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Osseous and Myotendinous Injuries About the Knee

Thomas H. Berquist, MD, FACR[a,b,*]

Osseous injuries

Osseous injuries may be articular, extra-articular, or physeal, and may be related to direct trauma, avulsion forces, or chronic microtrauma [1–3]. Displaced fractures can be diagnosed easily on radiographs; however, multiple, subtle osseous or osteochondral lesions may not be defined radiographically. In addition, subtle findings on MR images, such as bone bruises, can be useful for evaluating the mechanism and extent of bone and soft-tissue involvement [4]. MR imaging is also a valuable technique for the detection and follow-up evaluation of children with physeal injuries [5,6]. Table 1 summarizes osseous and osteochondral injuries about the knee, and optimal imaging approaches.

Bone bruise or marrow edema pattern

Bone bruises or marrow edema may be identified with numerous conditions, including trauma, infection, and osteoporosis [4,7–9]. Bone bruises related to trauma may be caused by a direct blow, articular compression forces, or avulsion injuries [4]. The extent of marrow edema tends to be more dramatic with compression or direct trauma, compared with avulsion injuries [8]. Typically, bone bruises are not visible on radiographs. However, these injuries are detected easily on MR images using T1-weighted sequences and either short T1 inversion recovery (STIR) or fat-suppressed T2-weighted sequences (Fig. 1) [1,7]. Specific edema patterns are also useful in predicting the mechanism of injury and the associated ligament, tendon, or meniscal involvement [4]. Five classic patterns have been described.

Patients who have pivot shift injuries typically have bone contusions involving the posterior lateral tibial plateau and midlateral femoral condyle. The posterior margin of the medial tibial plateau may be involved as well. Associated injuries include the anterior cruciate ligament, the posterior

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[a] Department of Diagnostic Radiology, Mayo Clinic College of Medicine, Rochester, MN 55901, USA
[b] Department of Diagnostic Radiology, E2 Mayo Clinic Jacksonville, 4500 San Pablo Road, Jacksonville, FL 32224, USA
* Department of Diagnostic Radiology, E2 Mayo Clinic Jacksonville, 4500 San Pablo Road, Jacksonville, FL 32224.
E-mail address: berquist.thomas@mayo.edu

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Table 1: **Subtle osteochondral injuries about the knee**

Injury	Imaging approaches	Comments
Bone bruise	Radiographs, then MR imaging	Assess ligaments, menisci, other soft-tissue injuries
Stress and insufficiency fractures	Radiographs, then MR imaging	Confirm fracture, exclude other pathology
Physeal fractures	Radiographs, then MR imaging	Detect, exclude growth plate closure
Tibial spine fractures	Radiographs, then MR imaging	Classify, exclude ACL and other injuries
Avulsion fractures	Radiographs, then MR imaging or CT	Detect, exclude soft-tissue injuries
Segond fractures	Radiographs, then MR imaging	Assess ACL, menisci, and other soft-tissue injuries
Reverse Segond fractures	Radiographs, then MR imaging	Assess PCL, menisci, and other soft-tissue injuries
Tibial plateau fractures	Radiographs, then MR imaging or CT	Assess articular deformity and separation, and soft-tissue and meniscal injuries
Fibular head avulsion fractures	Radiographs, then MR imaging	Assess posterolateral corner injury and PCL injury
Osteochondritis dissecans	Radiographs, then MR imaging	Confirm and classify

Abbreviations: ACL, anterior cruciate ligament; PCL, posterior cruciate ligament.

capsule, the arcuate ligament, and the posterior horn of the medial or lateral meniscus. The medial collateral ligament may be disrupted also.

A dashboard injury or direct trauma to the anterior tibia results in marrow edema in the anterior tibia. The posterior cruciate ligament and the posterior capsule may be torn with this injury pattern.

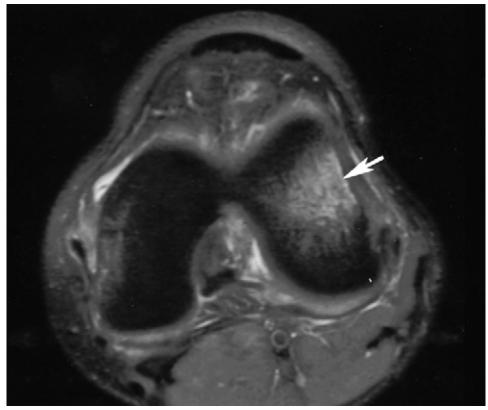

Fig. 1. Fat-suppressed fast spin-echo T2-weighted image demonstrates a bone bruise in the lateral femoral condyle (*arrow*).

