Chapter 6
Knee

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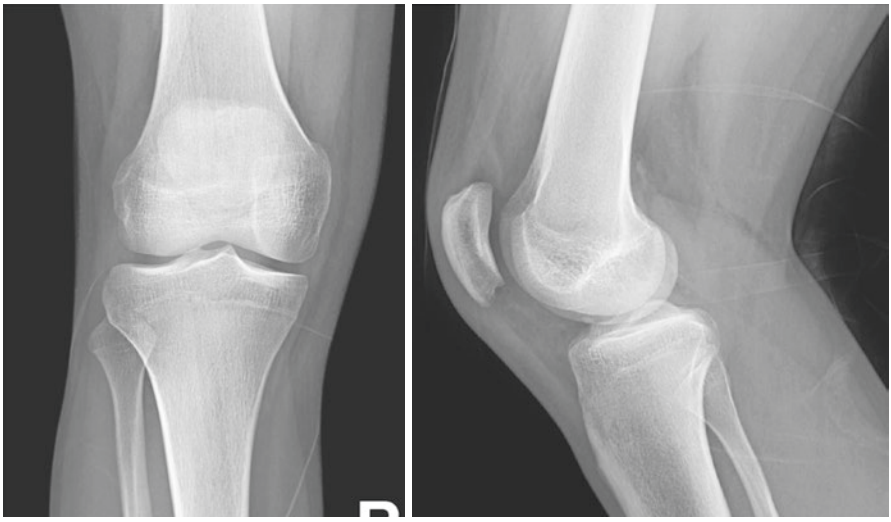

Figs. 6.1 and 6.2 Normal frontal and lateral radiographs of the knee

Standard views of the knee include AP standing view and lateral flexed view (Figs. 6.1 and 6.2). Standing view provides better assessment of the cartilage loss of the medial and lateral compartment. Lateral and "sun-rise" views allow evaluation of the patellofemoral joint. Each compartment should be analyzed individually and should demonstrate at least 3 mm of space.

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Assessment of knee radiographs begins with determination of the pattern of joint space narrowing which typically can be subdivided into three categories: processes that result in tricompartmental joint space loss, processes that specifically involve a specific compartment, or processes that initially do not result in joint space loss. Once the pattern of joint space loss is determined, often additional radiographic hallmarks discussed above in the "approach to the hand" section, in conjunction with physical exam and lab findings, can be used to further narrow the differential diagnosis (Table 6.1).

Table 6.1 Patterns of joint space narrowing in the knee

Total compartment involvement	Preferential compartment loss	Initial joint space preservation
Rheumatoid arthritis	Osteoarthritis	AVN
Psoriatic arthritis	CPPD arthropathy	Osteochondral defect
Reactive arthritis		
JIA		
Hemophilia		
Ankylosing spondylitis		
Septic arthritis		

Case 1

A 68-year-old male with worsening knee pain over several years, aggravated by walking or exercise.

Fig. 6.3 AP view of the knee demonstrates the radiographic hallmarks of osteoarthritis, including asymmetric joint space narrowing (arrows), sclerosis, and osteophyte formation (arrow heads)

Diagnosis Osteoarthritis.

Discussion

The knee is the most commonly involved joint in osteoarthritis. It is characterized by nonuniform joint space loss most commonly in the medial compartment (Fig. 6.3). In the knee, prior traumatic injury, particularly to the meniscus or the anterior cruciate ligament, can lead to accelerated onset of osteoarthritis (Table 6.2).

Table 6.2 Kellen and Lawrence radiographic scoring of knee OA

Grade	Description
0: Normal	
1: Questionable	Doubtful narrowing of the joint space and possible osteophyte lipping
2: Mild	Definite osteophytes and possible narrowing of the joint space
3: Moderate	Moderate multiple osteophytes, definite narrowing of the joint space, and some sclerosis with deformity of the bone ends
4: Severe	Large osteophytes, marked joint space narrowing, severe sclerosis, and definite deformity of the bone ends

Case 2

A 67-year-old male with knee pain, swelling.

