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Seminars in
ROENTGENOLOGY

The Knee: Breaking the MR Reflex

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The knee is a large joint prone to trauma and arthritis. Although magnetic resonance (MR) imaging has revolutionized evaluation of knee structures and their abnormalities, imaging the knee makes use of all imaging modalities. Radiography remains important in the diagnosis of knee pathology. This section is dedicated to the initial radiographic evaluation and the sometimes subtle clues to underlying pathology. Knowledge of injury patterns and frequently missed findings will improve the radiologist's ability to suggest the diagnosis on radiographs.

Anatomy

A routine radiographic evaluation of the knee includes an anteroposterior view, a lateral view, and a "sunrise" view. In the evaluation of osteoarthritis, weight-bearing views are usually obtained. The bones of the knee joint include the patella, femoral condyles, tibia, and fibula. The knee is composed of the medial tibiofemoral, lateral tibiofemoral, and patellofemoral joints. On AP view, the patella is centrally located between the femoral condyles. There is a slight overlapping of the proximal fibular head and lateral tibial plateau. The quadriceps and patellar tendons are seen best on lateral radiograph. The patellofemoral joint is best seen on "sunrise" and lateral views. Table 1 summarizes the important landmarks to evaluate on every radiographic examination of the knee.

Patella

As part of the extensor mechanism, the patella is loaded in both tension and compression and is superficial in location. These factors make it vulnerable to fracture. It is also the weakest link within the quadriceps mechanism; normal activities, such as climbing stairs, can result in strains close to fracture level. Fractures of the patella are caused by two mechanisms: direct and indirect trauma. Indirect trauma is the more common mechanism in which rapid flexion of the knee against a fully contracted quadriceps tendon subjects the patella to severe tensile forces.

Fractures resulting from indirect forces tend to be transverse and show less articular cartilage damaged than fractures caused by direct trauma. Fractures caused by direct trauma tend to be comminuted (Fig. 1). There are other rare types of patellar fractures which include the following: osteochondral fracture, patellar sleeve fracture, stress fracture, and fractures complicating surgical procedures on the patella.

Its isolated anterior position on the bowstring of the extensor mechanism predisposes to dislocation. At the time of initial presentation, transient lateral patellar dislocation is a commonly missed diagnosis. This injury accounts for about 2 to 3% of all knee injuries and 9 to 16% of acute knee injuries in young athletes with hemarthrosis. Patients may be unaware that they had a lateral patellar dislocation since most dislocations reduce spontaneously.[1,2] During the dislocation, the medial patellar facet impacts against the lateral femoral condyle producing characteristic marrow contusions, osteochondral fractures, or both (Fig. 2). Although MRI best demonstrates these findings, radiographs may demonstrate a subtle osteochondral fragment near the patella (Fig. 3). The donor site from the patella or lateral femoral condyle is typically not seen. Osteochondral fractures of the patella are the most common source for loose bodies in the knee. A direct blow to the patella is the usual mechanism. It may be difficult to identify the patellar donor site on conventional radiographs.

Patellar sleeve fracture typically occurs at the inferior pole. Such fractures occur in children and adolescents where the inferior pole is pulled off along with a considerable amount of articular cartilage.[3] Patellar sleeve fractures are difficult to evaluate on plain radiography, which usually demonstrates soft-tissue swelling and rarely a small bony fragment at the inferior pole.[3] MRI is helpful in demonstrating the more extensive cartilaginous fragment.[4] Ultrasound may also be used in the diagnosis.[5]

Spontaneous fractures of the patella in individuals engaged in athletic activities are almost always due to stress fracture. When complete, this fracture is typically a two part transverse fracture. In the early stages, this fracture can be incomplete and it always starts on the anterior surface of the patella.[6-10]

Patellar fractures are an infrequent (2 to 3%) complication

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Table 1 Radiographic Analysis of the Knee

Suprapatellar bursa <10 mm
Check for fat-fluid level on cross table lateral view
Joint spaces/articular surfaces
Avulsions around the knee
Patella location: baja versus alta
Tendons: quadriceps and infrapatellar
Prepatellar bursa
Tibial tubercle
Osteochondritis dissecans
LAME (lateral aspect of medial femoral condyle)
Spontaneous osteonecrosis (SONK)
Weight-Bearing portion of medial femoral condyle is due to subchondral insufficiency fracture

following total knee arthroplasty. Although patellofemoral pain is significantly relieved in patients treated with total knee arthroplasty and patellar resurfacing, resurfacing increases complications attributed to avascular necrosis secondary to medial arthrotomy, lateral release, and thermal necrosis due to the methylmethacrylate. Stress fractures after patellar resurfacing have been shown histologically and by bone scans to be due to avascular necrosis.[11,12]

Following ACL repair a fracture may occur when the central portion of the patellar tendon is used as a donor site for ACL reconstruction. The patellar tendon graft is harvested along with a wedge of bone from the patella, which weakens the patella. Fracture is still most often the result of a fall rather than force from extension. The fracture occurs in approximately 0.2 to 0.5% of ACL graft harvests. The following two fracture patterns are found: a non-displaced longitudinal fracture and the classic distracted transverse fracture[13,14] (Fig. 4).

Femur

Nearly half of supracondylar femur fractures occur due to minor injuries to osteoporotic bone, such as a fall onto the knee (Fig. 5). Intercondylar extension (T-shaped) may occur and may be better seen on an oblique radiograph.[15] Approximately 20% are severe, high-energy, open fractures.

Unicondylar fractures are rare, and often unrecognized, especially those in combination with other fractures. However, these fractures may seriously impair knee motion, even with minimal displacement, and require open reduction and internal fixation. Two-thirds will involve the lateral femoral condyle, which usually displaces superiorly and posteriorly; the step-off may be difficult to appreciate without a patellar view. The ACL and fibular collateral ligament typically remain attached. Medial femoral condyle fractures are displaced proximally and tilted backward. Osteonecrosis is a common complication due to vascular disruption. The medial collateral ligament but not the PCL are typically attached to the fragment[15-17] (Fig. 6).

Found with patellar dislocation, traumatic osteochondral fractures of the lateral femoral condyle may also be the result of a sudden, twisting movement on an extended knee. Often the fragment is purely cartilaginous or has minimal bone attached.[18] A depressed lateral femoral notch may be found from the rotation and impaction with valgus stress and heralds a tear of the ACL (Figs. 7 and 12B).

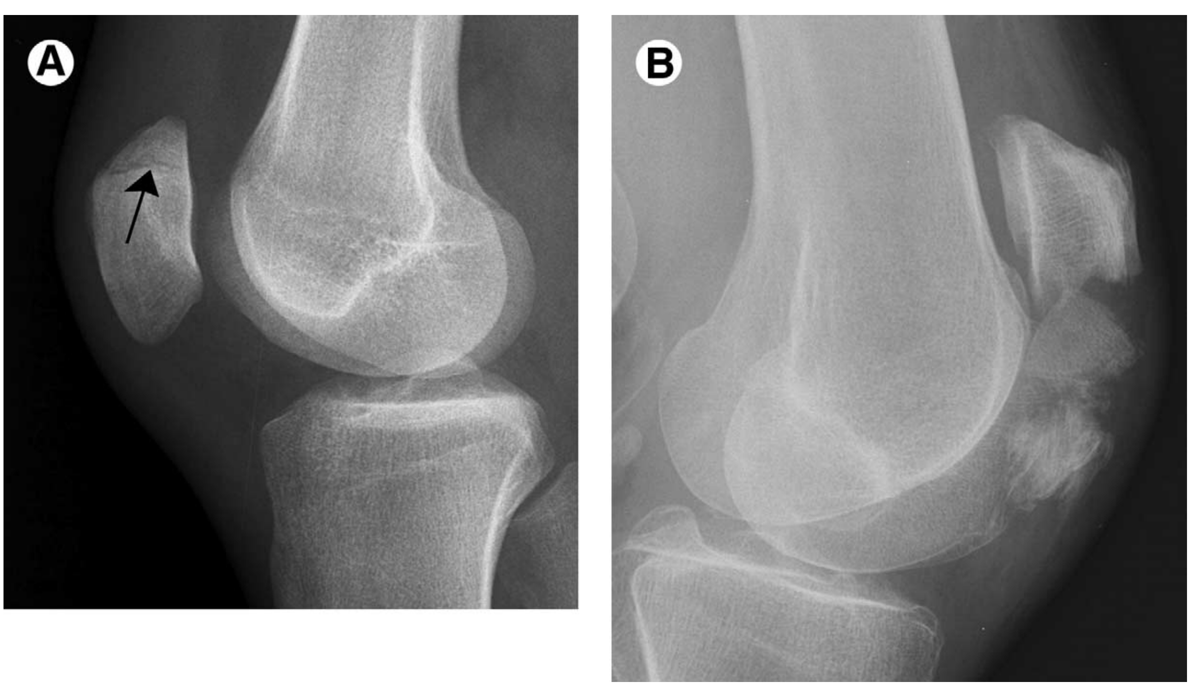

Figure 1 (A) Lateral knee radiograph demonstrates a non-displaced, transverse patellar fracture (arrow). (B) Radiograph of a comminuted patella fracture sustained during an automobile accident. Note the extensive articular disruption compared with (A).