Patients who have hyperextension of the knee present with kissing contusions of the anterior tibia and the adjacent anterior distal femur. Hyperextension injuries also may involve cruciate ligaments, the menisci, and, if severe enough, the posterior capsule and neurovascular structures posterior to the knee.

Clipping injuries, classically seen in football, result in prominent lateral femoral condyle edema and a smaller area of contusion in the medial femoral condyle. Medial collateral ligament injuries are common (Fig. 2). When more severe valgus force is applied, the anterior cruciate ligament and medial meniscus may be torn as well (O'Donoghue's triad).

Finally, lateral patellar dislocations lead to bone bruises or contusions involving the medial patellar articular surface and the anterior lateral femoral condyle. The medial retinaculum, the medial patellofemoral ligament, and the medial patellotibial ligament all may be disrupted with this injury pattern [4].

Stress and insufficiency fractures

Insufficiency fractures occur when normal stress or muscle tension acts on bone, with abnormal elastic resistance. These fractures commonly occur in the elderly population or in debilitated patients who have reduced bone stock (Fig. 3). Stress fractures or stress reactions result from repetitive stresses, less than those required to produce a complete fracture in normal bone.

Most stress fractures in the knee are related to running, jumping, or hurdling [2,10]. Stress fractures about the knee are common and may involve the proximal tibia, fibula, distal femur, patella, or fabella. Seventy-five per cent of exertional leg pain and stress fractures involve the tibia [10]. The proximal tibia is the most common site for stress fractures in the knee [2].

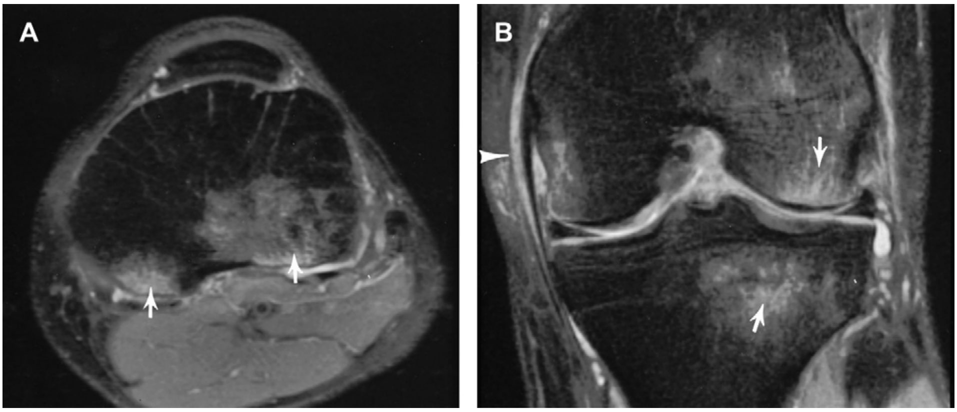

Fig. 2. Football injury associated with valgus and rotational forces. Axial (*A*) and coronal (*B*) fat-suppressed fast spin-echo T2-weighted images demonstrate posterior tibial bone bruises (*arrows in A*) with lateral femoral and tibial bruises (*arrows in B*) caused by valgus stress. The increased signal intensity in the medial collateral ligament (*arrowhead*) is caused by ligament sprain. The anterior cruciate ligament is also torn.

Radiographs are insensitive during the early phases of these injuries. Although radionuclide scans are sensitive during the early phases, they are less specific than MR imaging. Considering the numerous causes of bone pain about the knee, it is important to employ an imaging modality that is both sensitive and specific, so that more serious conditions, such as neoplasm, are not overlooked [1,2,10–12]. MR imaging has become the technique of choice for evaluating stress injuries. Injuries can be detected early, before an actual fracture line develops. Fredericson and colleagues [12] developed a system based on periosteal and marrow involvement on T1- and T2-weighted or STIR MR images. Grade 1 lesions demonstrate periosteal edema on T2-weighted or STIR images with normal marrow signal intensity. Grade 2 lesions demonstrate periosteal edema and marrow edema on T2 or STIR sequences, with little change on T1-weighted sequences. Grade 3 injuries demonstrate more significant periosteal changes, and marrow signal is abnormal on T1- and T2-weighted or STIR sequences. Grade 4 injuries demonstrate a clear fracture line (Fig. 4). Some investigators have also included Grade 0 for normal [1,10,12]. Usually, contrast enhancement is not necessary and is not included in the grading system.

