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Arthritis: A Radiologic Overview

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The diagnosis of arthritis is established by the correlation of clinical, laboratory and radiographic data. Some fundamental aspects of radiographic evaluation will be reviewed.

Baseline radiographic study of a patient with polyarthralgia should include films of involved joints and the contralateral joints if they are presently asymptomatic. Generally, a screening study for a peripheral arthritis should include a single view of the hands and wrists, not only because these sites are frequently affected during the course of the disease, but because differential radiographic features are more apparent here than in other joints. The clinical presentation may appropriately limit evaluation to a single joint, to the appendicular skeleton or the axial skeleton. Serial studies are useful in assessing progression of the disease and occasionally are helpful in differential diagnosis.

Because any single radiographic abnormality may lack diagnostic specificity, a comprehensive approach to the films is essential. One should search for abnormalities of soft tissue, bone mineralization, cartilage space and malalignment (Table I).[1]

Rheumatoid arthritis in the adult (Figures 1 and 2) has a predilection for the extremities. Any synovial joint can be affected, but those most commonly involved of the upper extremity include metacarpophalangeal, proximal interphalangeal, intercarpal, radiocarpal and radioulnar joints. The distribution in the feet is analogous,[2] though the interphalangeal joints are less frequently afflicted. Synovial inflammation, followed by pannus formation, results in periarticular soft tissue swelling, subarticular demineralization, marginal and articular erosions and joint space narrowing. Later changes include soft tissue atrophy, generalized osteoporosis, fibrous or bony ankylosis, and various types of alignment abnormalities. Alignment abnormalities can result from cartilage destruction, resorption of articular surfaces, alterations in the joint capsule or pericapsular ligaments, and imbalance of action of opposing muscles and tendons. The changes are often bilateral and symmetrical. Secondary degenerative joint disease is uncommon except in the knees and hips, and when present it usually is not prominent. When the spine is involved, the cervical region is most commonly affected. A typical finding is atlanto-axial subluxation.

Juvenile rheumatoid arthritis usually involves the knees, ankles and wrists. Less often affected are the hands, elbows, hips, feet, shoulders and cervical spine. Monoarticular disease is more common in children than in adults. Radiographic manifestations are similar to those in the adult but differ in several respects. Periosteal new bone is frequent. Bone length may be altered due to epiphyseal hypervascularity. Erosions and joint space narrowing are seen later in the course of the disease, and occasionally ankylosis and dislocation of large joints occur. The cervical spine is commonly involved, with a greater tendency for apophyseal joint ankylosis than in adult-onset disease.

TABLE I*

Soft Tissue	**Alignment Abnormalities**
Quantity	Flexion
Increased	Hyperextension
Focal or generalized	Deviation
Decreased	Subluxation
Focal or generalized	**Joint Space**
Density	Widening
Calcification	Effusion
Bone Mineralization	Bone resorption
Decreased	Cartilage overgrowth
Generalized	Fibrous deposition
Focal	Narrowing
Increased	Cartilage loss
Periosteal new bone	Cysts
Endosteal new bone	Erosions
Osteophytes	Fibrous or bony ankylosis

* Primarily applicable to hand and wrist films

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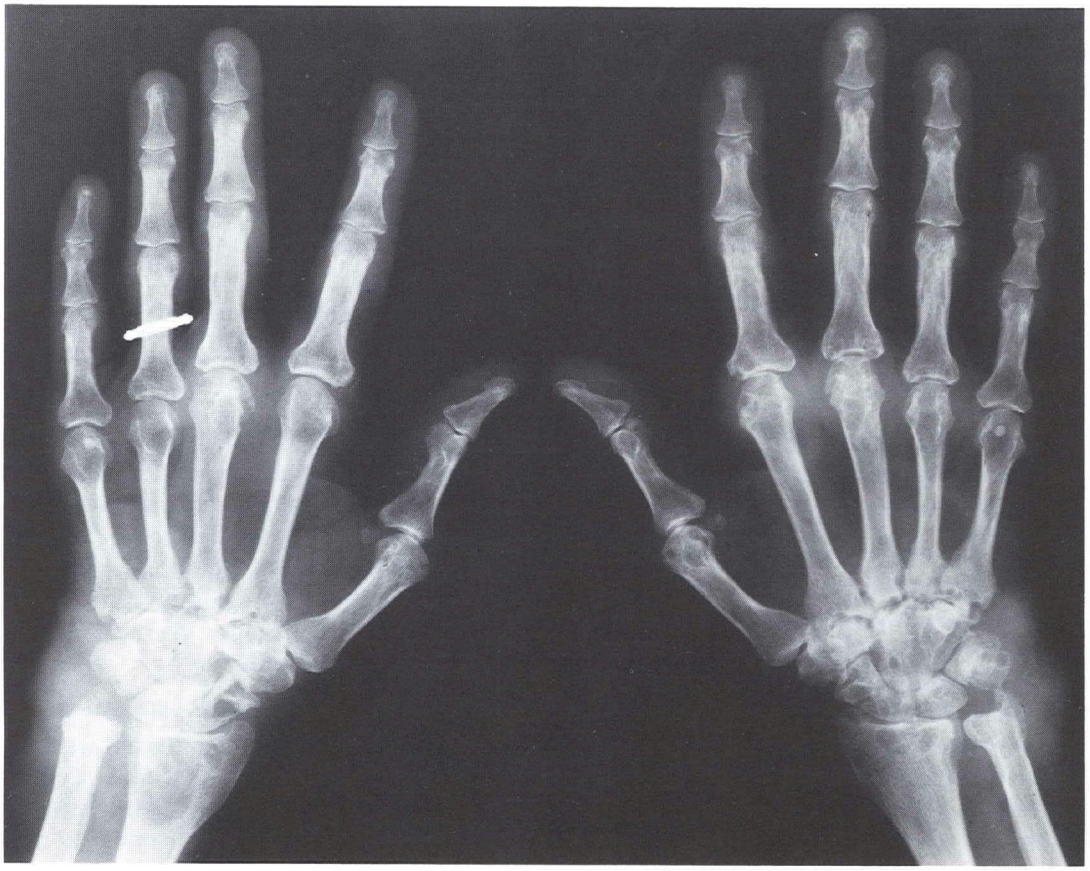