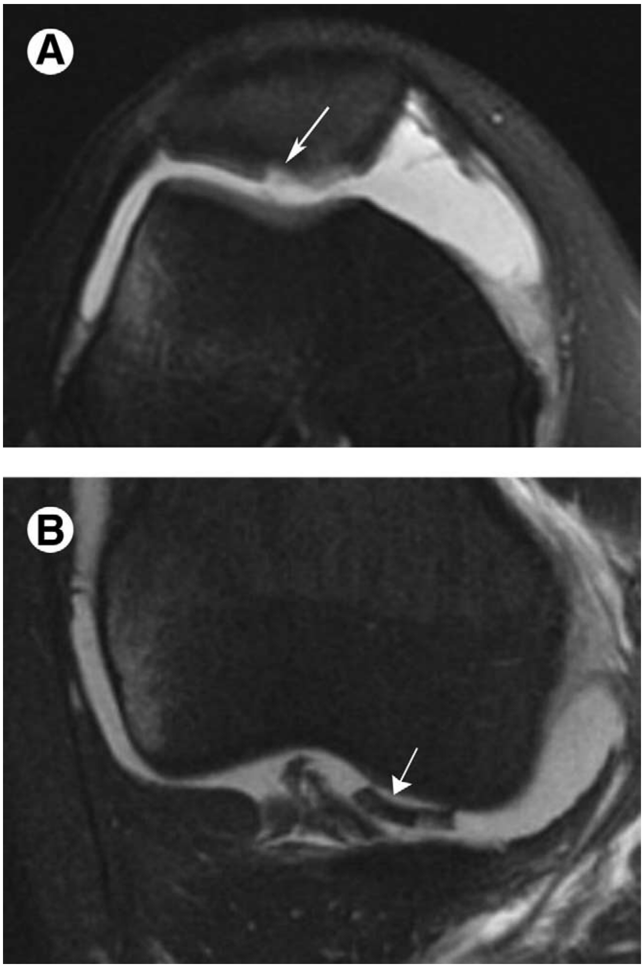

Figure 2 (A) Axial fat-suppressed proton-density weighted MR of the knee post patellar dislocation. An osteochondral defect is identified (arrow). Note the contusion of the lateral femoral condyle and the disruption of the medial retinaculum. (B) Coronal STIR knee MR demonstrates the large cartilage fragment (arrow) and the contusion.

Tibia

Tibial plateau fractures commonly result from a fall with valgus and compression force on the knee driving the anterior edge of the lateral femoral condyle into the plateau. Direct blows from a car dashboard or the bumper of a car hitting a pedestrian are also fairly common causes. The lateral tibial plateau is more frequently involved, accounting for approximately 75 to 80% of tibial plateau fractures. Isolated medial tibial plateau fracture accounts for 5 to 10%, with the rest involving both tibial condyles[19] (Fig. 8).

Lateral tibial plateau fractures may be classified as nondisplaced, depressed, split-depression with intact fibula, or split-depression with fibular fracture. A unicondylar fracture may have its fracture extend to the tibial spine; if the fracture extends to or beyond the spine, the fracture is essentially a fracture-dislocation and considerably less stable.[20]

Tibial plateau fractures are frequently associated with a variety of soft-tissue injuries demonstrated by MR imaging. These include tears of the tibial collateral ligament (55%), lateral meniscus (45%), ACL (41%), fibular collateral ligament (34%), PCL (28%), and medial meniscus (21%).[21] Injury to the posterior portions of the plateaus, in particular, have a significant association with ACL tears[22] (Fig. 9). CT often provides useful information regarding location of fracture fragments and is important in the preoperative evaluation. Axial images, with sagittal and coronal plane reformats, give the surgeon a three-dimensional perspective not available from radiographs alone.

Stress fractures of the proximal tibia are frequently of the insufficiency type due to normal activities on weakened bones in the elderly. They may also occur following knee replacement when activity suddenly increases.[23] In addition, they can be the result of a focal area of weakened bone created at the tibial tubercle harvest site for an ACL patellar tendon

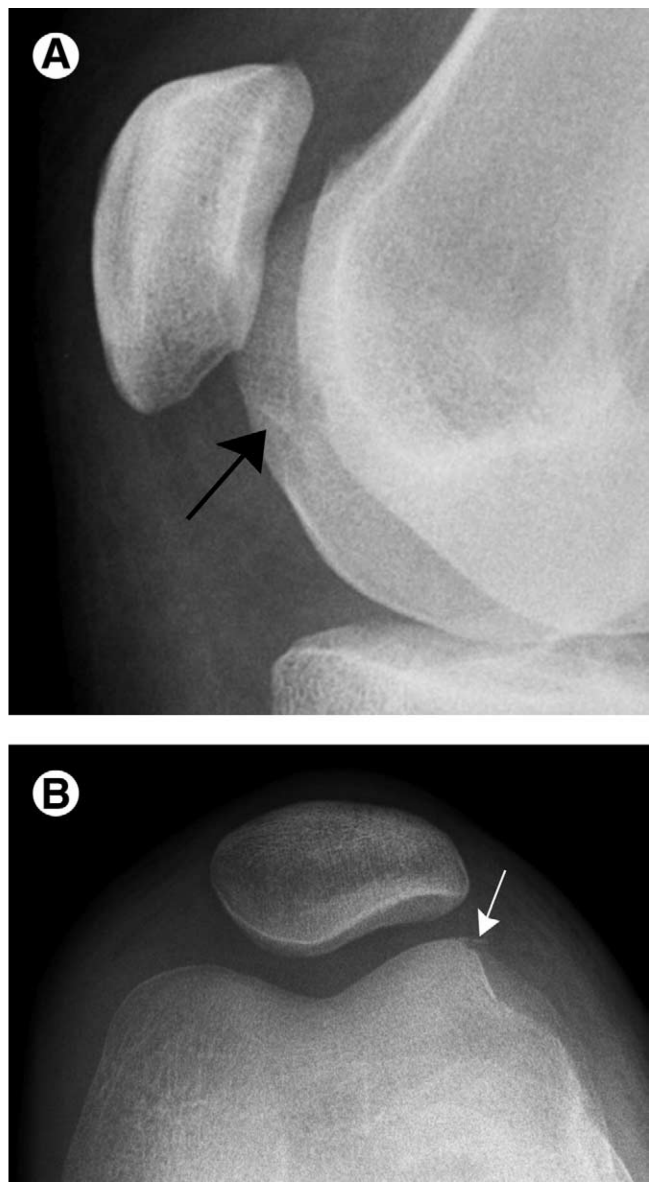

Figure 3 (A) Following patellar dislocation, this radiograph shows a thin line (arrow) from an osteochondral fracture. (B) Axial view of the patella in a different patient demonstrates tiny bony fragments (arrow) following lateral patellar dislocation.

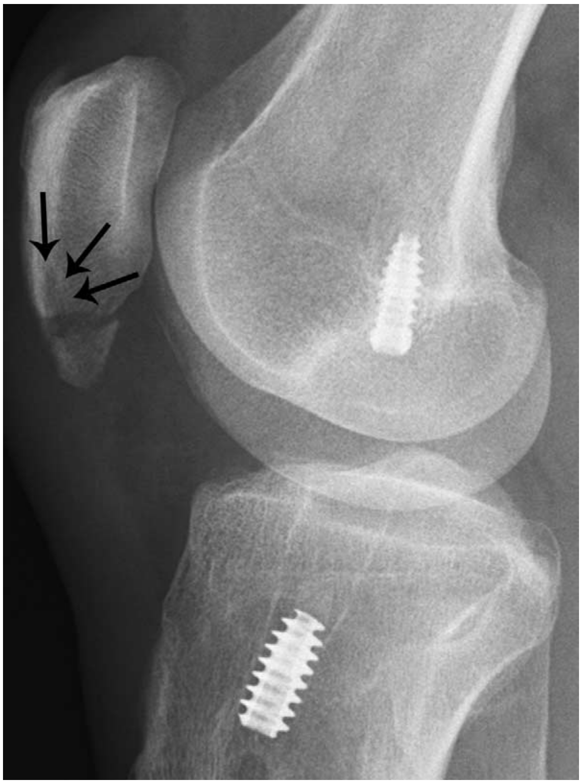

Figure 4 Lateral radiograph in an athlete with prior patellar graft ACL reconstruction. A non-displaced fracture in the weakened inferior pole is present involving the harvest site (arrows).

autograft or the created tunnel.[24] However, they are also found as fatigue fractures in children and runners.[25,26] The classic proximal tibial stress fracture is a vague, horizontal, sclerotic line in the medial proximal tibia (Fig. 10). These fractures may occur adjacent to either the anterior or the posterior cortex.[27]

Acute avulsions of the tibial tubercle are uncommon. They occur with violent active extension of the knee or passive flexion against contracted quadriceps muscles. These fractures typically occur in adolescents, which are discussed below. However, fracture of the tubercle has also been reported at the tibial harvest site following ACL graft harvest.

An ACL tear is often found when there is a fracture of the tibial spines (Fig. 11). Found in isolation in the preadolescent age group, these fractures are rarely isolated in adults, but found in combination with tibial plateau fractures.

The Segond fracture is named after Paul Segond who, in 1879, reported creating the fracture by internally rotating a knee in flexion, creating tension on the lateral aspect of the knee and an avulsion of the proximal tibia at lateral capsular ligament insertion.[28] The fracture fragment is typically thin, vertically oriented, and small, located at or just posterior to the midpoint of the lateral aspect of the plateau and a few millimeters inferior to the joint line, and is a strong indicator of an associated ACL injury[29] (Figs. 11C and 12).

The PCL may be avulsed from its attachment to the posterior surface of the tibia (Fig. 13A). At MR imaging, partial and complete PCL tears occur with nearly equal frequency (47% versus 45%); tibial bony avulsion is much less common (9%).[30] When the PCL avulsion fragment is displaced, surgical treatment by either K-wire or screw fixation is recommended[31,32] (Fig. 13B).

An avulsion at the attachment site of the semimembranosus tendon on the posteromedial tibia may occur. This avulsion is also associated with tears of the anterior cruciate ligament and medial meniscus. It is thought to be the result of valgus force with external rotation.[33,34] A similar fracture may occur as the result of impaction due to anterior subluxation of the medial tibial plateau following ACL rupture.[35]

Table 2 lists the common avulsion fractures of the knee and their associated injuries.

Fibula

Subluxation or dislocation of the proximal tibiofibular joint is rare and caused by a severe, sudden twisting of the knee, often associated with a fracture of the tibia. The dislocation is usually anterolateral due to the pulling of the peroneal muscles[36] (Fig. 14). The injury could be missed if there is partial reduction and the joint is not carefully evaluated.

Tears of the fibular collateral ligament and avulsions of the biceps femoris insertion are usually associated with other injuries. Failure to diagnose and treat an injury of the posterolateral corner in a patient who has a known tear of the anterior or posterior cruciate ligament can result in failure of the reconstructed cruciate ligament.[37] Radiographic findings of a small to large, horizontally oriented bony avulsion of the proximal fibula may be the only finding of this often-complex injury (Fig. 15).

Children and Adolescents

Fractures around the knee that involve the distal femoral or proximal tibial physis are uncommon and typically found in

Figure 5 Lateral radiograph of a supracondylar femur fracture in an elderly patient. Anterior and oblique views are often needed to see extension into the joint. Note the fat fluid level.