Tibial plateau fractures

Subtle tibial plateau fractures are overlooked easily on radiographs. The only finding may be a lipohemarthrosis, which can be detected on the cross-table lateral radiograph. Displaced tibial plateau fractures are detected easily on radiographs.

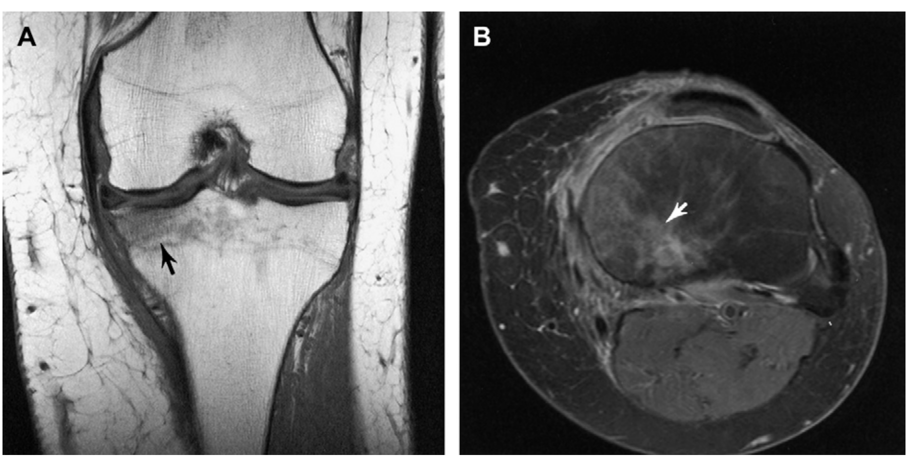

Fig. 3. Tibial insufficiency fracture. Coronal T1- (*A*) and axial fat-suppressed fast spin-echo T2- (*B*) weighted images demonstrate abnormal signal intensity in the proximal medial tibia (*black and white arrows*). Meniscal degeneration is also shown.

Fig. 4. Tibial stress fracture. Coronal T1-weighted image demonstrates a grade 4 stress fracture with a fracture line (*arrow*) in the medial tibia.

However, further imaging with CT or MR imaging is required to evaluate fragment position and associated soft-tissue injuries. CT is adequate for the evaluation of fracture position, articular step-off, and separation of fragments. MR imaging, especially with subtle fractures, can assess the bony injury and associated ligament and meniscal injury more easily (Fig. 5) [2,13]. Holt and colleagues [13], reviewed the MR features of tibial plateau fractures and found that its ability to detect occult injuries was superior to other modalities. In addition, the fractures were reclassified in 48% of patients and management was altered in 19% of cases.

Segond and reverse Segond fractures

The Segond fracture and its rare counterpart, the reverse Segond fracture, appear innocuous on radiographs. The first is a small, avulsion fracture proximal and posterior to the insertion of the iliotibial band on Gerdy's tubercle. This injury may be associated with several mechanisms. The avulsion may occur with internal rotation and the knee flexed, or with internal rotation and varus stress. The fracture is caused by avulsion of the meniscotibial portion of the middle third of the lateral capsular ligament, with possible associated fractures of the fibular head or Gerdy's tubercle [2,14]. In the case of severe varus stress, such as in a motor vehicle accident, the entire lateral ligament complex may be disrupted [14]. Segond fractures have a high incidence of anterior cruciate ligament tears and meniscal injury. MR imaging is ideal for the detection of osseous, meniscal, and ligament injuries (Fig. 6) [1,2,14].

The reverse Segond fracture, much less common, is a medial avulsion of the deep medial collateral ligament attachment on the tibia. The mechanism of injury is felt to be valgus stress with external rotation [15] and is associated with disruption of the posterior cruciate ligament and peripheral medial meniscus tears. Again, when this avulsion is detected on radiographs, MR imaging should be performed to evaluate the associated ligament and meniscal injuries [1,15].