Fig. 6.4 Lateral view of the knee demonstrates near complete loss of the patellofemoral joint space (arrow) with suggestion of subtle scalloping of the distal femur (arrow head) which is a result of repetitive movement of the patella as it abuts the femur when the knee is in extension

Diagnosis Calcium pyrophosphate deposition disease (CPPD).

Discussion
Calcium pyrophosphate deposition disease (CPPD) is the most common crystal arthropathy, and second in prevalence only to osteoarthritis. The changes very closely mirror osteoarthritis but in the knee are more pronounced in the patello-femoral compartment (Fig. 6.4). Chondrocalcinosis need not be present on imaging to raise suspicion for CPPD arthropathy. The knee is the most common joint involved in CPPD. Other joints affected include the hip, wrist, and spine.

Case 3
A 32-year-old male with long-standing knee pain, swelling, and diminished range of motion.

Fig. 6.5 AP view of the knee demonstrates widening of the intercondylar notch and overgrowth of the epiphyses (arrow). Prominent subchondral cysts are also evident (arrowhead)

Diagnosis Hemophilia.

Discussion
Rare, X-linked disorder that results in spontaneous bleeding into the synovial joints and resultant articular abnormalities. The most commonly affected joint is the knee, followed by ankle, elbow, shoulder, and hip in decreasing order of frequency. Recurrent intra-articular hemorrhage causes an inflammatory response within the

joint that is ultimately damaging to the cartilage. Radiographic hallmarks of this process include joint space narrowing, intermittent large joint effusion, epiphyseal "ballooning" or overgrowth (Fig. 6.5), soft tissue swelling, and erosions.

Differential considerations include: juvenile idiopathic arthritis, tuberculosis arthritis, and pigmented villondular synovitis (PVNS).

Case 4

A 35-year-old male with knee pain, swelling, locking, and diminished range of motion.

Fig. 6.6 Lateral radiograph of the knee demonstrates multiple relatively uniform lobulated calcified bodies within the suprapatellar bursa (arrows). Note the relatively preserved joint space, and normal mineralization, with are the radiographic hallmarks of primary synovial chondromatosis

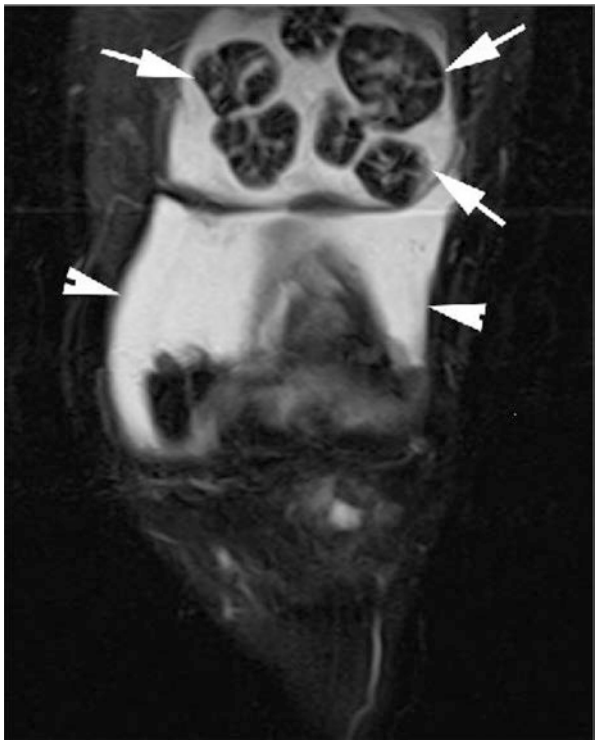


Fig. 6.7 Coronal T2 fat saturation image of the knee demonstrates relatively uniform low T2 signal masses (arrows) within a suprapatellar joint effusion (arrowheads). The MRI appearance of this entity can vary depending on the degree of ossification of the chondral bodies

Diagnosis Primary synovial osteochondromatosis.

This is a benign, relatively rare entity that typically affects patients in the third to fifth decade of life, most commonly affecting the knee. It is characterized by proliferation and sloughing of the synovium with intra-articular loose bodies that often subsequently calcify (Figs. 6.6 and 6.7). Reports suggest males are affected two to four times more often than women. It is often asymptomatic unless accompanied by osteoarthritis. Other joints involved include the hip, elbow, shoulder, and ankle. Reports of malignant transformation of primary synovial osteochondromatosis to chondrosarcoma exist in the literature, though this is considered extremely rare.

