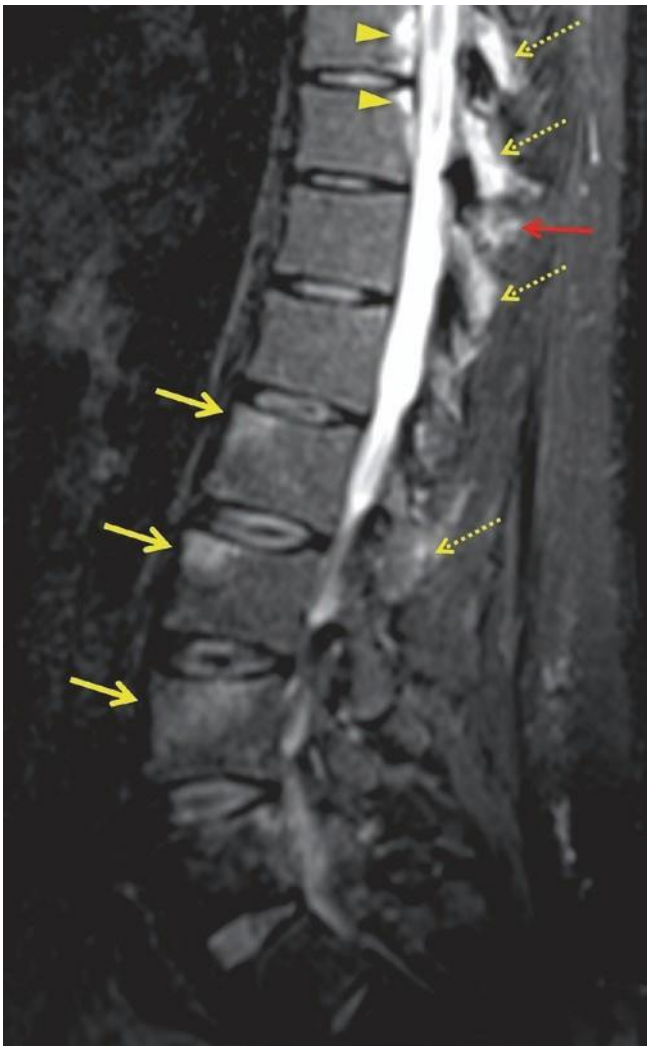

Fig. 11.15 Sagittal T2 fat-suppressed image of the lower thoracicand lumbar spine in a patient with ankylosing spondylitis. There are typical foci of high T2 signal (osteitis) in the anterior corners of the vertebral bodies (yellow arrows). Note the normal disks helping dis- tinguish the appearances from reactive (Modic type) endplate change. There are similar findings in the posterior vertebral bodies more crani- ally (arrowheads) and in the posterior spinal elements (dashed arrows). There is also inflammatory edema in the posterior soft tissues (red arrow)

11.3.4 Metabolic Joint Disease

11.3.4.1 Gout

Gout can be highly destructive, and the conventional radiographic appearances in the later stages of the disease are very characteristic. However, in the earlier stages of the disease characterized by acute inflammatory episodes, imaging abnormalities may only be observed with more advanced imaging modalities.

Radiographic Appearances

- *Joint space*: Even in advanced chronic tophaceous gout with extensive bone erosion, joint space may be maintained; this is a useful distinguishing feature from other forms of arthritis (Fig. 11.2).
- *Soft tissues*: Urate crystal deposition in chronic tophaceous gout leads to irregular and eccentric soft tissue swelling, a characteristic feature of gout. Tophi sometimes show significantly increased density compared to the surrounding soft tissues due to the variable deposit of microcalcifications within the urate deposit, often associated with renal disease (Fig. 11.2).
- *Bones*: Loss of normal bone mineral density is not a common feature of gout. However, bone erosion is frequent inthe chronic stages of the disease. The erosions have a characteristic round or oval configuration with sclerotic margins and sharp overhanging edges of bone. Erosions may be seen centrally, at the joint margin, or at some distance from the joint, often beneath soft tissue nodules (Fig. 11.2).
- *Alignment*: Deformity of joints affected by gout occasionally results from the extensive bone destruction that accompanies chronic disease, producing a severe mutilating arthritis.
- *Joint distribution*: In the majority of cases, the first MTP joint is initially affected; tarsometatarsal joint and carpometacarpal joint involvement is also common. However, disease progression leads to involvement of multiple joints typically with an asymmetrical distribution. Although any joint can be involved, the elbow, knee, and ankle are the most common large joints affected. The joints of the axial skeleton are rarely affected.

Advanced Imaging

Acute presentation of gout, before the chronic manifestations are apparent, involves synovitis and joint effusion. Both ultrasound and MRI will demonstrate these features. One feature of acute gout is the presence of crystal aggregates or “microtophi” within the synovitis and effusion. On ultrasound these can appear as bright reflective foci which may also be seen in gout tophi (Fig. 11.8). In the effusion, this a poor discriminator, since this appearance may be caused by fibrin deposits in rheumatoid arthritis and some types of septic arthritis including tuberculous arthritis. However, in the synovium, these fine reflective foci are more suggestive of acute gout and may even be seen in asymptomatic joints in patients with known gout [28]. On ultrasound, microaggregates may also be seen on the surface of cartilage giving

rise to the so-called "double contour" sign. Both ultrasound and MRI are able to demonstrate the soft tissue deposits and erosions of chronic gout. The characteristic "punched out" appearance to the erosions seen on radiographs is similar on these modalities. Gout tophi have an ill-defined, generally hyperechoic appearance on ultrasound, but this is dependent on the amount of calcification present (Fig. 11.8). Both ultrasound and MRI will also demonstrate gout involvement of tendons, tendon sheaths, and peritendinous tissues.