Fibular head avulsion fractures

Avulsion of the styloid of the fibular head can be detected on the anteroposterior, lateral, or internal oblique radiographs. On the anteroposterior view, the fragment may mimic a Segond fracture [16]. This injury is termed the "arcuate sign" because it indicates avulsion of the arcuate complex (fabellofibular, popliteofibular, and arcuate) ligaments. This injury results in posterior lateral instability. The mechanism of injury is a direct blow to the anterior medial tibia with the knee in extension [16]. MR imaging is important for evaluating these patients because all reported cases have had associated

Fig. 5. Lateral tibial plateau and fibular fractures. Coronal (*A*) and sagittal (*B*) T1-weighted and coronal dual-echo in steady state (DESS) (*C*) images demonstrate a fibular fracture and lateral tibial plateau fracture with slight separation and articular step-off. Tibial plateau fracture (*arrows; B, C*), and fibular fracture (*arrowheads; A, B*).

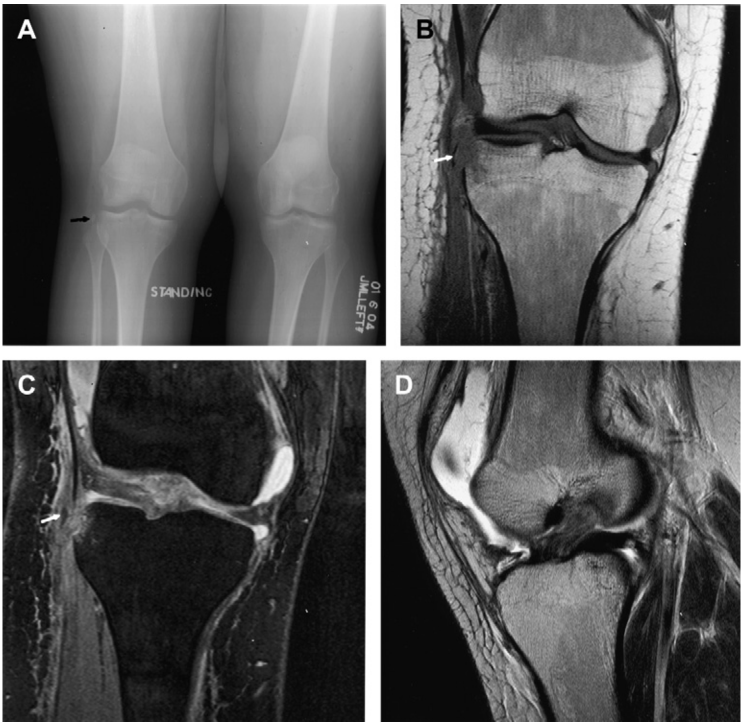

Fig. 6. Segond fracture. (*A*) Anteroposterior radiograph of the knees demonstrates a flake fracture from the proximal tibia laterally (*arrow*). Coronal T1-weighted (*B*), DESS (*C*), and sagittal proton density (*D*) images demonstrate the fracture (*arrows*), a large joint effusion, and anterior cruciate ligament tear.

posterior cruciate ligament tears. No anterior cruciate ligament tears have been reported. Also, MR images may demonstrate edema of the fibular head, although less commonly than a frank avulsion; this finding should also make one consider arcuate ligament complex injury [16].

Other locations of avulsion fractures about the knee include the posterior medial tibia because of semimembranosus tendon avulsion, and the lateral femoral condyle at the popliteus insertion [14].

Fractures in children

Fractures in children deserve a separate discussion. Physeal fractures are classified using the Salter-Harris system. Fractures of the distal femoral growth plate account for 7% of all physeal injuries. Proximal tibial growth plate fractures are less common and account for only 3% of all physeal fractures [17]. Salter-Harris II fractures occur most commonly in the femur and tibia. Most fractures are caused by hyperextension, which may lead to injury of the posterior neurovascular structures. Angular deformity and leg length discrepancy may result, especially with Salter-Harris III to V fractures [3,6,17].