Fig. 1. Rheumatoid arthritis (hands and wrists)
Marked nodular soft tissue swelling about the wrists is present. Generalized osteoporosis, marked joint space narrowing, and extensive erosions are seen. Partial carpal bone ankylosis, subchondral cysts in the radii, and mild subluxation of the right index finger (metacarpophalangeal joint) are also present. Findings are symmetrical.

In **degenerative joint disease** (Figure 3), appendicular involvement characteristically includes the distal interphalangeal joints of the hands, the first carpometacarpal joints of the wrists, first metacarpophalangeal joints of the feet, medial compartments of the knees, and the superior aspects of the hip joints. Radiographic features include nonuniform joint space narrowing, subchondral sclerosis, osteophytes, subarticular cysts or pseudocysts, normal mineralization and sometimes malalignment. Asymmetry is common, while ankylosis is not. Similar findings occur in the spine. The apophyseal joints can be involved, typically in the cervical and lumbar regions. In its primary and secondary forms, degenerative joint disease is the most common disorder of movable joints, and the radiographic features are usually distinctive.

Ankylosing spondylitis (Figures 4 and 5) primarily attacks the axial skeleton. Both cartilaginous and synovial joints are affected. The sacroiliac joints are almost always involved and usually represent the site of earliest involvement. Root joints (hips and shoulders) and knees may also be affected.[1]

In the sacroiliac joints, findings are always bilateral and typically symmetrical.[2] Early abnormalities include haziness of subchondral bone, erosions, joint space widening and reactive sclerosis. As the disease progresses, narrowing of the joint space and fibrous or bony ankylosis develop.

In the spine, early involvement with ankylosing spondylitis occurs at the thoracolumbar or lumbosacral junction. Anterior vertebral margins become straightened due to osteitis, with a resulting square appearance of the vertebral body. Syndesmophytes (vertical orientation of the reactive new bone as opposed to the transverse orientation of osteophytes seen in degenerative joint disease) form laterally. Progressive and universal syndesmophyte formation produces the classic "bamboo spine."[2] Apophyseal joint changes range from erosions and sclerosis to bony ankylosis. Less specific findings include osteoporosis, disc space narrowing, sub-

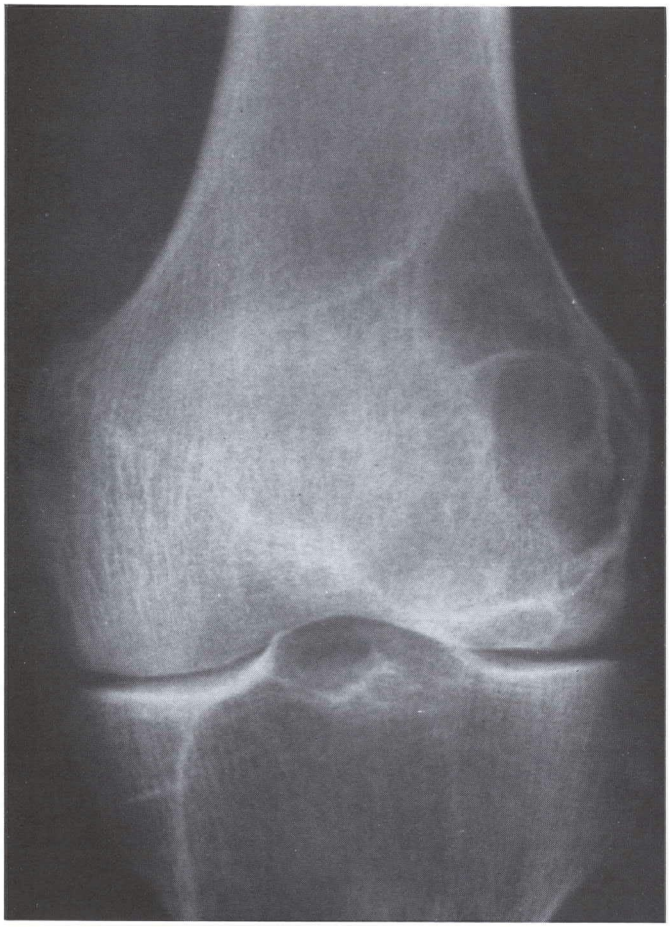

Fig. 2. Rheumatoid arthritis (knee)
Osteoporosis, uniform joint space narrowing of medial and lateral compartments, and extensive subchondral cystic change are present. Note lack of secondary degenerative, hypertrophic change.

luxation, fractures, interspinous ligament ossification, and bone destruction by granulomas.

