Radiographic Evaluation of Arthritis: Degenerative Joint Disease and Variations[1]

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In the presence of joint space narrowing, it is important to differentiate inflammatory from degenerative conditions. The presence of osteophytes, bone sclerosis, and subchondral cysts and the absence of inflammatory features such as erosions suggest osteoarthritis. Typical osteoarthritis involves specific joints at a particular patient age. When osteoarthritis involves an atypical joint, occurs at an early age, or has an unusual radiographic appearance, then other causes for cartilage destruction should be considered, such as trauma, crystal deposition, neuropathic joint, and hemophilia. There are several types of arthritis, such as juvenile chronic arthritis and gouty arthritis, that may have a variable appearance compared with that of other common inflammatory arthritides.

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Radiography is commonly used in the evaluation for arthritis. A basic algorithm based on radiographic findings can be followed to reach a final and usually correct diagnosis (Fig 1). While it is impossible to include all forms of arthritis with their variations into one scheme, this algorithm can be used as a framework for evaluation, as it encompasses the most frequent radiographic features of common arthritides.

The starting point for the algorithm is joint space narrowing. The next step is to determine if the joint process is inflammatory or degenerative. While an inflammatory condition is suggested by osteopenia and soft-tissue swelling, it is the presence of bone erosions that is the characteristic finding of inflammation. Early erosions will appear as discontinuities of the thin, white, subchondral bone plate, commonly involving the joint margins (Fig 2). Uniform joint space narrowing may also be present. In contrast, a degenerative cause of joint space narrowing is characterized by osteophytes; bone sclerosis; subchondral cysts, or geodes; asymmetric joint space narrowing; and lack of inflammatory features such as bone erosions (Fig 3).

Essentials

- With joint space narrowing, it is important to differentiate inflammatory from degenerative causes.
- Typical osteoarthritis involves specific joints at a particular patient age.
- Osteoarthritis of an atypical joint, at an early age, or with an atypical appearance suggests other less common causes for cartilage destruction.
- An atypical appearance of osteoarthritis can be due to trauma, crystal deposition disease, neuropathic joint, and hemophilia.
- Juvenile chronic arthritis and gouty arthritis are two types of arthritis that have an appearance that is different from that of other common inflammatory arthritides.

In part 1 of this review (1), common inflammatory arthritides were discussed. The present review will first focus on degenerative joint diseases, which include typical osteoarthritis as well as less typical forms of osteoarthritis, as may be seen with trauma, crystal deposition disease, and hemophilia. Finally, variations from the algorithm will be discussed, including conditions such as juvenile chronic arthritis, inflammatory osteoarthritis, and gouty arthritis.

Degenerative Joint Disease

A degenerative process is suspected when joint space narrowing, osteophyte formation, bone sclerosis, and subchondral cysts are seen in the absence of inflammatory changes (Fig 3). When degenerative joint disease involves a synovial articulation, the term osteoarthritis or osteoarthrosis is used. Commonly, joint space narrowing from osteoarthritis is associated with osteophyte formation, especially in the knee (2). With the hips and knees, a weight-bearing radiograph will improve detection of early joint space narrowing. The finding of marginal osteophytes is typically used to detect osteoarthritis, while the findings of joint space narrowing, bone sclerosis, and subchondral cysts are used to assess severity (2). As the joint space narrows, the osteophytes become larger, bone sclerosis increases, and subchondral cyst, or geode, formation may be seen. When osteoarthritis is identified at radiography, it is important to consider the joint involved, the age of the patient, and the radiographic appearance as the next step in the algorithm.

Typical Osteoarthritis

Osteoarthritis is typically the result of articular cartilage damage and wear and tear from repetitive microtrauma that occurs throughout life, although genetic, hereditary, nutritional, metabolic, preexisting articular disease, and body habitus factors may contribute in some cases. This process tends to involve specific joints during specific decades of a person's life and depends in part on the patient's body habitus and level of physical activity. For example, one of the first joints that may demonstrate osteoarthritis is the acromioclavicular joint, where minimal osteophyte formation may be seen in the 4th decade of life and beyond, owing to the stresses that occur at this joint (Fig 4). Another site of typical osteoarthritis is the first carpometacarpal joint, often beginning after the 5th decade of life, owing in part to stresses related to constant use of opposing thumbs or joint laxity (Fig 5a) (3). Osteoarthritis also characteristically involves the interphalangeal joints of the hands after the 4th or 5th decades of life; this is related in part to degree of use and overuse (Fig 5b) (4).