Tibial eminence (spine) fractures may occur in adults, but are much more common in children [17,18]. This injury occurs most often between the ages of 8 and 14. Again, hyperextension is the most common mechanism of injury. Myers and McKeever [19] categorized tibial eminence fractures into three types, based on the position of the fragments. Type I fractures are nondisplaced and account for 16% of injuries; type II factures are elevated anteriorly (39% of fractures); and type III fractures are displaced (45% of fractures). Type I and II fractures can be treated with closed reduction, whereas type III fractures require surgical intervention (Fig. 7) [17].

Tibial tuberosity fractures are divided into three categories as well. Type I fractures are small, avulsed fragments and account for 39% of tuberosity fractures (Fig. 8); type II fractures result in anterior hinging of the entire tuberosity (18%); and type III fractures extend into the tibial articular surface [19]. Type I fractures may be treated with cast immobilization. Type II and III fractures require reduction, with cancellous bone screws [17,19].

Radiographs can be used to define most of these injuries, especially if the fracture is displaced. However, MR imaging may be required to detect subtle fractures (see Figs. 7 and 8) during the healing process. This imaging is important especially with growth plate fractures [1–3,6,17]. Multiplanar MR imaging with T2-weighted or STIR sequences is useful for evaluating physeal fractures and assessing bone bars that may lead to angular deformity or growth arrest. MR imaging can identify and measure the degree of bony bar formation, which permits the orthopedic surgeon to make appropriate

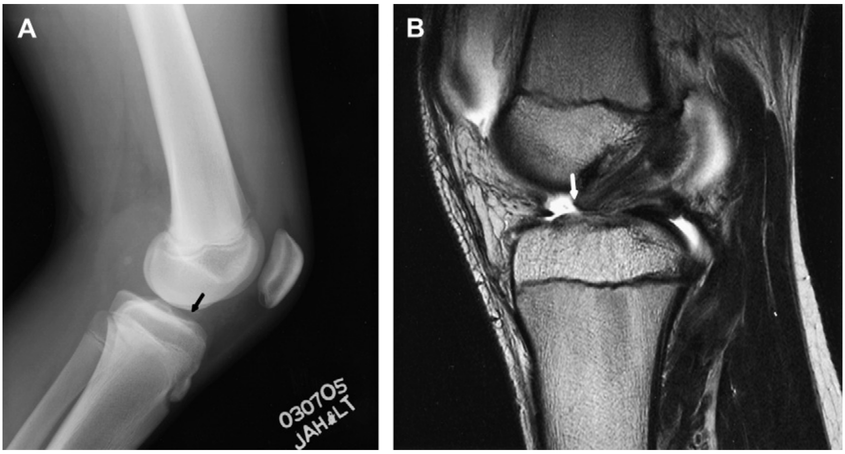

Fig. 7. Type III tibial eminence fracture. Lateral radiograph (*A*) and T2-weighted sagittal MR image (*B*) demonstrate a subtle eminence avulsion (*black and white arrows*).

decisions regarding operative intervention (Fig. 9). Physeal arrest or bone bars measuring less that 25% of the growth plate can be resected with good results. Surgical correction does not provide good results if more that 40% of the growth plate is involved [3].

Osteochondral lesions

Osteochondral lesions in the knee may be acute or chronic, and include conditions such as osteochondritis dissecans (OCD) [20]. Acute lesions result from impaction, or rotational or shearing forces. The fracture may involve only cartilage, or cartilage and underlying bone. The fracture line is parallel to the joint line, unlike more conventional fractures that enter the joint vertically or obliquely. Fractures may be impacted, elevated partially or displaced, or displaced completely and free in the joint [20,21].

OCD may have a similar appearance, although its presentation is more insidious or chronic in nature. Classically, OCD involves the lateral aspect of the medial femoral condyle in the knee. However, the patella and other sites may be involved as well. When imaging osteochondral lesions, radiographs may be useful, but detection and appropriate classification are accomplished more effectively with MR imaging using T1- and T2-weighted or STIR sequences. The axial and sagittal planes are most useful for femoral lesions, but all image planes, including the coronal, should be evaluated carefully [1,22]. Classification of these lesions is important for management decisions (Fig. 10). Lesions that are minimal (softening, fibrillation, or fissuring) show abnormal signal intensity without elevation or separation. These lesions may be treated with non–weight bearing activities for 6 to 12 weeks. Partially or completely displaced lesions that remain in the native bed may be reattached during arthroscopy. Lesions that are displaced and free in the joint are removed. Large bone defects