In the root joints, the abnormalities are similar to those of rheumatoid arthritis except for less osteoporosis and more reactive sclerosis. Occasionally, the end stage is bony ankylosis. Extraspinal bone-ligament-junction erosions and bony proliferation produce a "whiskering" pattern of the bony cortex, most frequently at the iliac crests and ischial tuberosities.

Reiter's syndrome has a predilection for the sacroiliac joints and the lower extremities, where involvement of heels and toes is most common. In the upper extremities, the proximal interphalangeal joints are typically involved. The distribution is usually asymmetrical. Spinal involvement is infrequent.

Distinguishing Reiter's syndrome from rheumatoid or psoriatic arthritis is sometimes difficult radiographically. The

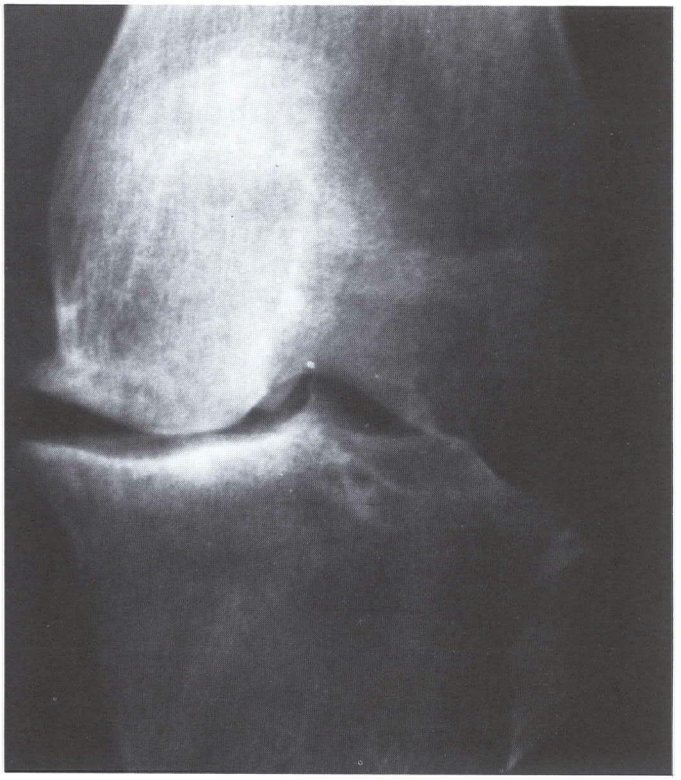

Fig. 3. Degenerative joint disease (knee)
Nonuniform medial joint space narrowing, medial subchondral sclerosis, and subchondral cystic change are present. Note the hypertrophic spurs at the medial tibial and femoral margins.

frequent presence of periosteal new bone formation and frequent lack of periarticular osteoporosis in Reiter's syndrome are useful in differentiating it from rheumatoid arthritis. In the foot, the calcaneus may demonstrate fairly characteristic erosions, spur formation and periosteal new bone. With sacroiliac involvement, which can be either unilateral or bilateral, the joint spaces are usually not obliterated.[2]

In the spine, asymmetrical and nonmarginal syndesmophytes are seen. These findings are similar to those of psoriatic arthritis.

Psoriatic arthropathy (Figure 6) has a predilection for the hands and, less commonly, the feet. It predominantly affects the distal interphalangeal joints, with asymmetric distribution. Fairly distinctive radiographic findings in the extremities include deformed nails, absence of periarticular osteoporosis, distal interphalangeal joint space widening due to bone resorption or fibrous deposition, periosteal reaction, and "pencil in cup" deformities (Figure 6). Occasionally, the radiographic abnormalities, including joint disorganization, may be indistinguishable from rheumatoid arthritis.