Involvement of the metacarpophalangeal joints is not infrequently associated with osteoarthritis of the interphalangeal joints, although this type of involvement is usually of lesser severity. Unlike in larger joints, joint space narrowing of the interphalangeal and metacarpophalangeal joints in osteoarthritis may be symmetric. Osteoarthritis of the first metatarsophalangeal joint is common beginning in the 5th decade of life (Fig 6) and may be associated with hallux valgus deformity.

As a person ages, osteoarthritis is identified involving the knee joints and hip joints, beginning after the 4th or 5th decade of life (4). With regard to the knee joints, joint space narrowing is typically asymmetric and most commonly involves the medial femorotibial compartment, possibly with the patellofemoral compartment (Fig 7) (5). Similarly, hip joint space narrowing is asymmetric, with superior migration of the femoral head more common than medial migration (Fig 8) (6). Underlying acetabular dysplasia is associated with superolateral migration. With early hip osteoarthrosis, a frog leg view will often

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Abbreviation:
CPPD = calcium pyrophosphate dihydrate

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reveal a rim or collar of osteophytes that may be more difficult to visualize on an anteroposterior radiograph.

The sequence of osteoarthritis described above can be somewhat variable. Regardless, when osteoarthritis is identified, it is important to consider which joint is involved, the severity of the radiographic changes, the distribution of osteoarthritis, and the age of the patient to make the distinction between typical and atypical osteoarthritis.

Atypical Osteoarthritis

If radiographic findings of osteoarthritis are identified but the involved joint is not one commonly affected by osteoarthritis, the severity of the findings are excessive or unusual, or the age of the patient is unusual, then other less common causes for cartilage damage and osteoarthritis should be considered. Possible causes for this atypical appearance of osteoarthritis include trauma, crystal deposition disease, neuropathic joint, and hemophilia. Other possible causes include congenital and developmental anomalies, such as dysplasia, that disrupt normal biomechanics.

Trauma is the most common cause for atypical osteoarthritis. This may be a sequela of *(a)* a prior traumatic event that causes cartilage damage and accelerated osteoarthritis or *(b)* an unusual and excessive repetitive injury, which may be seen in an athlete or may be occupational. For example, a remote athletic injury may produce an accelerated appearance of knee or hip osteoarthrosis. The clue for diagnosis is the relatively young age of the patient, involvement of an atypical joint (Fig 9), marked unilateral asymmetry of lower extremity joint involvement, or unusual severity. Another example of atypical osteoarthritis is due to excess occupational stresses and repetitive injury that is atypical because of patient's age and involvement of an unusual joint, such as the elbow.

Calcium pyrophosphate dihydrate (CPPD) crystal deposition disease may cause chondrocalcinosis and calcification of the synovium, joint capsule, tendons, and ligaments. In addition, CPPD crystal deposition disease may cause an arthropathy that can appear as atypical osteoarthritis. Although radiographic findings of CPPD appear somewhat similar to those of osteoarthritis, they are atypical because of joint distribution, extensive subchondral cyst formation, and associated calcium deposition, including chondrocalcinosis. For example, CPPD arthropathy characteristically involves the radiocarpal joint of the wrist and the second and third metacarpophalangeal joints of the hands (Fig 10) (6). Chondrocalcinosis of the triangular fibrocartilage is common, although calcium deposition in the intrinsic carpal ligaments (in particular the lunotriquetral ligament) and joint capsules is also seen (7). In the knee,