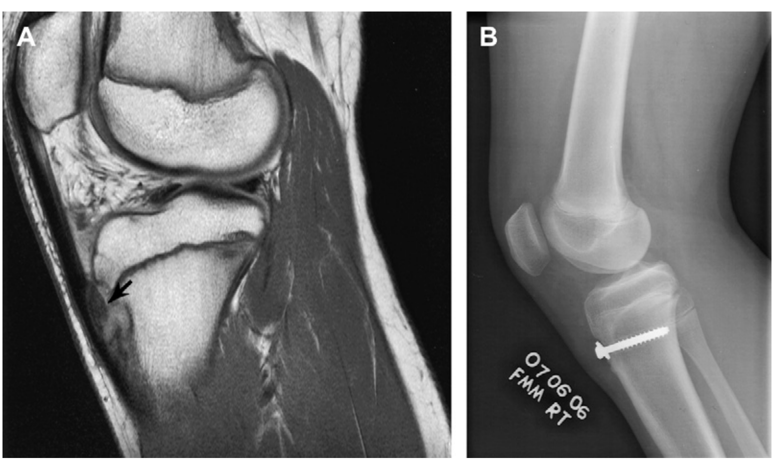

Fig. 8. Type I tibial tuberosity avulsion. Sagittal T1-weighted image (*A*) demonstrates a tibial tuberosity avulsion (*arrow*). The fragment was reduced with a cancellous screw (*B*).

Fig. 9. Coronal STIR image demonstrates a bone bar (*arrows*) involving about 10% of the physis.

can be drilled or transplanted with autologous cartilage, but the latter is still under evaluation [20].

DeSmet and colleagues [21] evaluated MR signs of unstable lesions. These findings included a high signal intensity line between the native bone and the osteochondral fragment (72%), focal defects (31%), articular fracture (25%), and adjacent subchondral cysts (22%). The first finding was the most accurate, compared with arthroscopic findings (Fig. 11).

Spontaneous osteonecrosis of the knee

Spontaneous osteonecrosis of the knee was considered classically a condition of vascular insufficiency, leading to bone infarction of the weight-bearing surface of the femoral condyle (Fig. 12). The condition was seen in older adults, unlike OCD, which commonly occurs in adolescents. The condition almost always was unilateral and involved most commonly the medial femoral condyle (Fig. 13) [23].

In more recent years, changes seen with spontaneous osteonecrosis have been questioned because of similarities to subchondral fractures in the femoral head. A growing base of knowledge in the literature suggests that a subchondral insufficiency fracture leads to focal osteonecrosis [24,25]. Similar features have been described in the medial tibial plateau as well [25].

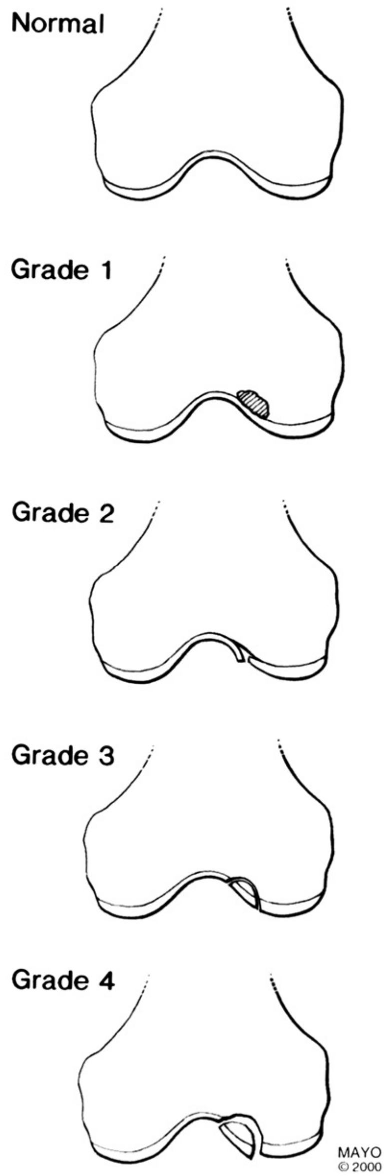

Fig. 10. MR features of OCD. Normal articular cartilage is Grade 0. Grade 1 shows abnormal signal intensity with cartilage intact. Grade 2 lesions demonstrate a linear cleft in the articular cartilage. Grade 3 lesions have abnormal signal intensity surrounding the lesion, and Grade 4 lesions are displaced. (*Courtesy of* the Mayo Foundation for Medical Education and Research; used with permission. All rights reserved.)