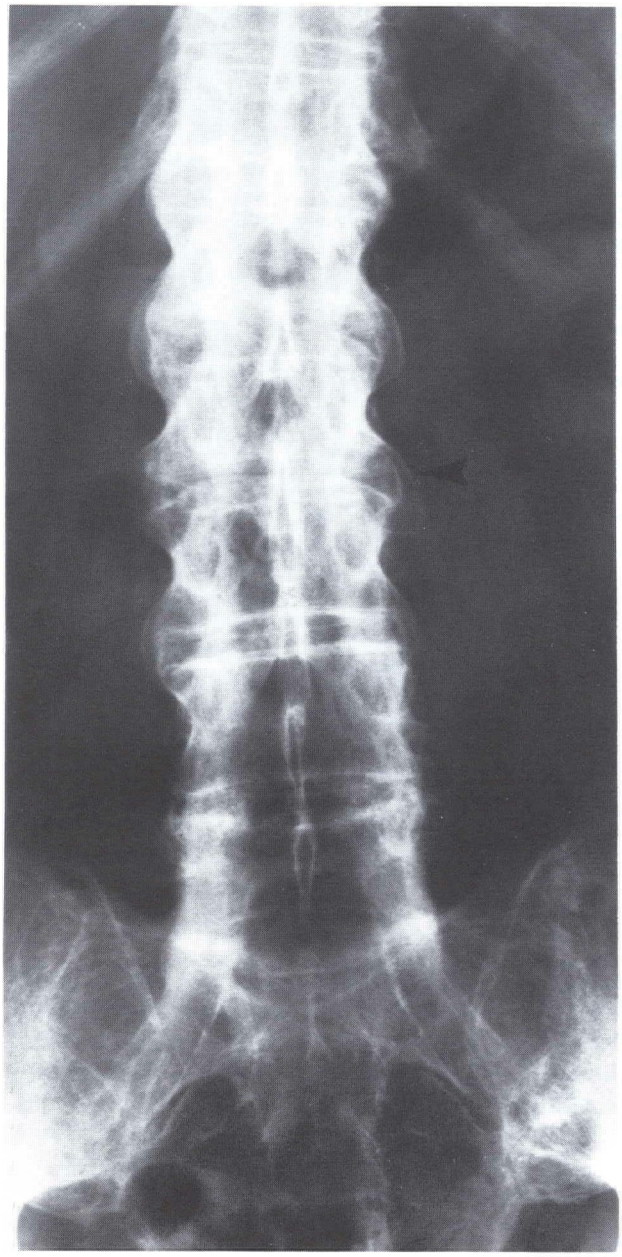

Fig. 4. Ankylosing spondylitis (lumbar spine and sacroiliac joints)
Ankylosed sacroiliac joints and marginal, lateral syndesmophytes (arrow) are seen.

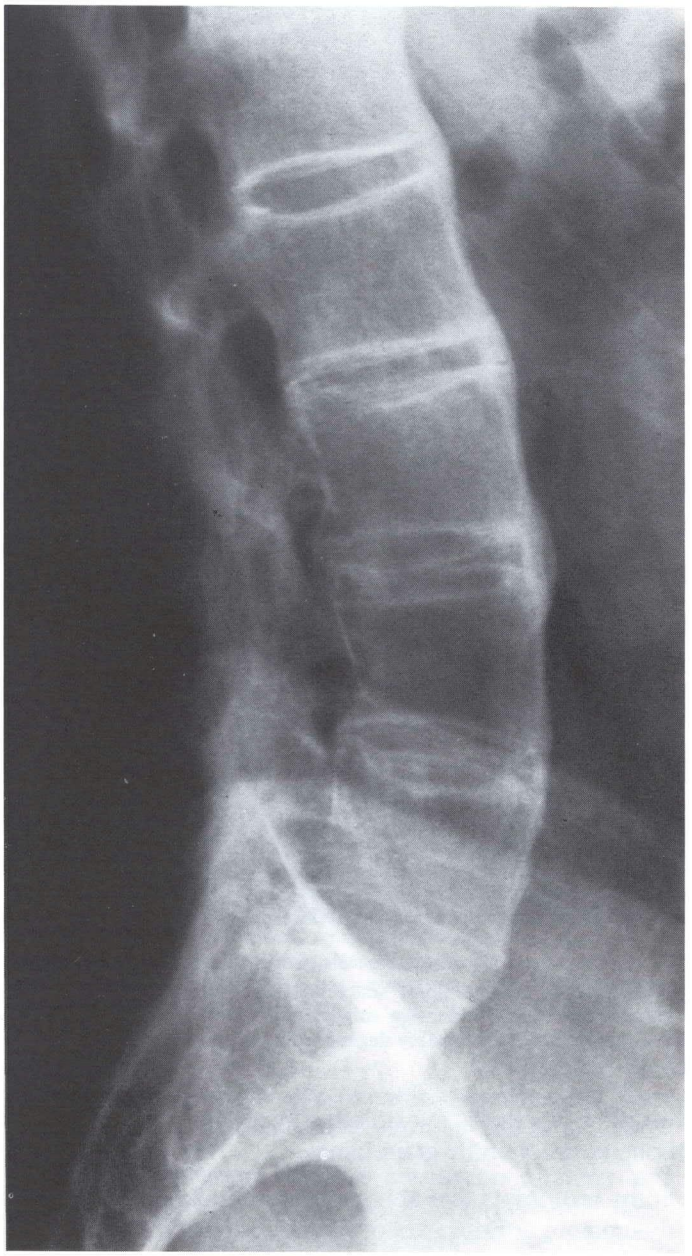

Fig. 5. Ankylosing spondylitis (lumbar spine)
Lateral view illustrates loss of concavity of anterior vertebral body margin, anterior and posterior spinal ligament ossification, disc space narrowing, osteoporosis and bony ankylosis of the apophyseal joints.

The axial skeleton is involved in fewer than half of patients with psoriatic arthritis and usually when peripheral joint disease is present. The most prominent radiographic abnormality in the spine is the presence of asymmetrical, nonmarginal syndesmophytes. Sometimes, the disease is dominant in the cervical spine and can resemble rheumatoid arthritis. In contrast to ankylosing spondylitis, "squaring" of vertebral bodies and apophyseal joint fusion are usually *not* seen.[2] Sacroiliitis can be unilateral or bilateral, with changes similar to those of ankylosing spondylitis.