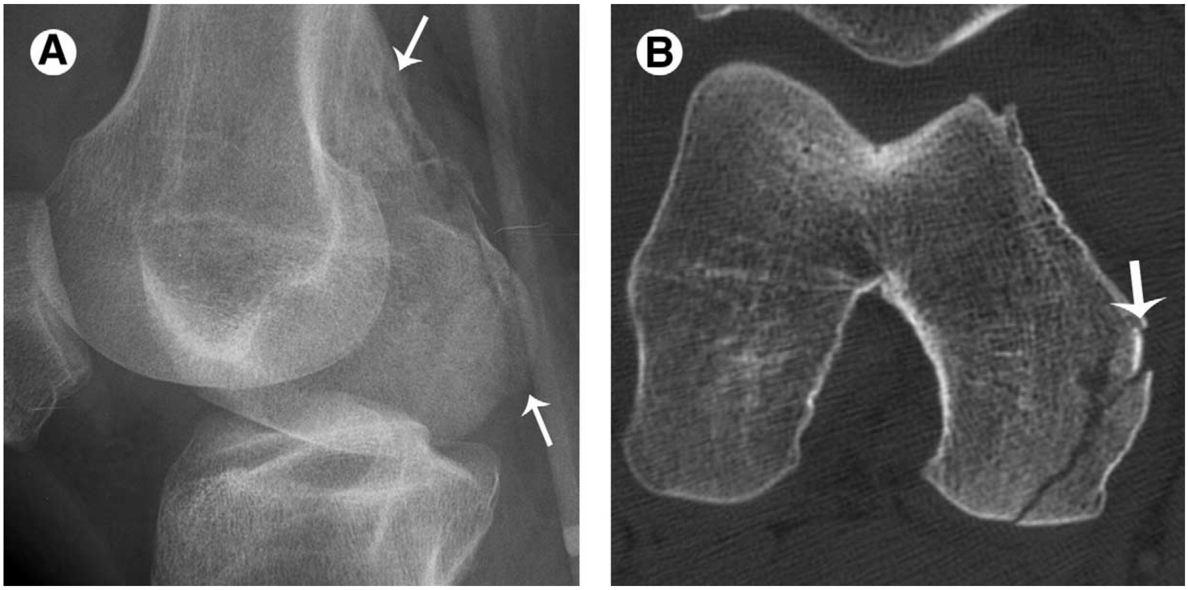

Figure 6 A. Oblique lateral view of the knee reveals the medial femoral condyle fracture (arrows) not seen well on AP or lateral view. B. As is typical, the CT shows that the region of MCL attachment (arrow) is involved by the fracture, but the lateral side of the MFC is not involved.

the adolescent age range. The distal femoral physis is more frequently involved than the proximal tibia and the notably rare proximal fibula physis.

Distal femoral physeal fractures are most often Salter–Harris II. In contrast, proximal tibial physeal fractures are more frequently Salter–Harris III and IV. Radiographs typically demonstrate the fracture line extending through the physis. If non-displaced, this may be a difficult film diagnosis. Stress radiographs can demonstrate physeal widening. MR imaging may reveal widening of a portion of the physis with demonstration of the metaphyseal and/or epiphyseal fracture line. Nearly half the patients may have associated ligamentous or meniscal injuries. Other associated injuries and complications include disruption of the popliteal artery, anterior compartment syndrome, and peroneal nerve palsy. There is a risk of physeal bar formation with subsequent asymmetric growth and limb malalignment. The proximal tibial physeal fractures, in particular, may have altered weight-bearing and early development of arthritis.

Figure 7 Oblique sagittal fat-suppressed proton density MR image demonstrates the typical lateral femoral condyle bone contusion and location for a deepened lateral femoral notch (see Fig. 12B).

Avulsion of the tibial tubercle in adolescence is uncommon. It occurs during a period of physiologic changes when the physis is more susceptible to tensile loading.[38] Three types of avulsion fractures are described in the Watson–Jones classification based on the extent of proximal tibial epiphysis involvement and degree of fracture displacement. In type 1 fracture, there is avulsion of the apophysis without injury to the tibial epiphysis. In type 2 fracture, the epiphysis is lifted cephalad but incompletely fractured (Fig. 16). Type 3 shows displacement of the proximal base of the epiphysis with the fracture line extending into the joint (Fig. 17). Type 1 and 2 fractures tend to occur in younger adolescents (12 to 14 years of age), whereas type 3 fractures occur in older adolescents (15 to 17 years of age). Articular extension is important to note, as anatomic reduction of the articular surface is the goal. With accurate reduction and fixation, uncomplicated union is anticipated.[39]

Proximal fibular physeal fractures are quite rare and usually the result of a pedestrian struck by a car with several concomitant injuries.[40]

Osteonecrosis

The femoral head is the most frequent location of osteonecrosis. This is followed by the distal femur and proximal tibia. Infarcts are not infrequently found in the metaphyseal re-

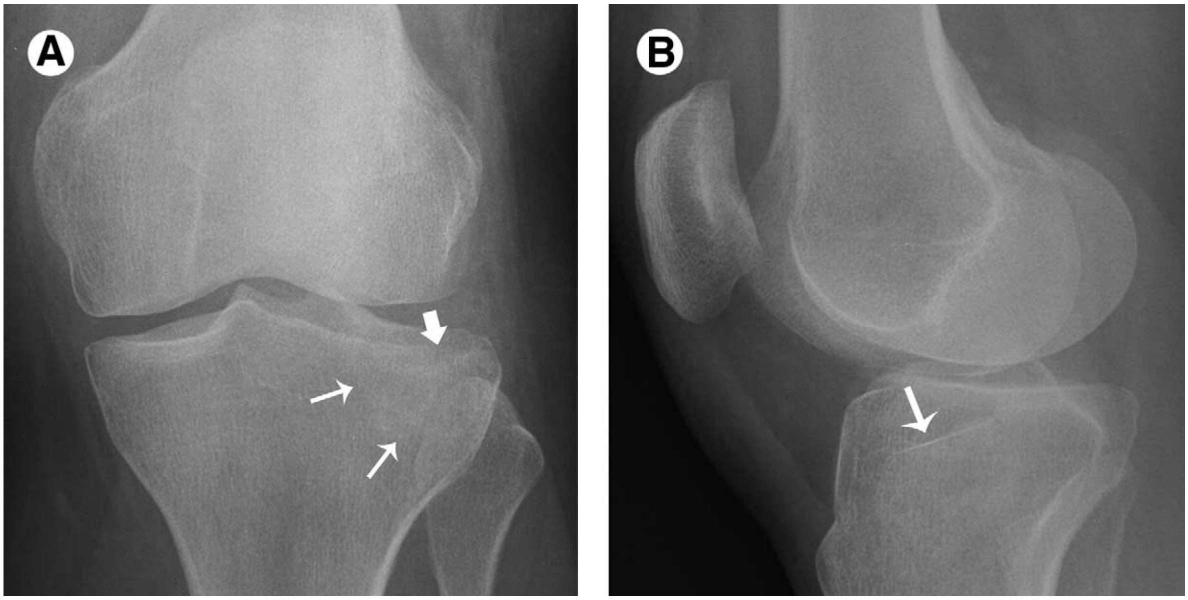

Figure 8 (A, B) Anterior and lateral views of the knee demonstrate a lateral tibial plateau fracture. The depressed fragment is easier to see on the lateral view (arrow) since the cortical edge is not tangential to the X-ray beam on the AP view. There is loss of the cortical margin and a "smudgy" linear density as clues on the anterior view.