Myotendinous injuries

Muscle and tendon injuries about the knee may occur alone or in association with more significant osseous and ligament injuries. Muscle and tendon injuries may be related to direct trauma (muscle contusion) or to indirect trauma with overextension. Indirect injuries may result in partial or complete disruption, and are classified as strains. Avulsion injuries may also occur. Tendon and muscle strains are categorized as first degree, when only a few fibers are torn; second degree, when about 50% of fibers are torn; and third degree, when there is a complete tear [1,26,27]. Hematomas commonly form with higher-grade injuries. Depending on the location, more aggressive

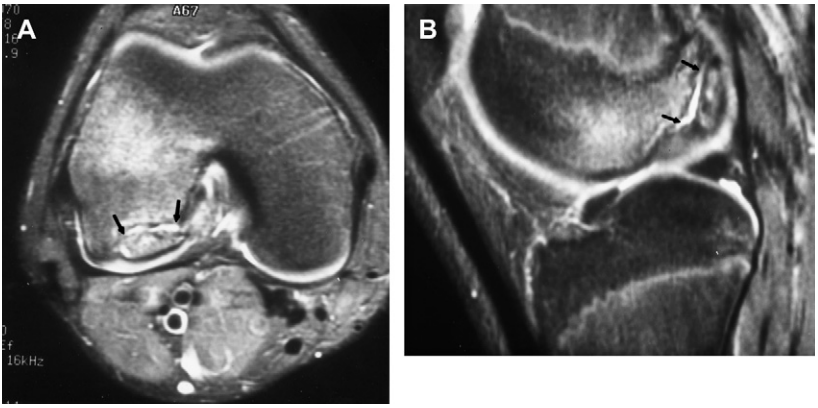

Fig. 11. Grade 4 OCD. Axial (*A*) and sagittal (*B*) T2-weighted images demonstrate fluid signal intensity (*arrows*) between the osteochondral lesion and the femur. Slight displacement of the fragment is also shown.

therapy, with evacuation of the hematoma, may be required [1,26].

Avulsion fractures may be evident on radiographs but MR imaging is the technique of choice for detection and classification of muscle and tendon injuries. Imaging should be performed in the two most appropriate planes (axial plus coronal, sagittal, or oblique), using T2-weighted or STIR sequences to identify and grade the level of injury. Other associated injuries can be detected also [1,26–28].

Quadriceps injuries

Injury to the quadriceps mechanism (rectus femoris, vastus medialis, vastus intermedius, vastus lateralis, and quadriceps tendon) may be the result of acute trauma caused by rapid deceleration, such as running when the foot is planted, or it may be caused by chronic microtrauma. In elderly patients or patients who have gout, diabetes, connective tissue diseases, or other systemic conditions, minor trauma may result in quadriceps injury [1,26,29]. Most injuries occur distally at, or near, the patellar attachment (Fig. 14) [29,30]. Patients who have first- or second-degree strains still can extend the knee. Third-degree strains (complete tear) result in an inability to extend the knee (see Fig. 14) and require surgical repair [1,29]. MR imaging in the axial and sagittal planes can grade the level of injury accurately [1].

Patellar tendon injuries

Patellar tendon injuries may be caused by chronic overuse ("jumper's knee," tendonosis, or tendinitis) or more acute injuries with partial or complete tendon tears [1,2,29,31–35]. Most injuries are caused by chronic microtrauma, resulting in tendinitis or tendonosis and partial tears at the inferior pole of the patella. These injuries are seen commonly in athletes involved in jumping; hence, the term jumper's knee [31,32,34]. Activities such as basketball, tennis, soccer, and track are associated most