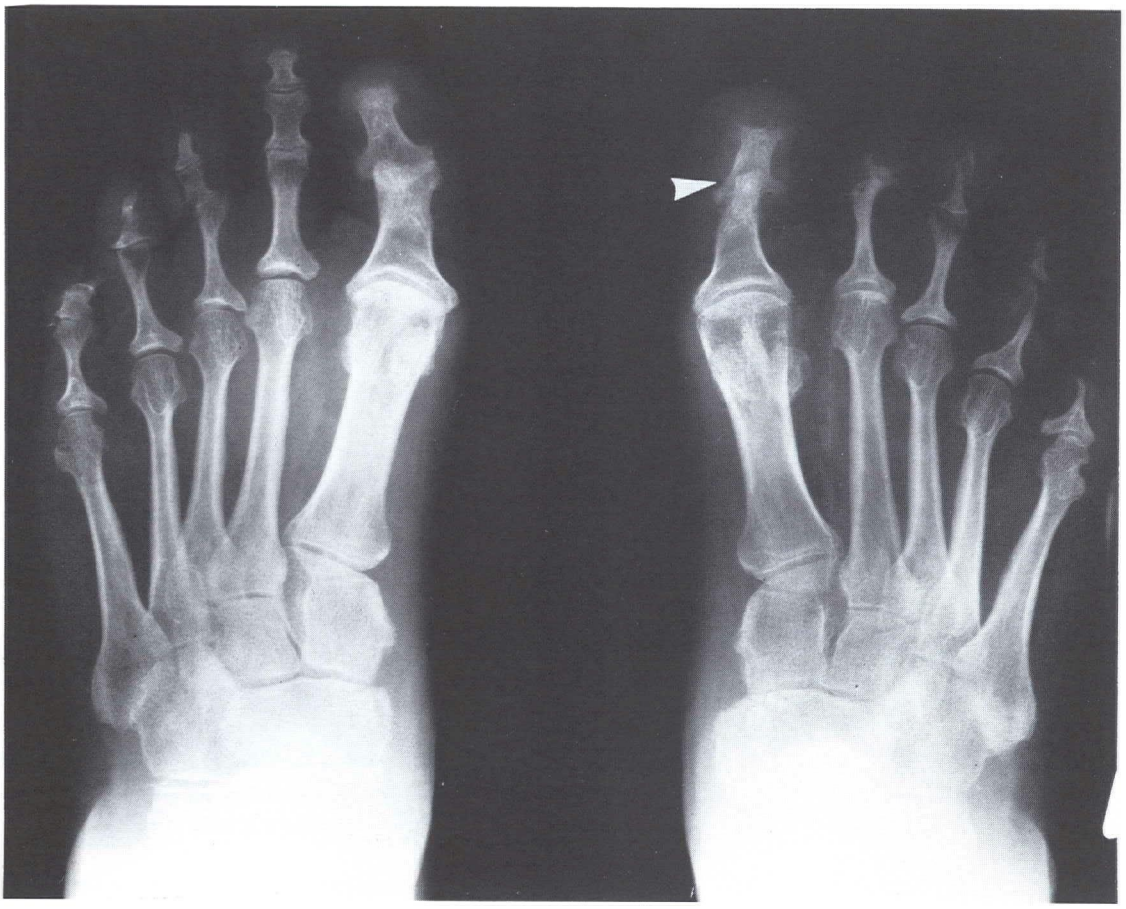

Fig. 6. Psoriatic arthritis (feet)
Asymmetrical involvement and predisposition for distal joints are typical. Terminal tuft and phalangeal resorption are seen, and characteristic "pencil in cup" deformity (arrow) is present. Minimal alignment deformity is noted. Periosteal new bone formation, joint space widening, and bony ankylosis are not seen.

The crystal deposition diseases are gout and CPPD (calcium pyrophosphate dihydrate) deposition disease, the latter more commonly known as pseudogout. The radiographic findings, however, are quite dissimilar.

In **gout** (Figure 7), the hands and feet are most commonly involved, with a predisposition for the great toe. Elbows, wrists and knees are also involved. Radiographic abnormalities include asymmetrical soft tissue swelling caused by tophi (subcutaneous accumulations of sodium monourate crystals) that may calcify, and uniform joint space narrowing. Bone mineralization is normal. A particularly distinctive feature is juxtarticular location of erosions, which are caused by tophi that may stimulate the formation of "overhanging edges."[3] The erosion margins are well defined.[2]

The **pseudogout syndrome** (Figure 8), which is characterized by the deposition of calcium pyrophosphate dihydrate crystals, usually involves the knee. The most frequent radiographic abnormality is calcium deposition in articular hyaline cartilage or fibrocartilage (chondrocalcinosis). It is seen most often in the knees, wrists, hips, symphysis pubis and intervertebral discs.[2] Articular calcifications in synovium and the joint capsule may occur, as well as periarticular calcification in tendons and soft tissues. Moreover, the pseudogout syndrome can present radiographically with typical degenerative features, but in atypical joints for degenerative joint disease, such as wrists, elbows and shoulders. Erosions are infrequent. Correlation between the clinical manifestations and the radiographic abnormalities[4] is often poor.

Septic arthritis most frequently affects the spine. The sacroiliac, symphysis pubis, sternoclavicular and knee joints are also commonly affected. Organisms usually enter the joint by the hematogenous route or by extension from an osteomyelitis. Radiologic features include soft tissue swelling, cartilage destruction leading to joint space narrowing, and subchondral bone destruction. Osteoporosis occurs promptly when joint destruction is present,[2] followed by