Figure 1

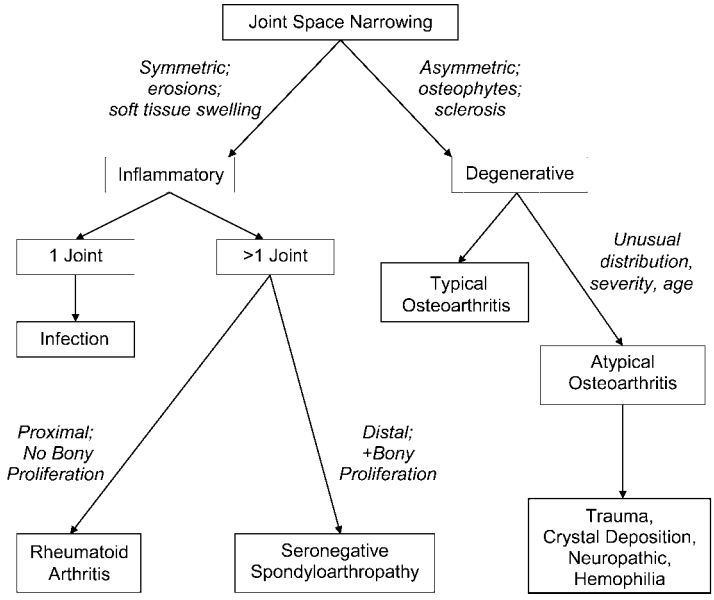


Figure 1: Flow chart shows approach to radiographic evaluation of arthritis. Algorithm begins with joint space narrowing and initially uses differentiation between inflammatory and degenerative findings to reach the final diagnosis. (Reprinted, with permission, from reference 1.)

Figure 2

Figure 2: Inflammatory arthritis (rheumatoid arthritis). Posteroanterior radiograph shows discontinuity of bone cortex, representing marginal erosions (arrows).

Figure 3

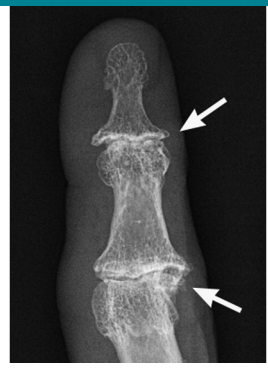


Figure 3: Osteoarthritis. Posteroanterior radiograph shows interphalangeal joint space narrowing, subchondral sclerosis, and osteophyte formation (arrows).

which is the joint most commonly affected by CPPD crystal deposition disease, disproportionate patellofemoral degenerative change is characteristic (Fig 11) and is associated with chondrocalcinosis, which affects the fibrocartilage menisci and hyaline cartilage (8). Calcium deposition in the gastrocnemius tendon origin is another finding seen with CPPD crystal deposition disease in the knees (Fig 11) (8). Other sites of chondrocalcinosis include the pubic symphysis and the hip labrum (9).

Figure 4

Figure 4: Osteoarthritis. Anteroposterior acromioclavicular joint radiograph shows joint space narrowing, sclerosis, and osteophyte formation involving the acromioclavicular joint (arrow).

Because the finding of chondrocalcinosis alone is nonspecific (other causes include hemochromatosis and hyperparathyroidism, among others), it is the coexistent finding of CPPD arthropathy that suggests CPPD crystal deposition disease as the cause. It is important to consider the diagnosis of hemochromatosis when the radiographic findings of CPPD are identified, as there is substantial overlap in their radiographic findings. In hemochromatosis, more extensive involvement of the second through fifth metacarpophalangeal joints has been described, and metacarpal radial hooklike or drooping osteophytes are more common (Fig 12) (9).

Another cause for an atypical appearance of osteoarthritis includes an early neuropathic joint. In this situation, the loss of feedback mechanisms of sensation and proprioception leads to joint instability and degenerative changes during daily activities. While the characteristic findings of a neuropathic joint—namely sclerosis, fragmentation, and subluxation—are obvious in the later stages of this process, the early changes of a neuropathic joint will often appear as atypical osteoarthritis (10). The primary clue to the diagnosis of an early neuropathic joint is the distribution of radiographic changes, which depends on the cause of the neuropathy. For example, involvement of the midfoot is characteristic with diabetes mellitus, where findings of joint space narrowing, bone sclerosis, and osteophytes are seen (Fig 13). The findings of coexisting arterial calcifications further suggest the diagnosis of neuropathic joint, and correlation with patient history is important. Other causes of neuropathic joint include syphilis or tabes dorsalis (involving the lower extremity joints and spine) and syrinx (involving bilateral shoulder joints).