Case 5
A 45-year-old female with diffuse joint pain for several months, most pronounced in the wrists and knees bilaterally.

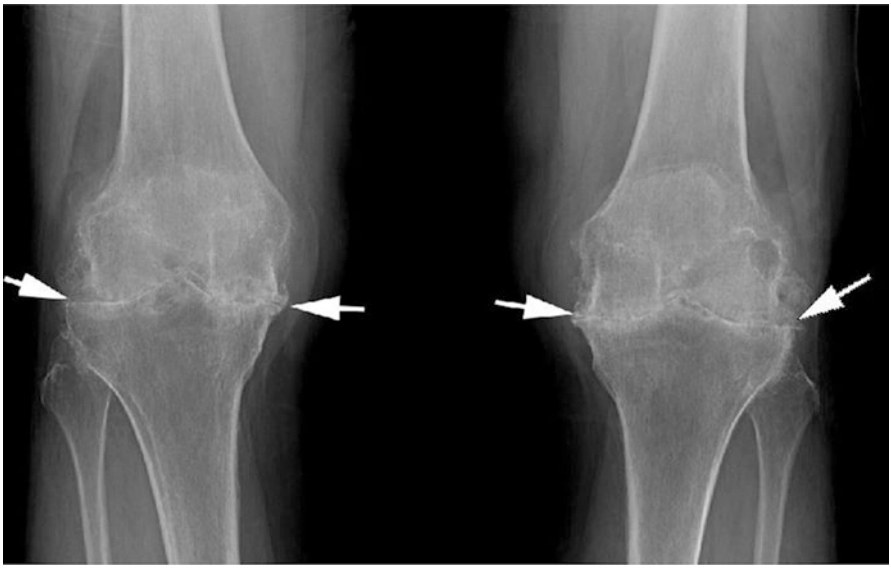


Fig. 6.8 Frontal standing views of both knees depict severe bilateral, *symmetric* joint space narrowing (arrows) with relative paucity of productive changes

Diagnosis Rheumatoid arthritis.

Discussion
The knees are affected in 75–80% of patients with rheumatoid arthritis, and typically affect both knees. Ideally, radiographs include standing AP and flexed lateral views to best assess alignment and joint spaces. This absence of productive change and symmetric joint space narrowing is the radiographic hallmark of rheumatoid arthritis in the knee (Fig. 6.8), and other larger joints, although erosions can also be seen.

Case 6

A 43-year-old man who presents with knee swelling, redness, and pain following arthroscopic procedure 2 weeks prior for meniscal repair.

Fig. 6.9 Lateral image of the knee depicts a large joint effusion (arrows), suggestion of periarticular osteopenia as depicted by subtle lucencies within the femoral condyles (arrowheads). No definite erosions or productive change are seen

Fig. 6.10 Axial STIR image of the knee demonstrates suprapatellar joint effusion (arrowhead), marrow edema (white arrow) and perisynovial edema (black arrow) suggesting the presence of an inflammatory process within the synovium

Diagnosis Septic knee.

Discussion

The knee is the most common site of septic arthritis. As stated previously, rapid diagnosis of septic arthritis requires a high degree of clinical suspicion, and a close level of interaction with the radiologist and the managing clinicians. The initial imaging manifestation is the presence of a joint effusion which is appreciated in the knee on the lateral radiograph (Fig. 6.9).

MRI can be helpful as an adjunct to diagnosis when clinical findings are equivocal. MR findings include marrow edema, erosions, synovial thickening, and perisynovial enhancement (Fig. 6.10).

Case 7

A 57-year-old female with worsening knee pain over several years.

Fig. 6.11 Lateral knee radiograph reveals broad-based calcific density arising from the posterior aspect of the proximal tibia (arrow). In addition, smaller excrescences arising from the distal femur (arrow heads), oriented perpendicular to the long axis of the native bone. The distal femur demonstrates a widened metadiaphyseal junction

Diagnosis Hereditary multiple exostoses (HME).