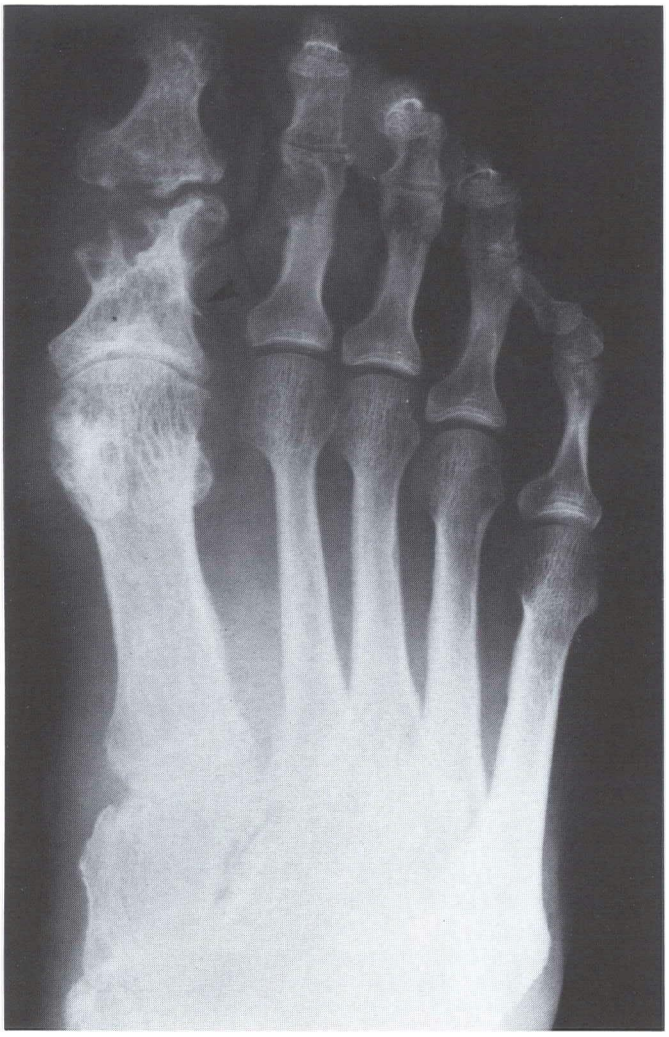

Fig. 7. Gout (foot)
Note characteristic predilection for the great toe. Soft tissue swelling and intra-articular erosions are present. The great toe remains normally mineralized. Particularly distinguishing are the juxta-articular erosions, with "overhanging edges" (arrow).

reactive sclerosis, with either an irregular articular surface or bony ankylosis. If osteomyelitis is a component, sequestration and periosteal new bone may develop.

In the spine, the disease originates in the intervertebral disc space. Early radiographic abnormalities include paravertebral swelling, disc space narrowing, vertebral body end plate destruction, and collapse of the adjacent vertebral bodies. Later changes include sclerosis, osteophytes and ankylosis. Dystrophic paraspinal calcifications can also be seen.

Tuberculous arthritis (Figure 9) also most commonly affects the spine, as well as the knees and hips. Radiologic manifestations differ from those of septic arthritis in that osteoporosis appears early, as do marginal erosions. Joint

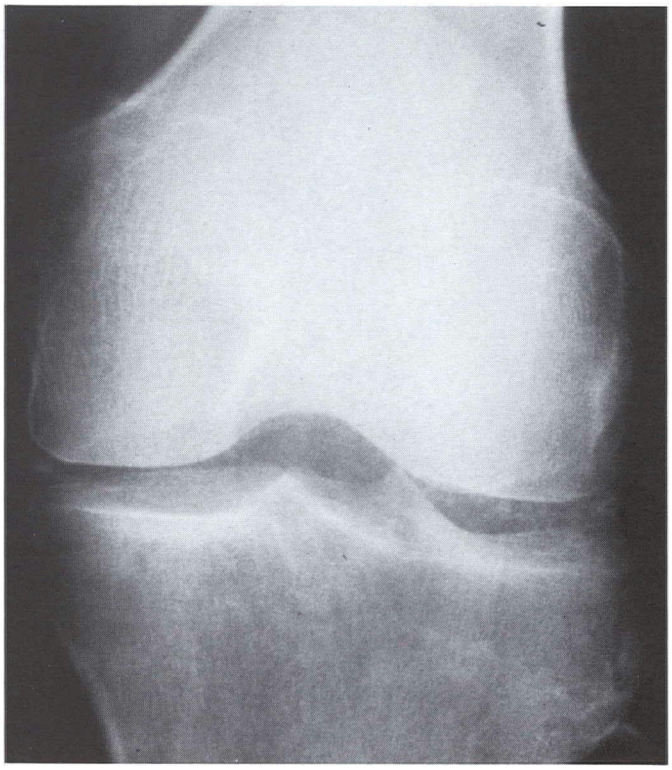

Fig. 8. CPPD deposition disease (knee)
Chondrocalcinosis is present in both meniscal and articular cartilage.

space narrowing occurs late because the articular cartilage is spared initially.

Neurotrophic arthropathy (Figure 10) results from repeated trauma as a consequence of losing pain sensation. The changes can be seen in numerous disease states, have a predilection for certain spinal levels, and correspondingly manifest with either upper or lower extremity involvement. Two forms are seen. More common is the hypertrophic form which usually involves the lower extremities. Radiographic findings include effusion, normal bone mineralization, joint space narrowing, fragmentation of articular surfaces, bony debris in the soft tissues, exuberant reactive marginal bone, dislocation, and total joint disorganization. The atrophic form is usually seen in the upper extremities and manifests by effusion, osteoporosis, resorption of articular cartilage and subchondral bone, and dislocation.[2] In the neurotrophic spine, narrowed disc spaces, prominent osteophytes, fragmentation of vertebral bodies, and paraspinal ossific debris are typical manifestations.