Repetitive intraarticular hemorrhage, as seen with hemophilia, may cause cartilage destruction and radiographic features of atypical osteoarthritis (Fig 14). Although bone erosions due to secondary synovial inflammation may be seen, often the osteophytes, bone sclerosis, and subchondral cysts are most apparent. The combination of bone erosions and osteophyte formation creates an irregular appearance to the articular surface. When one sees these degenerative changes, it is the possible atypical joint distribution and young age that are in contrast to characteristics of typical osteoarthritis (Fig 15). Other features of hemophilia include somewhat more symmetric joint space loss, the presence of excessive subchondral cyst for-

Figure 5

a. b.

Figure 5: Osteoarthritis. **(a)** Posteroanterior and **(b)** oblique hand radiographs show joint space narrowing, sclerosis, and osteophyte formation of **(a)** first carpometacarpal (arrow) and **(b)** interphalangeal and metacarpophalangeal joints.

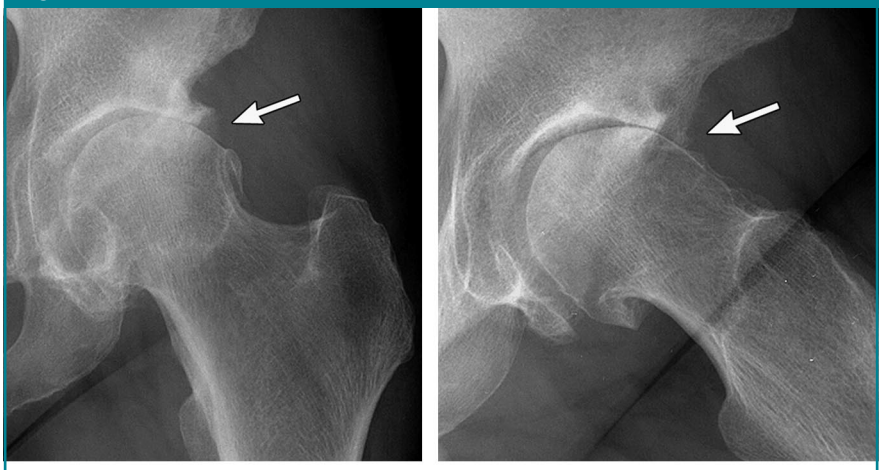
Figure 6

Figure 6: Osteoarthritis. Anteroposterior foot radiograph shows first metatarsophalangeal joint space narrowing, sclerosis, and osteophyte formation (arrows).

Figure 7

Figure 7: Osteoarthritis. Anteroposterior knee radiograph shows joint space narrowing, sclerosis, and osteophyte formation (arrow) predominately involving the medial compartment.

Figure 8



a. b.

Figure 8: Osteoarthritis. **(a)** Anteroposterior and **(b)** frog-leg hip radiographs show superolateral joint space narrowing, sclerosis, subchondral cyst, and osteophyte formation (arrow) with buttressing of the femoral neck.

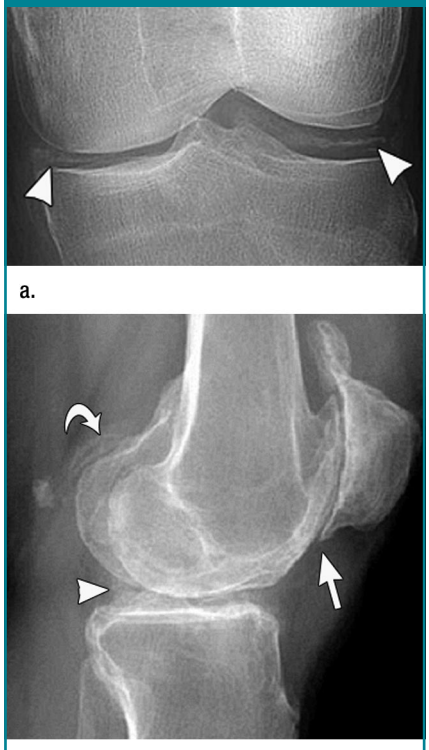
Figure 9

Figure 9: Atypical osteoarthritis due to trauma. Mortise ankle radiograph shows joint space narrowing, sclerosis, subchondral cyst, and osteophyte formation (arrow).