Dual-energy CT, with its ability to characterize urate crystals in soft tissues, is becoming widely used in clinical practice, with high sensitivity and specificity.

11.3.4.2 Calcium Pyrophosphate Deposition Disease

Acute pseudogout is generally a clinical diagnosis supported by crystal analysis from aspirated fluid. However, as with gout, MRI and ultrasound will demonstrate effusion and synovitis.

Radiographic Appearances

- *Joint space*: CPPD arthropathy is associated with joint space narrowing as cartilage is lost. Calcium pyrophosphate deposited in the articular cartilage and, where present, fibrocartilage (chondrocalcinosis) will be visible within the joint (Fig. 11.4). In fibrocartilage, particularly in the knee menisci, the calcification has a coarse irregular appearance, while in hyaline cartilage, the calcification appears as a thin, linear density paralleling the subchondral bone margin.
- *Soft tissues*: CPPD crystal deposition may also be evident in the synovium and joint capsule. Although less frequent, ligament and tendon calcifications can occasionally be seen.
- *Bones*: The radiographic appearances of CPPD arthropathy resemble those of osteoarthritis, with subchondral sclerosis, cyst formation, and osteophytosis. However, characteristic findings include large cysts, often associated with collapse of the bone in the later stages of the disease, and less prominent osteophytes than would be expected for the degree of arthropathy seen (Fig. 11.4).
- *Alignment*: As with osteoarthritis, joint deformity is largely the result of subchondral collapse and cartilage loss. At the wrist, it is not uncommon for ligamentous dysfunction to lead to scapholunate disassociation (Fig. 11.4).
- *Joint distribution*: Along with crystal deposition, the unusual distribution compared to OA is the most characteristic feature of CPPD arthropathy. In particular, involvement of the index and middle MCP joints in the hand is very typical of CPPD arthropathy, along with radiocarpaland midcarpal wrist involvement (Fig. 11.5d). At the knee, a common feature is predominant or even isolated patellofemoral joint involvement. Hemochromatosis-related arthropathy, which is associated with pyrophosphate deposition, frequently involves all of the MCP joints and may be associated with prominent hook-like osteophytes at the metacarpal heads.

Advanced Imaging

The deposition of pyrophosphate crystals in hyaline cartilage, synovium, and joint fluid can be demonstrated on ultrasound. CPPD crystal deposition in the substance of the cartilage may be distinguished from urate crystal deposition on the surface of the cartilage in gout, but the double contour sign described in gout may also be seen with pyrophosphate chondral deposition and, despite early reports, seems not to be specific for gout [29, 30].

On MRI, calcium deposition in fibrocartilage is not detected because of its similar low signal characteristics. However, in hyaline cartilage, MRI may sometimes depict chondrocalcinosis as punctate or linear hypointense signal.

Key Point

- Radiographic features of chronic tophaceous gout include irregular soft tissue swelling, preservation of joint space, and characteristic punched out erosions. Ultrasound can demonstrate aggregates of urate crystals in synovium and on the surface of articular cartilage. Tophi are readily identified with MRI and ultrasound. CPPD arthropathy, associated with chondrocalcinosis and crystal deposition in synovium and capsular tissues, is characterized by radiographic appearances similar to OA, but in atypical locations.

11.4 Concluding Remarks

While recognizing that there are many other causes of joint disease with characteristic findings, this review has concentrated on some of the most common arthritides seen in clinical practice. The fundamental role conventional radiographs continue to play in the diagnosis and management of these conditions has been emphasized, and a logical method of reviewing the radiograph assessing joint space, soft tissues, bones, alignment, and joint distribution has been suggested. Increasingly, advanced imaging modalities are playing an important part in assessing patients with arthritis, with ultrasound and MRI both playing roles in identifying early dis- ease before radiographic findings become apparent. These advanced imaging modalities continue to contribute to our understanding of the pathophysiology of joint disease and enable the early instigation of treatment.

Take Home Messages

- Conventional radiographs remain fundamental to the imaging workup of patients with arthritis and provide valuable information relating to the assessment of joint space, periarticular soft tissues, bone (including erosions and osteophytes), joint alignment, and the distribution of the arthritis.
- Ultrasound and MRI allow sensitive assessment of synovitis and erosions in rheumatoid arthritis and the spondyloarthritides, with MRI also able to identify bone marrow changes including osteitis, along with articular cartilage changes.
- OA findings of uneven (asymmetric) joint space loss, osteophytes, and subchondral bone changes are typically seen at DIP and PIP joints and at the thumb base, whereas CPPD arthropathy characteristically involves the index and middle MCP joints along with radiocarpal and midcarpal wrist involvement.
- RA is characterized by marginal erosions and joint space narrowing typically seen at the PIP, MCP, and wrist joints, whereas spondyloarthritis is characterized by erosive change, enthesophytes, and osteitis at the sacroiliac joints and in characteristic entheseal locations in the spine.
- While gout shows an asymmetric distribution of irregular and eccentric soft tissue swelling, maintained joint space and bone erosions with a characteristic round or oval configuration, and sclerotic margins with sharp overhanging edges of bone on conventional radiographs, advanced imaging modalities, in particular ultrasound and dual energy CT, have an increasingly important role in characterizing the disease.

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