Discussion

This is a rare, hereditary condition transmitted in an autosomal dominant fashion resulting in multiple bony exostoses, or osteochondromas, throughout the skeleton, most often around the knee and shoulder. Males are affected 1.5 times more commonly than females, likely to a hypothesized incomplete penetrance in females, possibly a result of hormonal factors. Complications of the presence of these osteochondromas (Fig. 6.11) include growth disturbances and metaphyseal widening. The widening of this region results in the "Erlenmeyer flask" deformity which is one hallmark of this condition. Forty percent of the patients with HME manifest clinically with short stature. Local complications include fracture of osteochondroma, regional mass effect on adjacent nerves or blood vessels, and formation of neobursa. The joint space is not directly affected.

The most feared complication of osteochondroma is malignant transformation to chondrosarcoma, which reportedly occur in 3–5% of patients with HME.

Case 8

A 76-year-old female admitted for chest pain, rheumatology consulted for knee and thigh pain, history of prior car accident when the patient was very young.

Fig. 6.12 This lateral view of the knee demonstrates marked joint space narrowing between the femur and the tibia (white arrows), with anterior subluxation of the femur. In addition, there are calcific densities of varying sizes surrounding the remnant knee joint (black arrow heads). The quadriceps tendon (white arrowheads) and the patella (∗) are shown for orientation. (*Courtesy Dr. Aman Kugasia*)

Diagnosis Neuropathic joint.

Discussion

Neurosensory loss is the basic cause of a wide variety of diseases that result in eventual neuropathic arthropathy. The most common cause of neuropathic changes within the knee historically is related to tertiary syphilis, or tabes dorsalis which results in demyelination of the posterior columns of the spinal cord. Diabetes can also result in neuropathic changes at the knee. Recurrent joint effusions and subluxations occur and eventually become more pronounced with continued weight bearing. Radiographic findings (Fig. 6.12) which include malalignment, joint space narrowing, calcific debris, and sclerosis may overlap with findings of osteoarthritis and infection.

Case 9
A 38-year-old male with chronic knee pain over several years.

Fig. 6.13 Frontal image of the knee demonstrates a curvilinear lucency in the subchondral portion of the medial femoral condyle (arrow)

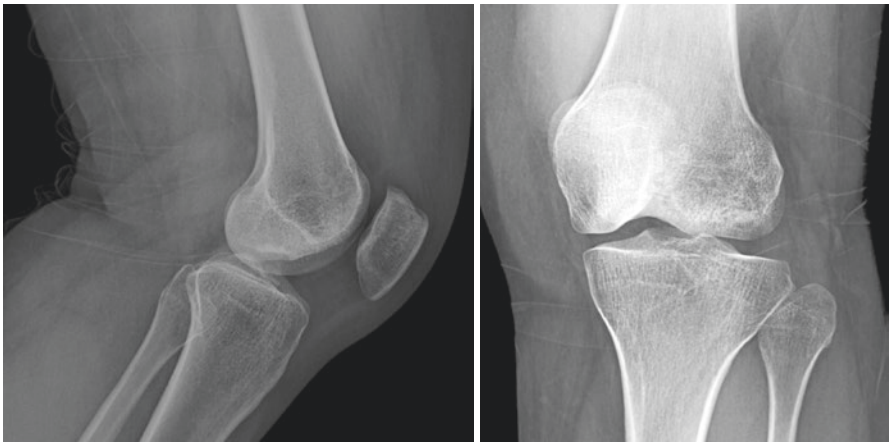
Diagnosis Osteochondral defect.

Discussion
As discussed in chap. 5, osteochondral defects, formerly called osteochondritis dessicans, typically arise from traumatic injury to the articular cartilage and the underlying bone. Sequelae of these injuries typically results in lucent defect within the articular bone (Fig. 6.13). The most common location for these lesions is the lateral portion of the medial femoral condyle. Differential considerations given the radiographic appearance include osteonecrosis, subchondral fracture, or osteoarthritis. MRI is typically obtained to better characterize osteochondral defects and assess the need for operative intervention.