Figure 10

Figure 10: CPPD crystal deposition disease in the hand. Posteroanterior radiograph shows second and third metacarpophalangeal joint space narrowing, sclerosis, subchondral cyst, and osteophyte formation (arrowheads). Note chondrocalcinosis of the triangular fibrocartilage (arrow), and severe osteoarthritis of the first carpometacarpal joint.

Figure 11



a. b.

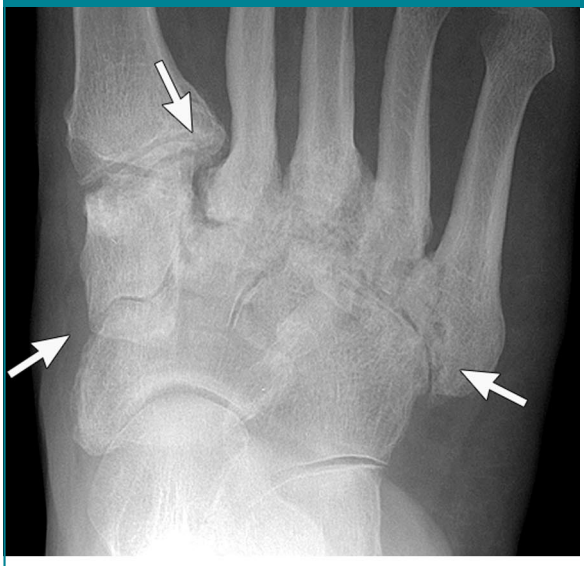
Figure 11: CPPD crystal deposition disease in the knee. **(a)** Anteroposterior and **(b)** lateral radiographs shows chondrocalcinosis involving the menisci (arrowhead) and hyaline cartilage, predominant patellofemoral joint osteoarthritis (straight arrow), and calcification of the gastrocnemius tendon origin (curved arrow).

mation, and possible dense effusion from hemorrhage. In addition to osteopenia, epiphyseal overgrowth is seen, due to chronic hyperemia in childhood (11). In the knees, elongation or squaring of the patella and widening of the intercondylar notch may be seen (Fig 14). Repeated hemorrhage may produce a large expansile and destructive abnormality known as hemophiliac pseudotumor, most commonly involving

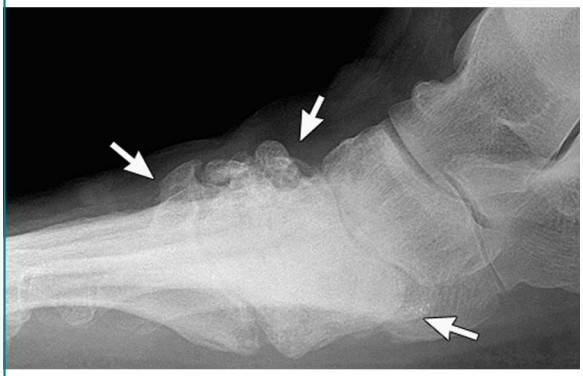
Figure 12

Figure 12: Hemochromatosis. Posteroanterior hand radiograph shows osteoarthritis of metacarpophalangeal joints, with hooklike osteophytes (arrowheads).

Figure 13



a.



b.

Figure 13: Neuropathic joint. **(a)** Anteroposterior and **(b)** lateral foot radiographs show joint space narrowing, sclerosis, subchondral cyst, and osteophyte formation (arrows). Note plantar navicular tilt and pes planus.

the femur and osseous pelvis. There is often overlap between the radiographic features of hemophilia and those of juvenile chronic arthritis; however, knee, ankle, and elbow involvement are more common in hemophilia. Correlation with patient history is also important in the diagnosis of hemophilia.