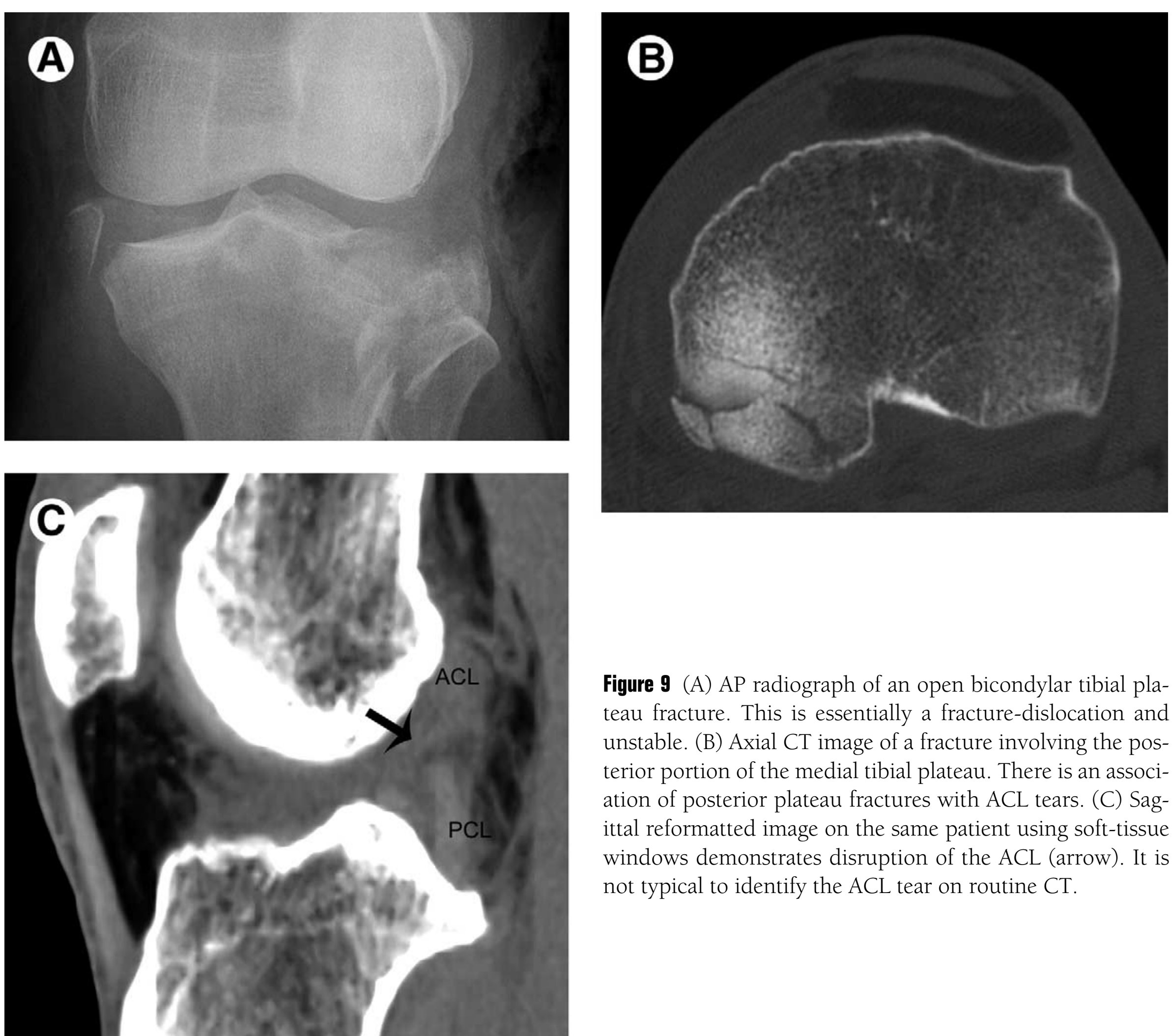

Figure 9 (A) AP radiograph of an open bicondylar tibial plateau fracture. This is essentially a fracture-dislocation and unstable. (B) Axial CT image of a fracture involving the posterior portion of the medial tibial plateau. There is an association of posterior plateau fractures with ACL tears. (C) Sagittal reformatted image on the same patient using soft-tissue windows demonstrates disruption of the ACL (arrow). It is not typical to identify the ACL tear on routine CT.

Figure 10 (A) Typical band of sclerosis in the medial tibial plateau of insufficiency fracture. (B, C) The fatigue fracture in this young athlete has the same appearance. It involves the lateral tibial plateau and is more posterior than anterior.

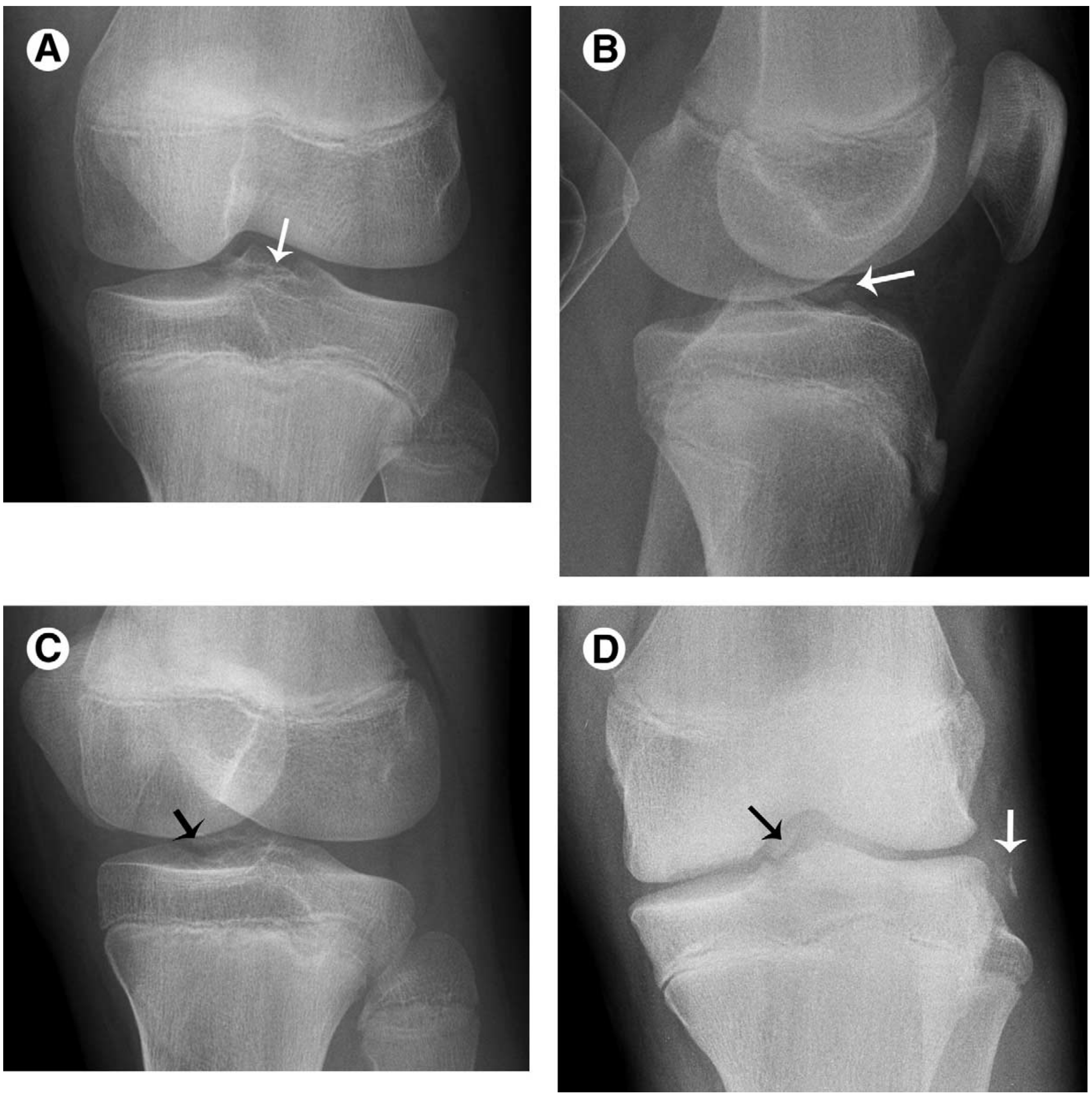

Figure 11 ACL avulsion in a 14-year-old. The fracture (arrows) is not well seen on the AP (A) and lateral (B) views, but is best seen on the oblique view (C). Oblique views are very helpful in the setting of acute trauma. (D) Anterior knee film in another patient shows a smaller bony fragment at ACL insertion (black arrow). Note that this patient also has a Segond fracture (white arrow).

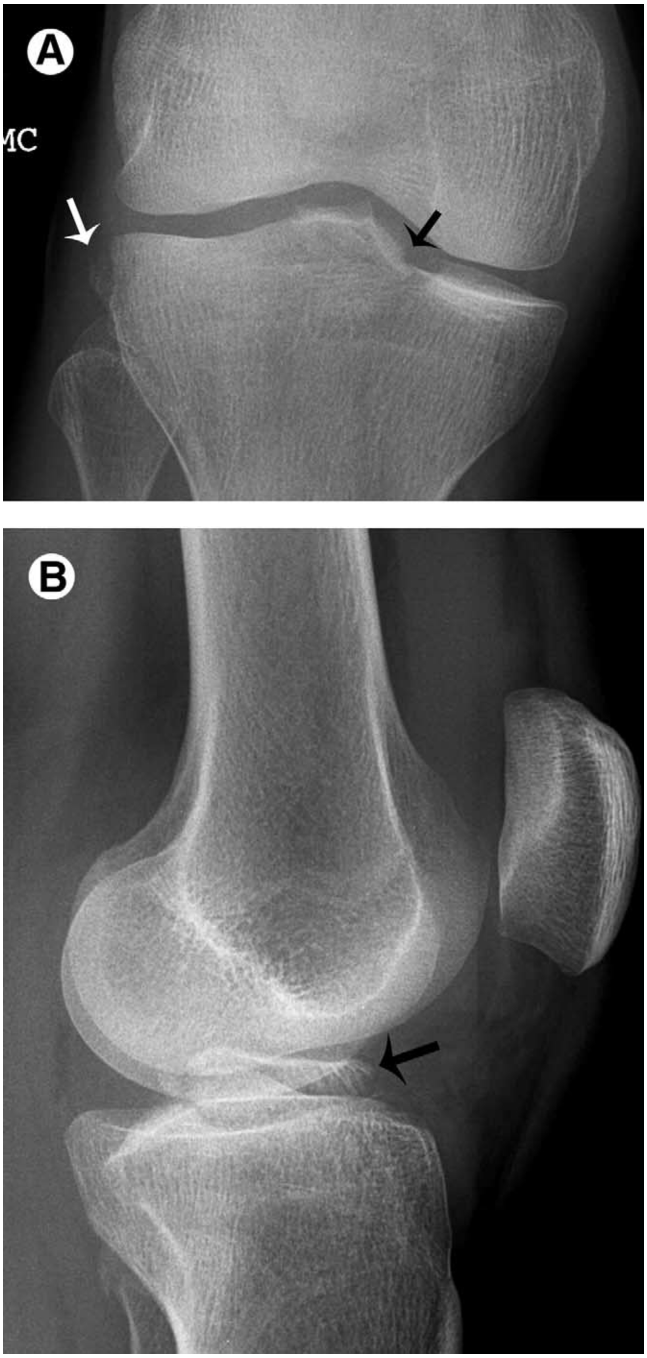

Figure 12 (A, B) Anterior and lateral view demonstrate a large fragment from ACL avulsion (black arrow) in this 30-year-old. Although more common in adolescents, this isolated fracture can occur in young adults. Displacement and rotation should be described when reporting this injury. More often, the Segond fracture (white arrow) is seen with ligamentous tear of the ACL. Note the fat-fluid level and proximal fibular fracture in this case.

gions around the knee on routine radiographs and MR examinations.