Practice Cases

Question 1. A 34-year-old with known history of lupus and worsening dull knee pain over several months.

What is the most likely etiology of the patient's knee pain?



A. Osteoarthritis.
B. CPPD arthropathy.
C. Avascular necrosis.
D. Rheumatoid arthritis.

Discussion
Lateral and oblique views of the knee (See figs above) demonstrate linear sclerosis of the lateral joint compartment with subchondral surface irregularity (best seen on the lateral view). These serpiginous or linear areas of sclerosis imply disruption of blood supply to the bone, resulting in bone death. By convention, the term avascular necrosis is used to describe areas of subarticular involvement. When the diaphyseal or metaphyseal portions of the bone are involved, the term bone infarct is applied. The joint spaces are relatively well maintained initially in avascular necrosis.

Question 2. A 38-year-old female presents with long-standing bilateral knee swelling and pain most pronounced in the right knee.

The most likely diagnosis is?

A. Rheumatoid arthritis.
B. Psoriatic arthritis.
C. CPPD arthropathy.
D. Hemophilia.

Discussion

The knee is affected in the majority of patients with rheumatoid arthritis. The above image depicts marked, symmetric joint space narrowing in both the medial and lateral compartments with relative absence of productive changes. There are prominent erosive changes present. Psoriatic arthritis may involve the knee, but typically presents with enthesopathic changes at the extensor tendons, rather than the extensive erosive changes seen above. CPPD involves the patellofemoral compartment asymmetrically (Fig. 6.4) and does not typically result in such extensive erosive changes. Hemophilia can result in erosive changes secondary to the deleterious effects of recurrent intra-articular hemorrhage (Fig. 6.5), though the entity is X-linked, and therefore seen only in male patients. Note, septic arthritis was not listed as an option, and must always be considered in the setting of isolated erosive changes involving a single joint.

Question 3. Given the following lateral radiograph in a patient with atraumatic knee pain, the best next step in the management of the patient is which of the following?

A. Knee MR arthrogram.
B. CT angiogram.
C. Standing radiographs of both knees.
D. Arthrocentesis of the knee.

Discussion

The lateral knee radiograph depicts a large joint effusion with pockets of superimposed gas. The presence of a large effusion with areas of intra-articular gas is nearly pathognomonic for septic arthritis; therefore, further imaging should not precede an arthrocentesis (See fig above).

Question 4. This image best supports which diagnosis?

A. Pigmented villonodular synovitis (PVNS).
B. Synovial osteochondromatosis.
C. Tuberculous arthritis.
D. Scleroderma.

The lateral radiograph of the knee (See fig above) depicts numerous calcified foci grouped together posterior to the knee joint, which is a typical appearance of intra-articular bodies clumped within a Baker's cyst, confirmed on subsequent MRI (not shown). Pigmented villonodular synovitis (PVNS) is a synovial proliferative disorder which results in a joint effusion and possible erosive changes with preservation of the joint space. This entity rarely calcifies, thus is not the best answer choice.

Answers to the Question

Q1: C. Avascular necrosis
Q2: A. Rheumatoid arthritis
Q3: D. Arthrocentesis of the knee
Q4: B. Synovial osteochondromatosis

Further Reading

Jones EA, Manaster BJ, May DA, Disler DG. Neuropathic osteoarthropathy: diagnostic dilemmas and differential diagnosis. Radiographics. 2000;20:S279–93.

Manaster BJ. Diagnostic imaging musculoskeletal: non-traumatic disease. 2nd ed. Philadelphia: Elsevier; 2016. p. 1044–7.

Murphey MD, Choi JJ, Kransdorf MJ, Flemming DJ, Gannon FH. Imaging of osteochondroma: variants and complications with radiologic-pathologic correlation. Radiographics. 2000;20:1407–34.

Murphey MD, Vidal JA, Fanburg-Smith JC, Gajewski DA. Imaging of synovial chondromatosis with radiologic-pathologic correlation. Radiographics. 2007;27:1465–88.

Resnick D, Kransdorf MJ. Bone and joint imaging, 3rd ed. Philadelphia. Elsevier Saunders; 2005: 357–393.