Other less common causes for an atypical osteoarthritis appearance include epiphyseal dysplasia, ochronosis,

Figure 14

Figure 14: Hemophilia. Anteroposterior knee radiograph in 20-year-old man shows joint space narrowing that is somewhat symmetric, sclerosis, subchondral cyst, and osteophyte formation (arrowheads), with widening of intercondylar notch (arrows). Note flattening of distal femoral condyle surfaces.

Figure 15

Figure 15: Hemophilia. Lateral foot radiograph shows joint space narrowing, sclerosis, and osteophyte formation (arrows).

Radiology

Figure 16

a. b.

Figure 16: Juvenile chronic arthritis: Still disease. **(a)** Posteroanterior hand radiograph shows joint space narrowing and inflammatory changes at several joints, with epiphyseal overgrowth and other growth disturbances due to early epiphyseal fusion. **(b)** Bilateral anteroposterior knee radiographs show uniform joint space narrowing (arrows), osteopenia, and epiphyseal overgrowth with widening of the intercondylar notch (arrowheads). Note secondary osteoarthritis.

Figure 17

Figure 17: Early osteoarthritis. Posteroanterior radiograph of the fingers shows proximal and distal interphalangeal joint space narrowing with minimal subchondral sclerosis and relatively few osteophytes.

Figure 18

Figure 18: Rheumatoid arthritis. Anteroposterior knee radiograph shows diffuse uniform joint space narrowing.

and acromegaly. With epiphyseal dysplasia, multiple joints will be involved, with irregular articular surfaces and abnormal shape of the epiphyses. Ochronosis, a term that describes abnormal pigmentation in the disorder alkaptonuria, is associated with characteristic multiple disk calcifications. With acromegaly, other radiographic findings include spade-shaped distal phalanges, initial widening of joint spaces, increased heel pad thickness, posterior vertebral scalloping, and mandibular and sinus enlargement.

Variations to Algorithm

In the presented algorithm as an approach to the diagnosis of arthritis on radiographs, joint space narrowing was used as an arbitrary starting point, primarily to emphasize the important distinction between inflammatory and degenerative arthritis when joint space narrowing is seen. However, there are several conditions that do not precisely fit into the algorithm; these include juvenile chronic arthritis, inflammatory arthritis with secondary osteoarthritis, erosive or inflammatory osteoarthritis, gout, and systemic lupus erythematosus. Although not discussed here, pigmented villonodular synovitis and synovial osteochondromatosis may cause secondary osteoarthritis with pressure erosions, especially if the condition is

Figure 19

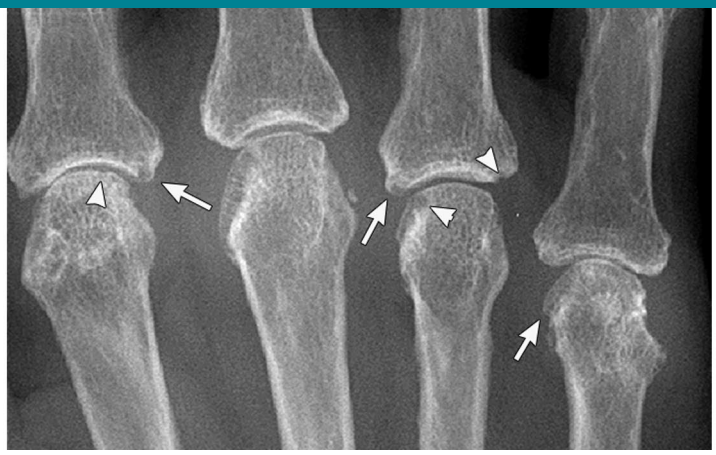


Figure 19: Rheumatoid arthritis with secondary early osteoarthritis. Posteroanterior hand radiograph shows uniform joint space loss of each metacarpophalangeal joint. Note small erosions (arrowheads) and small osteophytes (arrows).