Spontaneous osteonecrosis of the knee (SONK) is characterized by an acute onset of intense knee pain. It is more common in older patients and classically found in the weight-bearing surface of the medial femoral condyle. There may be a joint

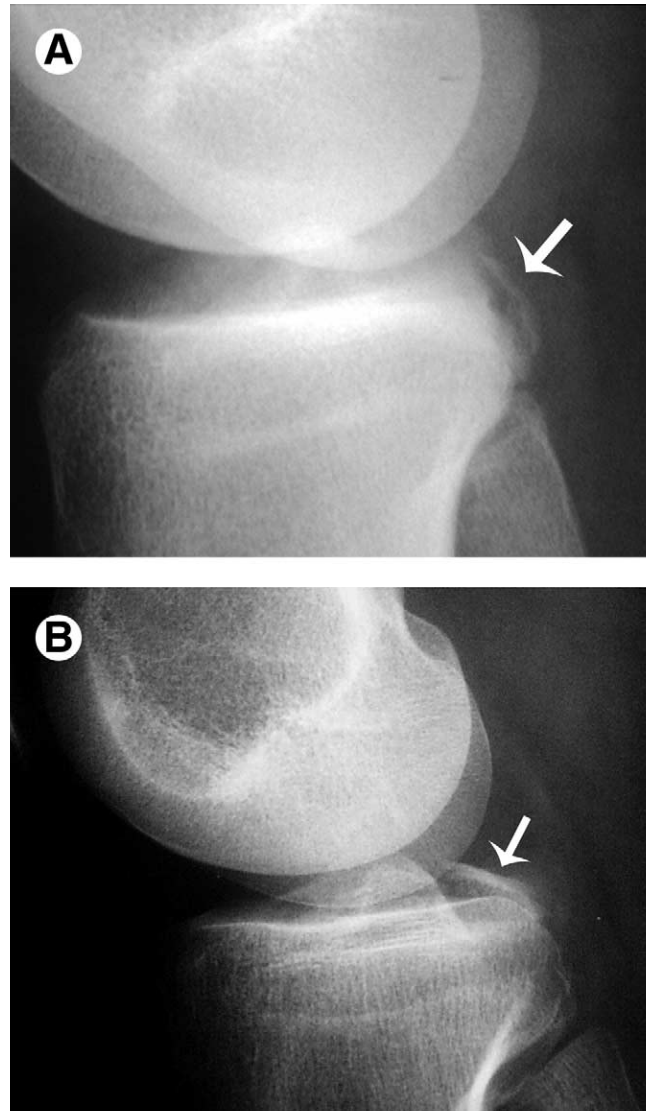

Figure 13 (A, B) Two examples of PCL avulsions (arrows), which are seen on lateral radiographs. The fragment may be quite thin as in (A). Displacement and rotation should be reported.

Table 2 Avulsion Fractures Around the Knee

Name/Location	Associated Injury
Pelligrini–Stieda	MCL tear, ACL tear
Segond fracture	LCL tear, ACL tear, lateral meniscus tear
Reverse Segond fracture	MCL avulsion, PCL tear, medial meniscus tear
Medial tibial spine	ACL avulsion
Posterior tibia	PCL avulsion
Fibular head	LCL avulsion or biceps femoris tendon tear, ACL tear, PCL tear

ACL = anterior cruciate ligament; PCL = posterior cruciate ligament; MCL = medial collateral ligament; LCL = lateral collateral ligament.

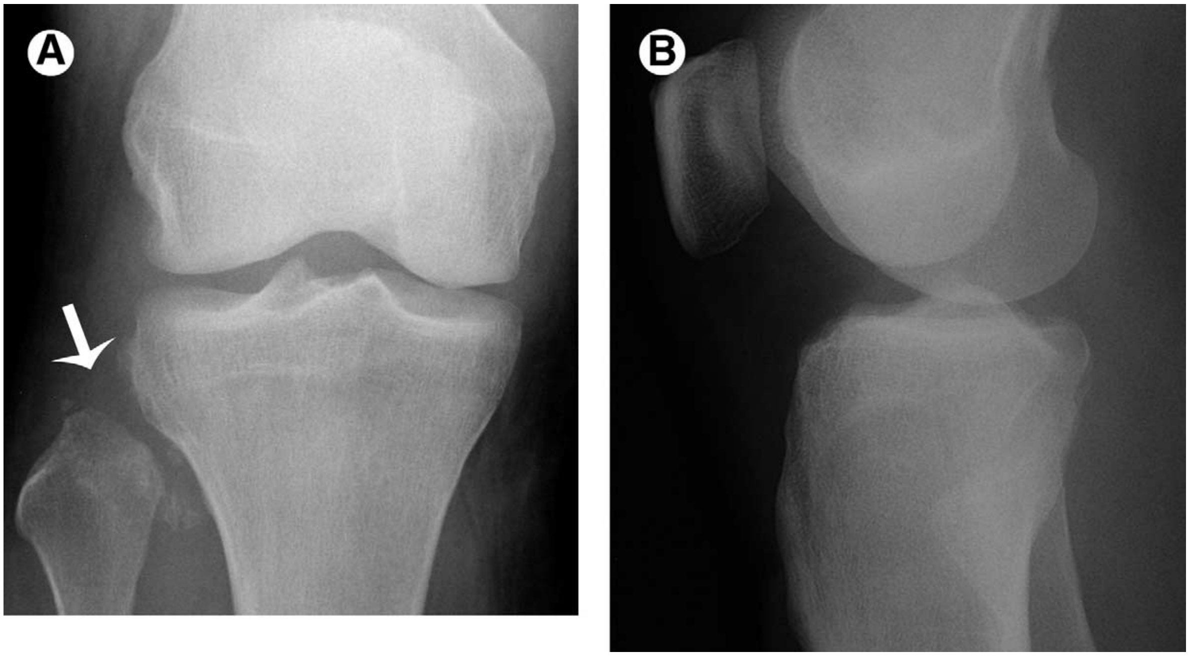

Figure 14 (A, B) AP and lateral radiographs reveal dislocation of the proximal tibiofibular joint. The joint space is clearly widened on the anterior view (arrow) and numerous tiny fragments are seen from the capsular avulsion. Associated mid tibial and distal fibular fractures are not shown. (Case is courtesy of Dr. Liem T. Bui-Mansfield, Brooke Army Medical Center, San Antonio, TX.)

effusion present, but initial radiographs are often normal. The infarct typically progresses to articular collapse of the involved area of bone (Fig. 18). This abnormality is now thought to be a subchondral insufficiency fracture due to underlying meniscal degenerative tear[41-44] (Fig. 19).

The etiology of osteochondritis dissecans remains controversial, although most theories suggest repetitive trauma and/or ischemia. The classic location is the lateral aspect (non-weight-bearing portion) of the medial femoral condyle, but other areas of the knee can be involved. This is an abnormality of adolescence and boys outnumber girls nearly three to one. Radiographic clues to an unstable fragment include displacement of the fragment, either removed from the donor site or rotated. Stable fragments often heal with conservative treatment while unstable fragments benefit from surgical intervention, usually reattachment of the fragment (Fig. 20).

Arthritis/Cartilage

Imaging of articular cartilage has largely focused on MR imaging and the knee joint has received the most interest. Radiographic changes usually suggest more advanced cartilage loss with remodeling of the articular surface. Initially, the changes may be subtle. Subchondral sclerosis, subchondral cysts, or osteophytes may all predate frank joint space narrowing (Fig. 21).

Joint Replacement

A total knee replacement consists of components for the articular surfaces of the femur, tibia, and patella. Most are metal-backed components, although the patellar component may consist only of polyethylene. Components may or may not be cemented in place.

The most common prosthesis is an unconstrained or partially constrained total knee replacement, which allows some flexion, rotation, and distraction. Partially constrained prostheses provide some ligament-replacing function. This can be accomplished by having conforming surfaces of the femoral and tibial articulating surfaces.

Assessment of alignment requires true weight-bearing views. Asymmetric widening of the prosthetic implies ligament laxity, whereas narrowing over time reflects polyethylene wear. The femoral component should be within 4 to 11° of anatomic valgus. The tibial component should be perpendicular to the shaft of the tibia on an anterior view. It should be horizontal or slope downward posteriorly up to 10°. Mechanical axis views may be obtained. Measurements are obtained on a full-length leg film by drawing a line from the center of the femoral head to the medial tibial spine and then to the center of the tibial plafond. Ideally a near-neutral axis is obtained (Fig. 22).

Aseptic loosening is thought to be due to cumulative mechanical stress, particle debris, and poor bone stock. Radiographic criteria are a wide or progressively widening lucency between cement or prosthesis and bone of more than 2 mm, component migration, and cement fractures (Fig. 23). One caveat is that a radiolucent zone between the cement and cortex may be the intact trabecular bone and not evidence of loosening. A thin, dense line will usually surround the true pathologic lucency. Large focal areas of lucency may be the result of particle debris-associated osteolysis. Loosening is easiest to detect in the tibial component.