Hemophilia (Figure 11) most commonly affects the knees, elbows and ankles. Repeated hemorrhage in the joint results in effusions and chronic synovitis followed by marginal erosions, cartilage destruction with joint space narrowing, and secondary degenerative changes. Subchondral cysts, caused either by degenerative changes or intraosseous

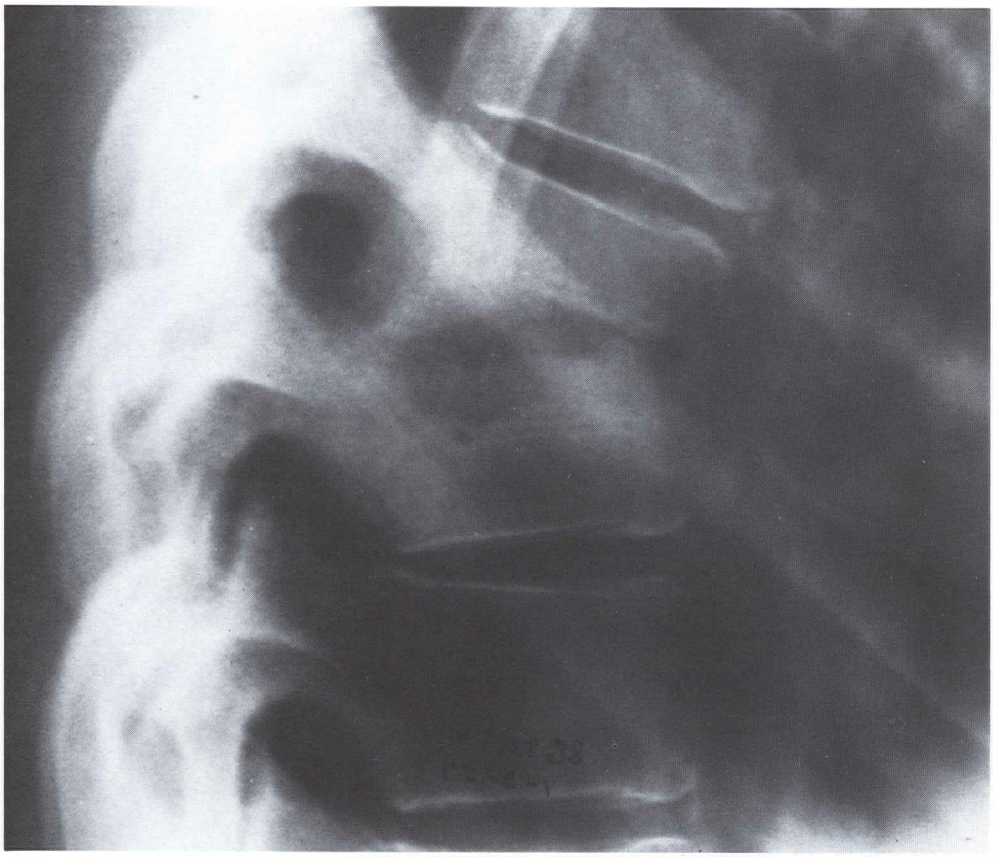

Fig. 9. Tuberculous spondylitis (thoracic spine)
Disc space narrowing, with destruction of the adjacent vertebral body end plates and resultant kyphosis are seen.

hemorrhage, can occur. A fairly distinctive sign is widening of the intercondylar notch of the femur due to hemorrhage at the insertion of the cruciate ligaments. Epiphyseal enlargement may develop in any affected joint.

Ochronosis (Figure 12) is the abnormal phenotype of alkaptonuria, a metabolic disease. The spine is generally involved, with earliest changes seen in the lumbar region. Eventually, the entire spine is affected; the hips, shoulders and knees are less often involved.

Radiographic findings in the spine include narrowed, calcified intervertebral discs, osteophyte formation, osteoporosis and sometimes interspinous ligament calcification. Apophyseal joints are not involved. In the peripheral joints, ochronosis can produce effusions, joint space narrowing, osteophytes, subchondral sclerosis, calcified loose bodies and ligamentous ossification. Recently, Lee and Stenn[5] have reported that the disc calcifications observed in an Egyptian mummy were the result of ochronosis.

For the physical anthropologist and paleopathologist, applying current radiographic knowledge to ancient specimens poses special problems. The soft tissues have limited value, and biochemical studies can rarely be obtained. In many of the specimens, only the spine, root joints or the pelvis are adequately preserved. Often, because specimens of the hands and feet have decayed, diagnostic specificity is limited. An additional diagnostic constraint is imposed by the lack of serial films. For example, when evaluating an end-stage arthritis, it is difficult to distinguish between primary, uncomplicated degenerative joint disease and mixed arthritis. In perplexing situations, the best approach may be to correlate radiographic information with the gross pathology. Hopefully, new biochemical techniques will be able to confirm and supplement diagnostic possibilities raised by radiographs and gross pathology.

Radiographic findings of many common arthritides have been discussed. The student of arthritis, ancient or modern, should employ a systematic approach to the radiographs.