Figure 20

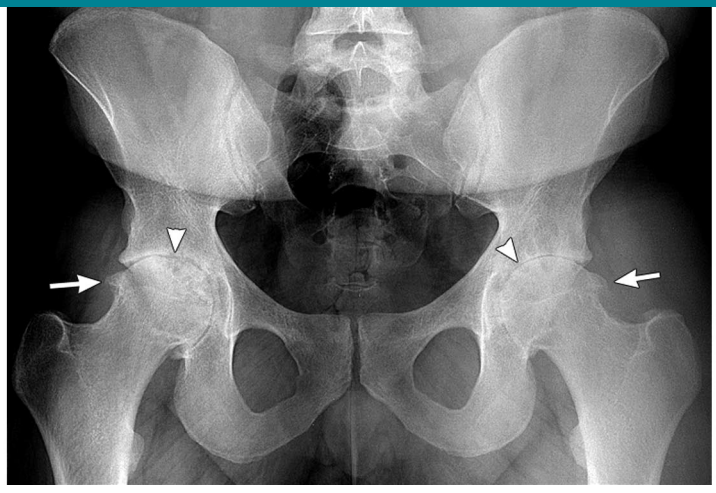


Figure 20: Rheumatoid arthritis with secondary osteoarthritis. Anteroposterior pelvis radiograph shows joint space narrowing of each hip joint. Note small erosions (arrowheads) and osteophytes (arrows). Sacroiliac joint involvement is also present with narrowing, irregularity, and sclerosis.

Figure 21

Figure 21: Inflammatory or erosive osteoarthritis. Posteroanterior finger radiograph shows joint space narrowing, sclerosis, and osteophyte formation of distal interphalangeal joint with prominent central erosion (arrow).

Figure 22

Figure 22: Gout. Posteroanterior hand radiograph shows sclerotic erosion (arrow), with soft-tissue swelling and wide joint space.

longstanding and involves a joint of small capacity.

Juvenile Chronic Arthritis

The category of juvenile chronic arthritis (or juvenile rheumatoid arthritis) consists of Still disease (or seronegative chronic arthritis), juvenile-onset adult-type rheumatoid arthritis, juvenile-onset ankylosing spondylitis, psoriatic arthritis, arthritis of inflammatory bowel disease, other seronegative spondyloarthropathies, and miscellaneous arthritis (12). This discussion will primarily focus on Still disease because it is the most common type, accounting for 70% of cases of juvenile chronic arthritis.

Still disease has three subtypes: pauciarticular, polyarticular, and systemic. The most common is pauciarticular disease (60% of cases), which involves the larger peripheral joints such as the knees, ankles, elbow, and wrists and affecting one to four joints (13). Another subtype includes polyarticular disease (20% of cases), commonly affecting bilaterally the hands, wrists, knees, ankles, and feet (Fig 16). A third subtype, systemic disease (20% of cases) may or may not be associated with arthritis but is characterized by fever, rash, lymphadenopathy, hepatosplenomegaly, pericarditis, myocarditis, and anemia.

Common radiographic features of arthritis in Still disease include soft-tissue swelling and osteopenia; however, there are several distinct differences when compared with adult rheumatoid arthritis. These differences include delayed joint space narrowing and erosive changes, possible periostitis, growth disturbances, and, later, joint fusion (Fig 16). The presence of periostitis is due to the relatively loosely adherent periosteum in children compared with that in adults. Growth disturbances include osseous overgrowth of the epiphyses due to chronic hyperemia and bone undergrowth due to premature growth plate fusion.

Joint Space Narrowing without Erosions or Osteophytes

In the presented algorithm, the first step is to determine if erosions or osteophytes are present in the setting of joint space narrowing. In the absence of either erosions or osteophytes, one must rely on the distribution of joint involvement, the characteristics of joint space narrowing, and secondary signs of inflammation to arrive at the correct diagnosis. For example, if joint space narrowing involves the distal interphalangeal joints in a 60-year-old patient

Figure 23

Figure 23: Gout. Anteroposterior foot radiograph shows multiple punched-out sclerotic erosions (arrows), with soft-tissue swelling.

Figure 24

Figure 24: Gout. Posteroanterior finger radiograph shows substantial destruction centered at distal interphalangeal joint (arrow).

Figure 25

Figure 25: Gout. Anteroposterior knee radiograph shows punched-out sclerotic erosion (arrow) and soft-tissue swelling (arrowheads).

without periarticular osteopenia or soft-tissue swelling, then early osteoarthritis is likely (Fig 17). If joint space narrowing involves the knee but symmetrically involves the joint with periarticular osteopenia, then an inflammatory arthritis such as rheumatoid arthritis is suggested (Fig 18). If joint space narrowing involves a single joint with soft-tissue swelling and periarticular osteopenia, then early septic joint must be considered.