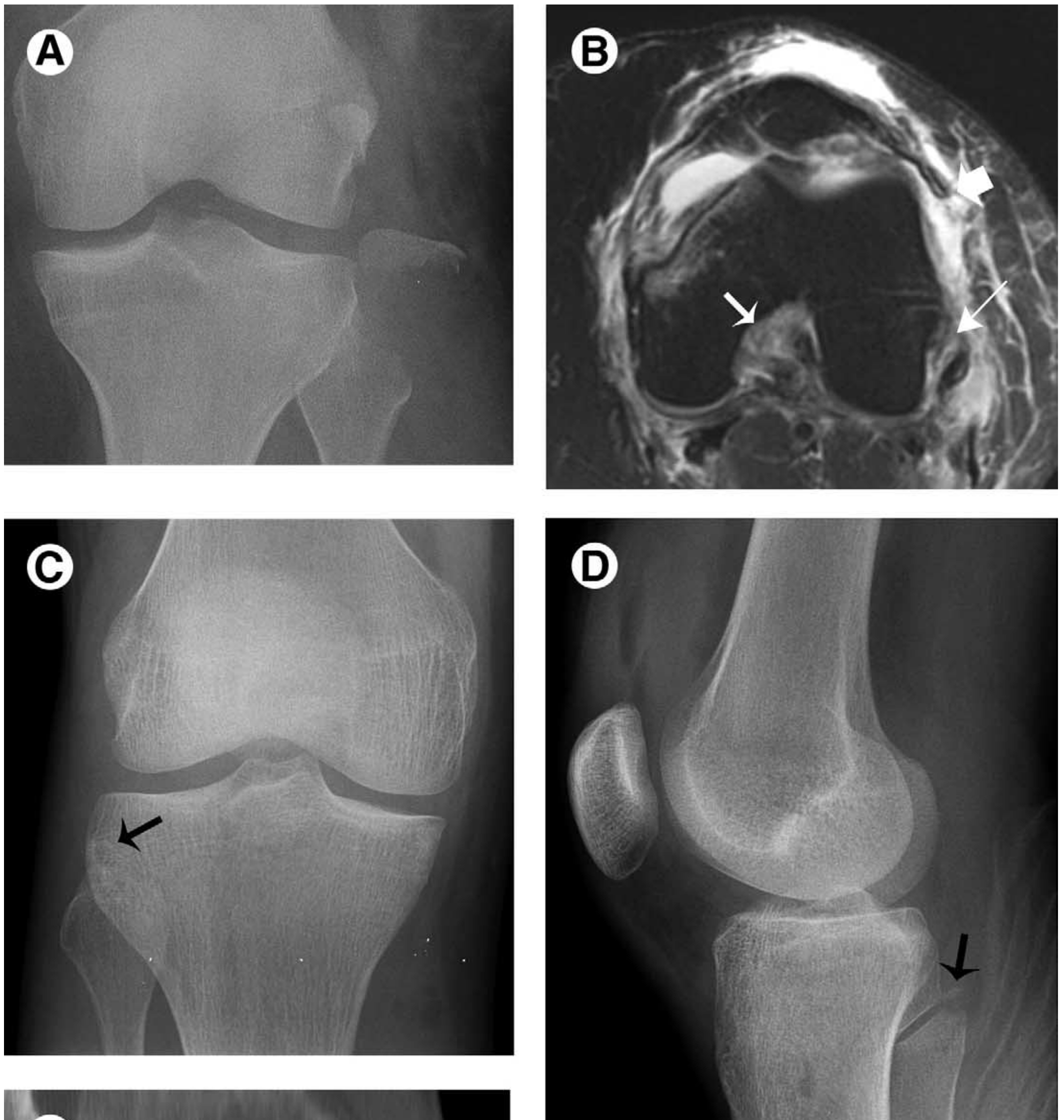

Figure 15 (A) A large fragment from the proximal fibula suggests a more serious injury than isolated avulsion of the biceps femoris. (B) Axial fat-suppressed T2-weighted MR image defines some of the more extensive knee abnormalities including disruption of PCL (arrow), lateral retinaculum (short, broad arrow), and popliteus tendon (long, thin arrow). (C, D) Small bony fragment of biceps femoris tendon avulsion (arrow). Anterior tibial plateau fracture not seen on radiograph, discovered on CT (E). One should be suspicious of other injuries associated with biceps femoris tendon avulsion.

Figure 16 Grade 2 tibial tubercle fracture in which the epiphysis is lifted, but incompletely fractured.

Figure 17 Grade 3 tibial tubercle avulsion with the physeal fracture line clearly extending into the joint.

Figure 18 Spontaneous osteonecrosis of the knee (SONK) in its typical location of the weight-bearing surface of the medial femoral condyle (MFC). Recent studies showed that this process begins as a subchondral insufficiency fracture secondary to an underlying meniscal tear and progresses to osteonecrosis.

When followed for 10 to 20 years, approximately 3.5% of knee prostheses will need revision for loosening and 1 to 2.5% will need revision for infection.[45,46] Based on the guidelines set forth by ACR appropriateness criteria, the initial study for suspected loosening without infection is radiographs with comparisons to prior studies. The findings may be identical to aseptic loosening (Fig. 24). With normal radiographs and suspicion of loosening or infection, the most appropriate evaluation is aspiration of the joint, with or without arthrography to evaluate for tracking of contrast along the

Figure 19 Subchondral insufficiency fracture of the medial femoral condyle in an elderly woman (arrow). Compare the broad, sclerotic line to those in Figure 10.

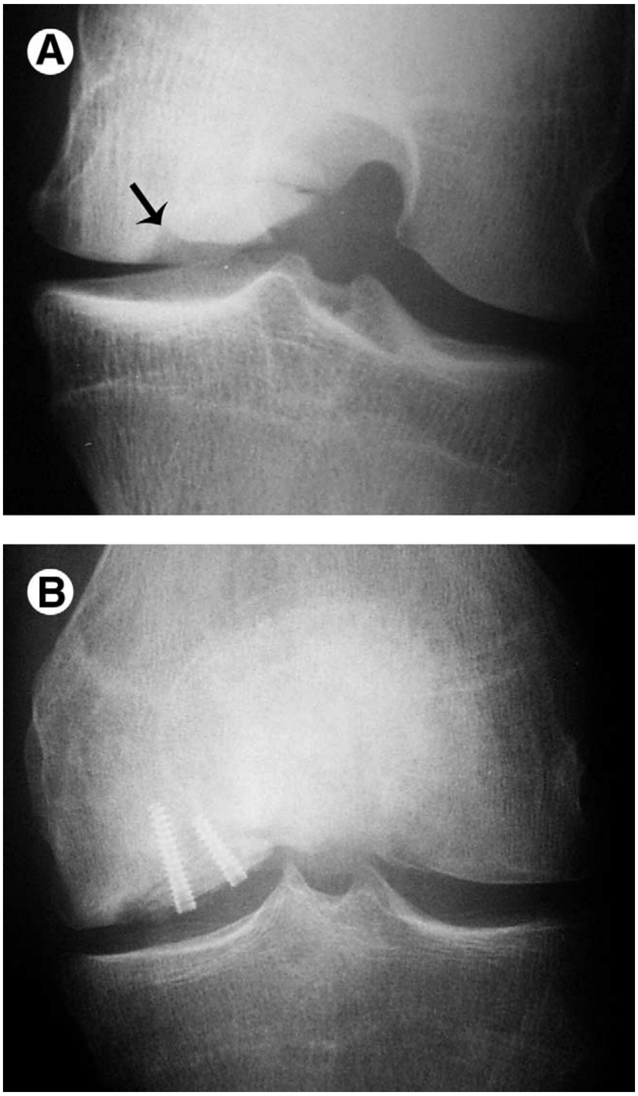

Figure 20 (A) AP view of knee shows an osteochondritis dissecans in the lateral aspect of the medial femoral condyle. Note the offset of the articular surface suggesting an unstable fragment (arrow). (B) Postsurgical image following fragment stabilization.

prosthesis. Joint aspiration has a sensitivity of 67% and a specificity of 96%.[47,48]

Polyethylene wear is a late complication of knee prostheses and most often affects the medial posterior tibial component and the patellar component. There is narrowing of the joint space on weight-bearing views. A joint effusion is usually present.

Ligaments

The knee ligaments consist of intra- and extraarticular structures. The healing of extraarticular ligaments is analogous to other soft tissue, with formation of scar tissue. Conversely, intraarticular ligaments have a much more limited healing response.

Tears of the anterior cruciate ligament may be difficult to fully assess in the acute setting. When a patient can be fully evaluated, however, clinical evaluation for an intact ACL is excellent.[49,50]

The posterior cruciate ligament is stronger and shorter than the ACL. The PCL is less susceptible to tearing than the ACL and, thus, less frequently torn.[51] PCL injuries are found in association with severe knee trauma such as dislocation. The most common mechanism for an isolated PCL tear is a force directed posteriorly on the proximal tibia with the knee flexed (contact with the dashboard in an MVA, a fall onto the knee, or soccer injury). Hyperextension injuries are a less

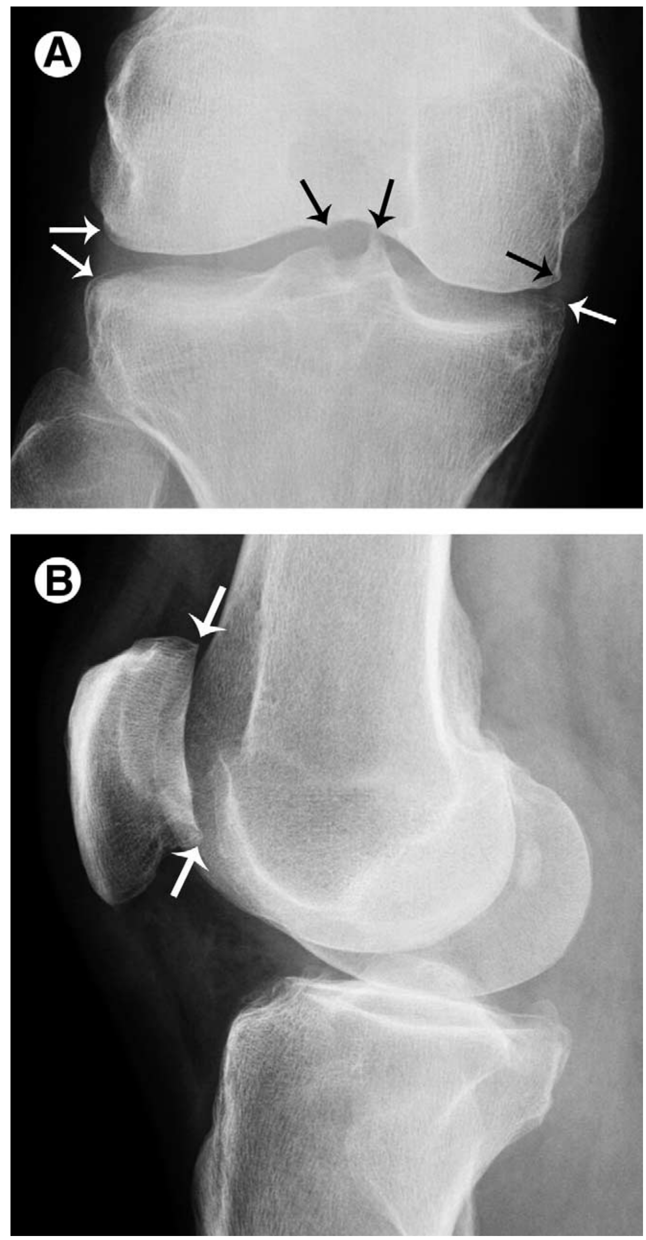

Figure 21 (A) Standing knee demonstrates small osteophytes (arrows), subchondral cysts, and sclerosis with preserved joint spaces. (B) Lateral view is useful to evaluate the patella. Note the change in contour of the posterior surface of the patella compared with Figs 12B and 15D. It has become somewhat concave and tiny osteophytes (arrows) are seen. Moderate chondromalacia can be reported.