Acknowledgment

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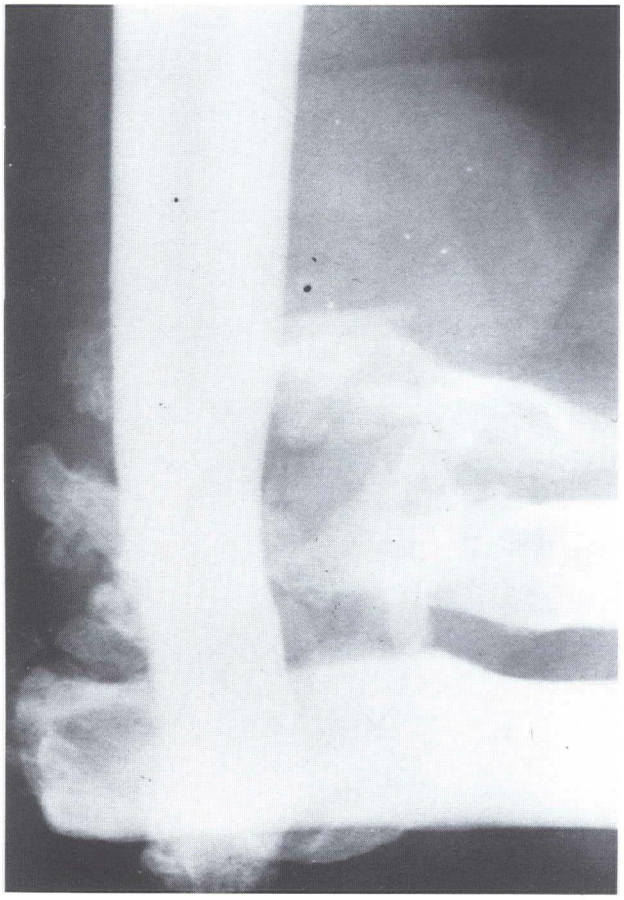

Fig. 10. Neurotrophic arthropathy, or Charcot's joint (elbow)
Bone mineralization is normal, but joint is extremely disorganized, with bony debris and dislocation as prominent features. Syringomyelia, which characteristically affects the upper extremities, is the etiology.

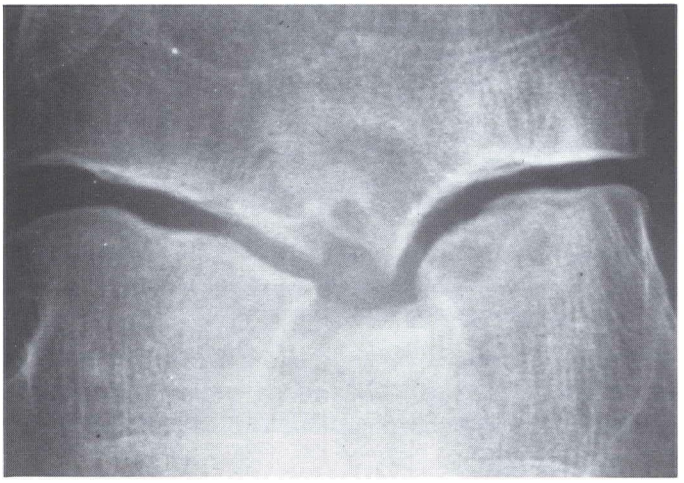

Fig. 11. Hemophilia (knee)
Overgrowth of the now-fused epiphyses, and secondary degenerative changes, including joint space narrowing, irregular articular surfaces, and subchondral cystic change, are seen.

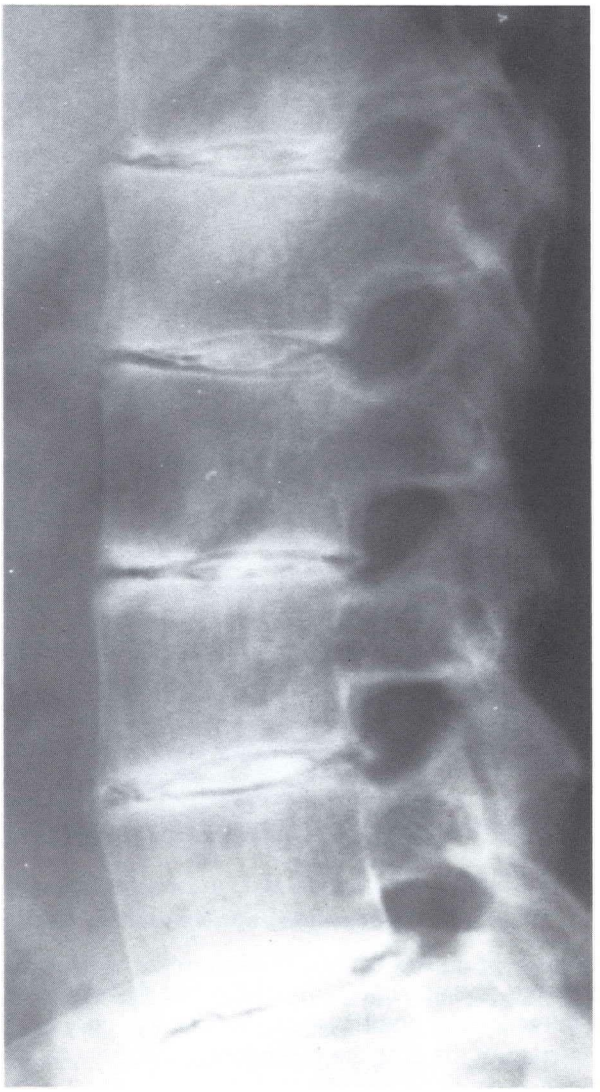

Fig. 12. Ochronosis (lumbar spine)
Lateral view demonstrates calcified intervertebral discs, narrowed disc spaces and eburnative changes in the vertebral end plates.

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