Inflammatory Arthritis with Secondary Osteoarthritis

A patient with chronic and possibly treated inflammatory arthritis may develop secondary changes of osteoarthritis. Assessment using the presented algorithm becomes difficult in this situation, because a combination of erosions and osteophytes may be present involving the same joint. There are several radiographic features that indicate inflammatory arthritis with secondary osteoarthritis. Many times, the most obvious feature is involvement of a joint not typically affected by osteoarthritis, such as the metacarpophalangeal joints. When osteophytes are identified in this situation, one may initially consider causes for atypical osteoarthritis. However, other findings of underlying inflammatory arthritis are often present, such as symmetric joint space loss and evidence for erosions (Fig 19). Healed erosions may demonstrate a smooth or sclerotic margin. The characteristic distribution of joint abnormalities with inflammatory arthritis may also be seen, such as bilateral, symmetric, proximal involvement of the extremities or bilateral fifth metatarsophalangeal joint involvement, as seen in rheumatoid arthritis. The finding of symmetric joint space loss with osteophytes also suggests inflammatory arthritis with secondary osteoarthritis (Fig 20).

Inflammatory or Erosive Osteoarthritis

Inflammatory or erosive osteoarthritis can be viewed as a variation of osteoarthritis in that it commonly involves the interphalangeal joints of the hand, and osteophytes are quite obvious. The additional characteristic feature is a central erosion that produces two convexities of the joint surface, likened to the wings of a seagull (Fig 21). This central erosion should not be confused with the marginal erosions of rheumatoid arthritis. Proliferative synovitis is present, and consequent inflammation of the involved joint can result in ankylosis (14).

Gout

Gouty arthritis is caused by monosodium urate crystals, which display strong negative birefringence at polarized light examination. The radiographic features of gout do not fit into the presented algorithm, in that joint space narrowing occurs late (Fig 22). In addition, the erosions are characteristic in that they are frequently near a joint but not specifically marginal and they have sclerotic margins that produce a punched-out appearance (Fig 23) (15). Periarticular osteopenia is also absent. Another clue to the diagnosis of gout is the presence of marked soft-tissue swelling from gouty tophus deposition. Calcification of such tophi is uncommon in the absence of coexisting renal disease. Marked bone destruction occurs in severe cases, with substantial soft-tissue swelling (Fig 24). The most common site for gout involvement is the first metatarsophalangeal joint of the foot. Other joints, such as the interphalangeal joints of the hands and feet are not uncommon, although gout can occur in other joints as well (Fig 25). Another characteristic site for gouty erosions are the tarsal bones. Rounded lucencies about a joint may represent erosions or intraosseous tophi. Gout may also produce soft-tissue swelling from bursitis, such as olecranon bursitis. Because the radiographic findings may at times be confusing and appear quite unusual, it may be helpful to remember, "When in doubt, think gout."

Systemic Lupus Erythematosus

The radiographic features of systemic lupus erythematosus (SLE) may not be obvious, in that joint space narrowing and erosions are not frequent. The most common finding with SLE is the pres-

Figure 26

a. b.

Figure 26: Systemic lupus erythematosus. **(a)** Posteroanterior and **(b)** oblique hand radiographs show reducible subluxation and swan-neck deformities at several joints (arrowheads).

ence of reducible metacarpophalangeal joint subluxation without erosions; such findings are often identified only on oblique radiographs and are absent on posteroanterior views (Fig 26). Periarticular osteopenia and soft-tissue swelling may be seen.

Conclusion

Once joint space narrowing is recognized, the presence of erosions suggests an inflammatory arthritis, while the presence of osteophytes indicates a degenerative arthritis. When osteoarthritis is suggested, it is important to take into account the distribution of joint involvement, the severity of disease, and age of the patient to consider less common causes of cartilage damage. One must also be familiar with the arthritides that do not cleanly fit into the algorithm, such as gouty arthritis.

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