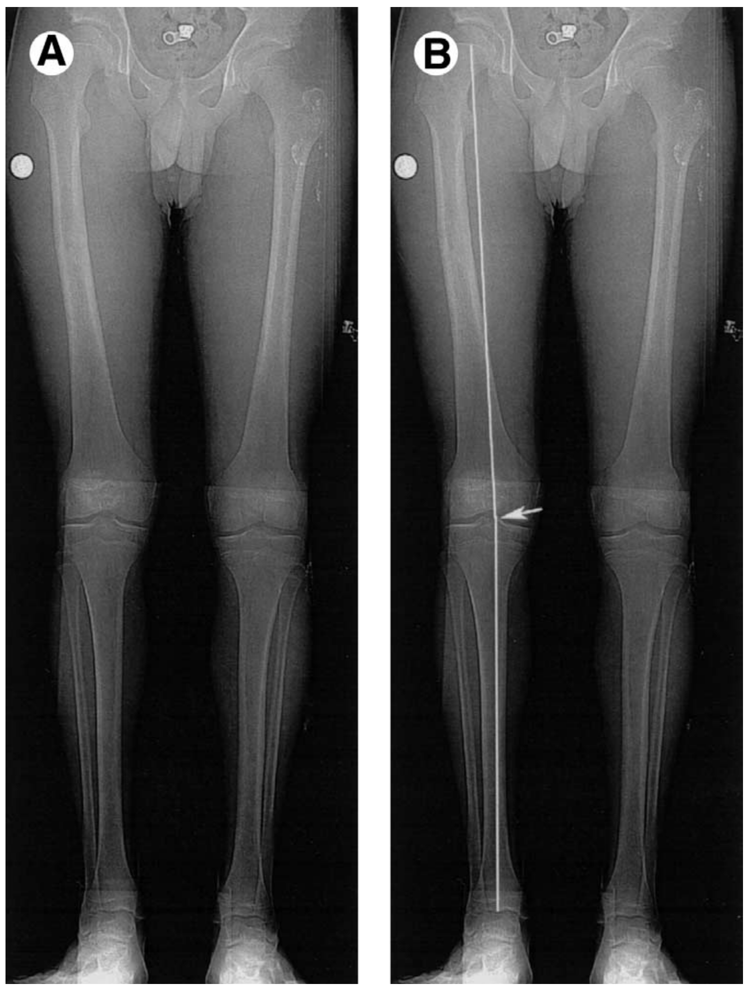

Figure 22 (A) Standing full-length leg view is used to determine the mechanical axis. (B) Lines from center of femoral head to medial tibial spine (arrow) and then to middle of plafond determine the angle of the mechanical axis. It is neutral in this patient.

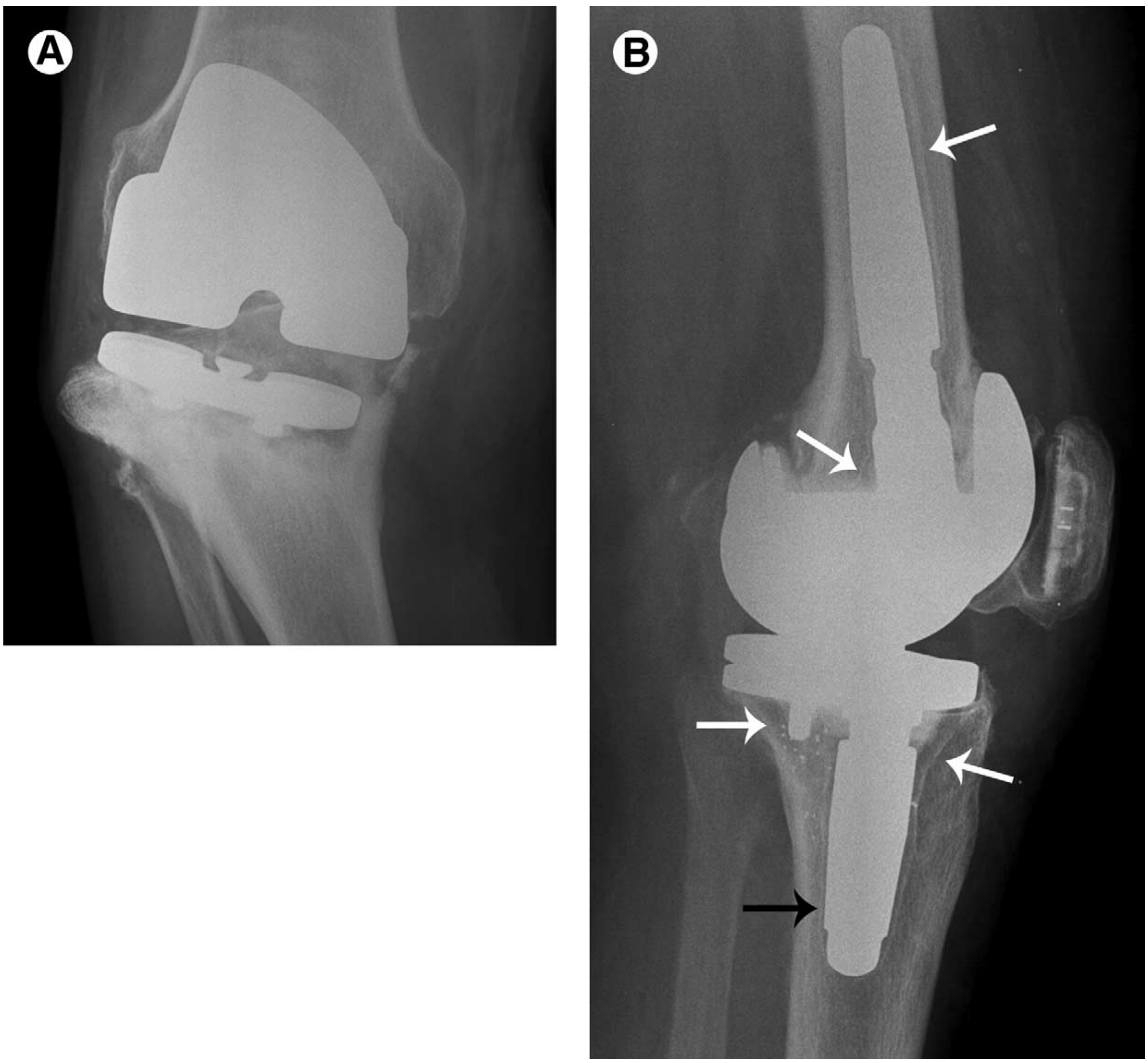

Figure 23 (A) Obvious loosening of the tibial component, which has prominent bone loss medially. (B) Widening of the lucency at the prosthesis bone interface (white arrows) indicates loosening. Note the normal distance (black arrow). There is metallic particle debris in posterior tibia.

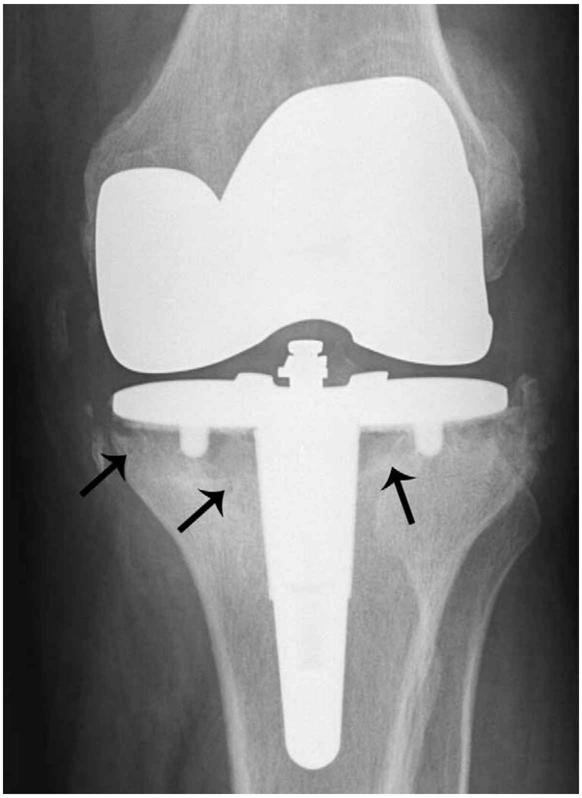

Figure 24 Infected prosthesis is radiographically not different from aseptic loosening with focal loosening around tibial component (arrows). Aspiration was positive for *Staphylococcus aureus*.

frequent cause. The PCL may be avulsed from its attachment to the posterior surface of the tibia.[52] With an isolated injury, the patient outcome is more a reflection of the muscular strength of the quadriceps muscle group rather than the ligament itself and conservative treatment is common.[31]

Figure 26 Maturing ossification at medial collateral ligament origin known as Pelligrini–Stieda lesion.

Tears of the MCL can be classified as Grade 1 (sprain), Grade 2 (partial tear), or Grade 3 (complete disruption of fibers).[53] Radiographs are often normal, but may demonstrate widening of the medial compartment with valgus stress (Fig. 25). Calcification or ossification seen adjacent to the medial femoral condyle is a plain film indicator of prior MCL injury[54] (Fig. 26).

Muscles/Tendon

The extensor mechanism consists of the quadriceps femoris muscles (rectus femoris, vastus medialis and lateralis, and

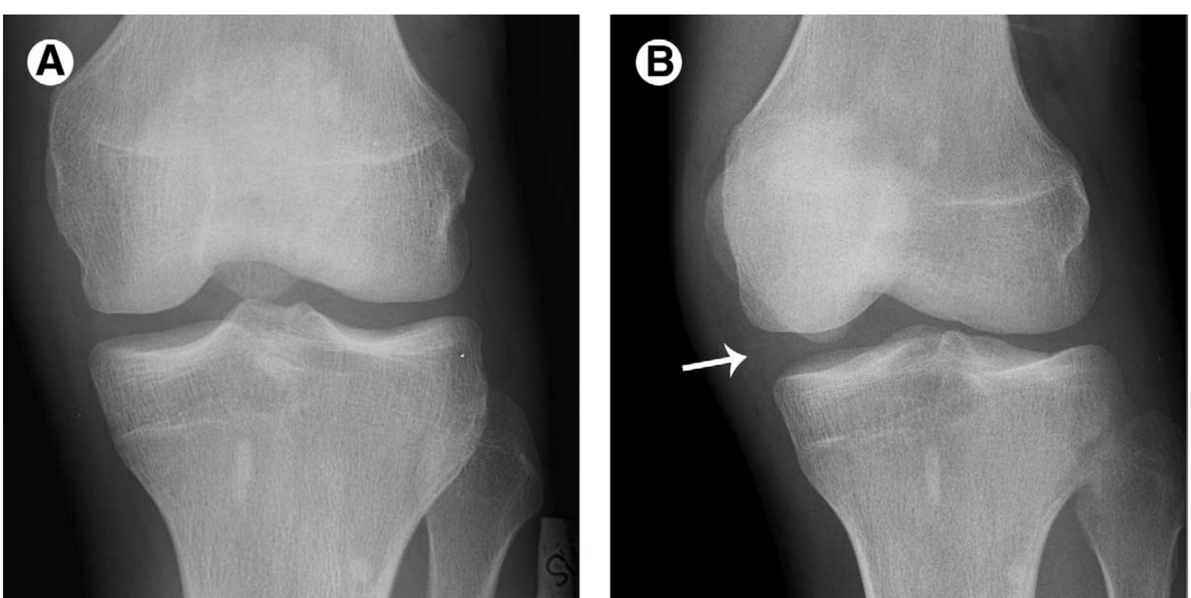

Figure 25 Medial collateral ligament tear. Normal appearance in (A) with widened medial compartment (arrow) with valgus stress (B).

Figure 27 Quadriceps tendon tear. Initial images would have a large amount of edema at the superior pole of the patella. Over time, retraction of the quadriceps tendon leaves a fat-filled gap (arrow). The patella is not inferiorly displaced due to either positioning or intact fibers that insert on the patellar retinaculum.

vastus intermedius), quadriceps tendon, patella, patellar tendon (also called patellar ligament), medial and lateral patellar retinaculum, and tibial tubercle.

Complete disruption of the quadriceps musculotendinous unit at the tendon level mostly occurs at its junction with the patella. However, strong deceleration may result in acute partial or complete tears of the quadriceps tendon a few centimeters from the upper patellar pole.

The majority of patients are over the age of 40 years, probably because of age-related collagen degeneration and men are more affected than women.[55] About one-third of all patients with bilateral tears have a predisposing factor such as uremia, hyperparathyroidism, diabetes mellitus, or collagen vascular diseases. The mechanism of injury involves violent contraction of the quadriceps muscle against a full body weight. On physical examination, there is loss of active extension of the knee or inability to maintain a passively extended knee against gravity. Immediate surgical repair is recommended for complete tears. Radiographically, there is a soft-tissue mass superior to the patella; the patella appears low in position (patella baja) and its upper pole is tilted anteriorly (Fig. 27).

In patellar tendinitis or jumper's knee, the disease is characterized by pain at the proximal insertion of the patellar tendon. It is seen often in basketball or volleyball players and is caused by repetitive microtrauma. Jumper's knee occurs during the adolescent years and early adulthood and is seen more often in boys. Irregularity/bony overgrowth of the inferior aspect of the patella suggests the diagnosis[56] (Fig. 28). Patellar tendon tears typically occur at the bony attachment sites and demonstrate superior displacement of the patella (patella alta), small avulsion fracture, and loss of a defined patella tendon on radiograph (Fig. 29).

Synovium

The synovial cavity of the knee is the largest in the body. Fullness within the knee joint is best identified by distension of the suprapatellar bursa by fluid, blood, or thickened synovium. Usually, no specific diagnosis can be made, but occasionally some additional findings may suggest the diagnosis.

Pigmented villonodular synovitis (PVNS) is a tumorous proliferation of stromal and giant cells with a lack of inflammation. Pathologically identical to giant cell tumor of tendon sheath, the knee and hip are the most frequently involved joints. In the knee, PVNS may form a focal nodule or be diffuse along the synovial lining of the joint. It is diagnosed in young to middle-aged men more often than women. The brown "pigmentation" is hemosiderin deposition, which has a typical MR appearance. Rarely, subchondral synovial-filled cysts out of proportion to the degree of osteoarthritis may suggest the diagnosis[57] (Fig. 30).

Figure 28 Jumper's knee. Areas of ossification develop at the patellar attachment of the patellar tendon from repetitive injury. Similar findings may be seen at the quadriceps attachment as well.

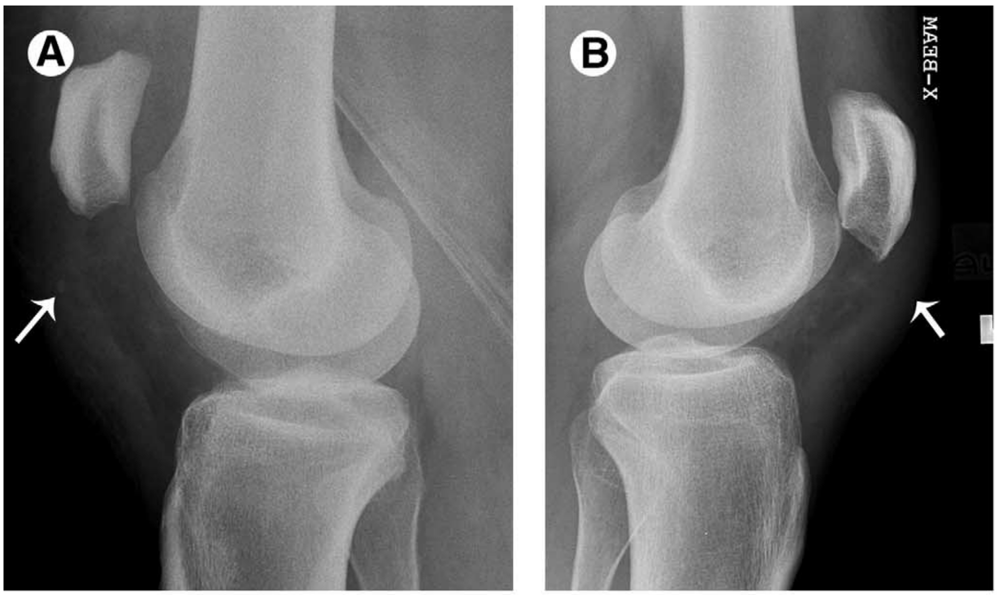

Figure 29 (A) Re-tear of a patellar tendon 1 year after surgery. The patella is elevated and there is soft-tissue swelling. Note the tiny ossific fragment from the remote tear (arrow). (B) With the knee extended, the slightly high-riding patella may be overlooked. There is focal swelling at the inferior pole of the patella (arrow). (C) Radiograph following anchor placement for repair of the torn patellar tendon in B.

Synovial osteochondromatosis may be idiopathic, called primary osteochondromatosis, which occurs in young adults, men more frequently than women, and the knee is the most common site. Synovial hyperplasia and cartilage metaplasia create villous and nodular projections from the synovium.[58] Osteocartilaginous nodules are 0.2 to 2 cm in diameter. Pain, locking, and swelling are the presenting features. Radiographs may reveal numerous calcified or ossified bodies in the joint of relative uniform size. MR may demonstrate a greater extent of disease with thickened synovium and nodules within the joint. Arthrography (routine, CT, or MR) may also play a role in its diagnosis.[59]

Secondary synovial osteochondromatosis is much more common. There are loose osteocartilaginous bodies in the joint, typically the result of cartilage disruption or fragmentation due to osteoarthritis. The bodies may become attached

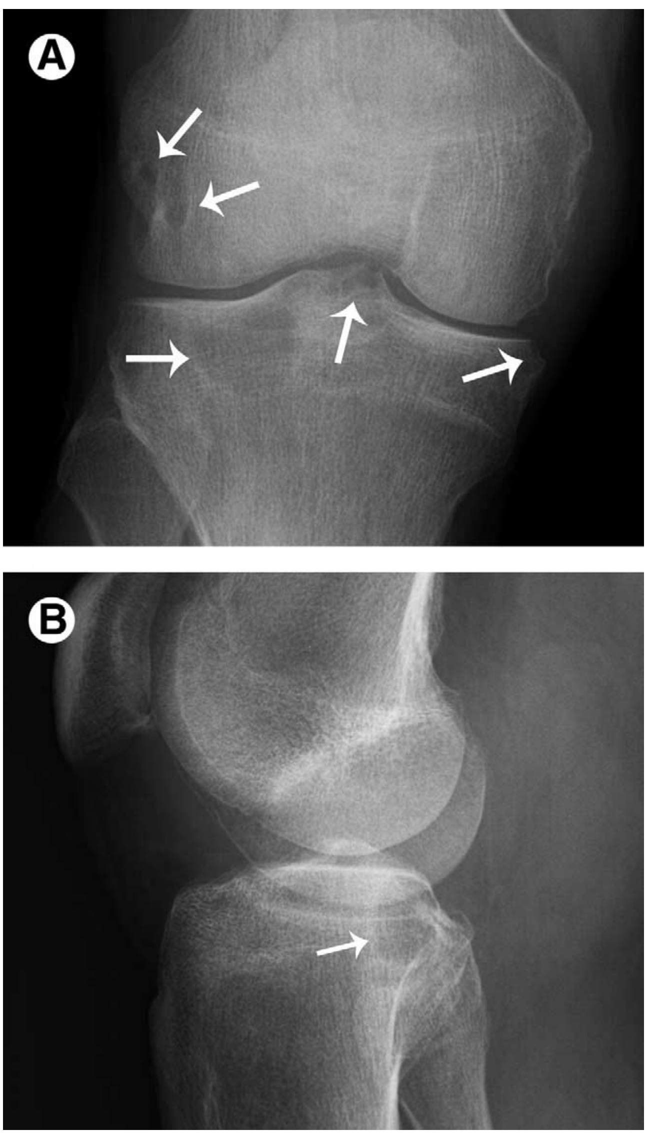

Figure 30 (A, B) Multiple erosions (arrows) with maintained joint space in this young woman raised the question of pigmented villonodular synovitis (PVNS). Final histology suggested a chronic synovitis, not otherwise specified.

Figure 31 Numerous osteocartilaginous bodies in a Baker's cyst.

to synovium or move about the joint or into connected bursae (Fig. 31). Radiographs demonstrate a fewer number of "joint mice" than in the primary form. They are often found in a Baker's cyst, suprapatellar bursa, or the posterior joint, behind the PCL. A donor site may or may not be found.

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