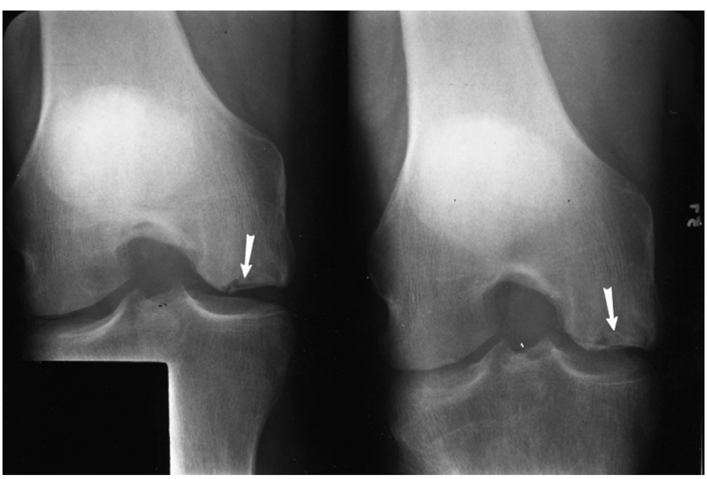

Fig. 12. Notch views of the knee demonstrates osteochondral collapse (*arrows*) of the weight-bearing surface of the medial femoral condyle. (*From* Kelley EA, Berquist TH. The knee. In: Berquist TH, editor. MRI of the musculoskeletal system. 5th edition. Philadelphia: Lipincott-Williams and Wilkins; 2006. p. 303–429; with permission.)

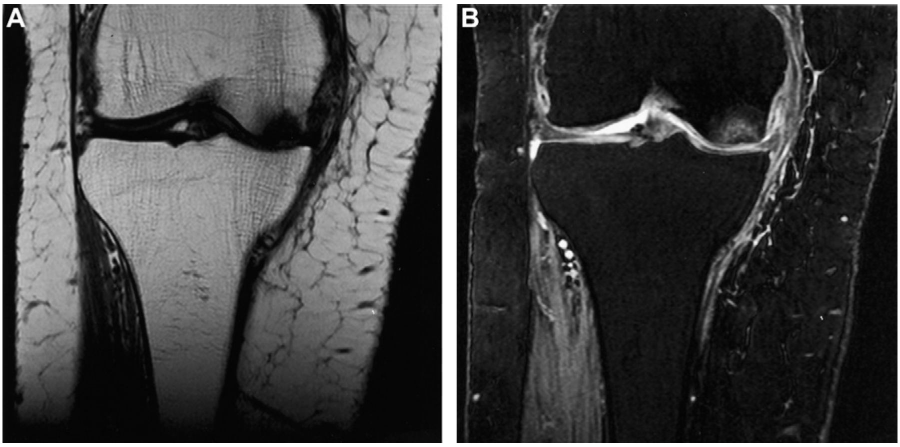

Fig. 13. Coronal T1-weighted (*A*) and DESS (*B*) images demonstrate osteonecrosis of the medial femoral condyle.

commonly with this condition. MR images demonstrate thickening and increased signal intensity at the inferior pole of the patella (Fig. 15). Adjacent marrow edema is not uncommon. Features are appreciated most easily on sagittal images [1,29,31]. Patients who have patellar tendonosis may have associated patellar tracking disorders as well (45%) [33].

Complete tears of the patellar tendon are less common than tendinitis or partial tears. Injury usually occurs with the knee flexed against a contracted quadriceps mechanism. Most tears occur near the patellar attachment [29]. The tendon has a wavy appearance and typically, the patella is retracted to some extent, depending on the degree of knee flexion. Again, sagittal T2-weighted or STIR images are most useful for evaluating this injury (Fig. 16).

Chung and colleagues [35], described the MR features of another patellar tendon condition termed "lateral condyle friction syndrome," which is analogous to the clinical syndrome, fat pad impingement. Patients present with anterior pain with exertion, and focal tenderness over the inferior pole of the patella. MR features include abnormal signal intensity in the soft tissues between the inferior lateral patella and femoral condyle, marrow edema, and abnormal patellar alignment [35].

Patellar retinacular tears

Patellar retinacular injuries are associated most commonly with lateral patellar dislocations [36–39]. The medial soft tissue support of the patella is divided into three layers. The most superficial layer, layer 1, lies just deep to the subcutaneous tissues and is composed of the fascia of the sartorius muscle. Layer 2 lies just deep to layer 1, where the superficial medial ligament fuses anteriorly with

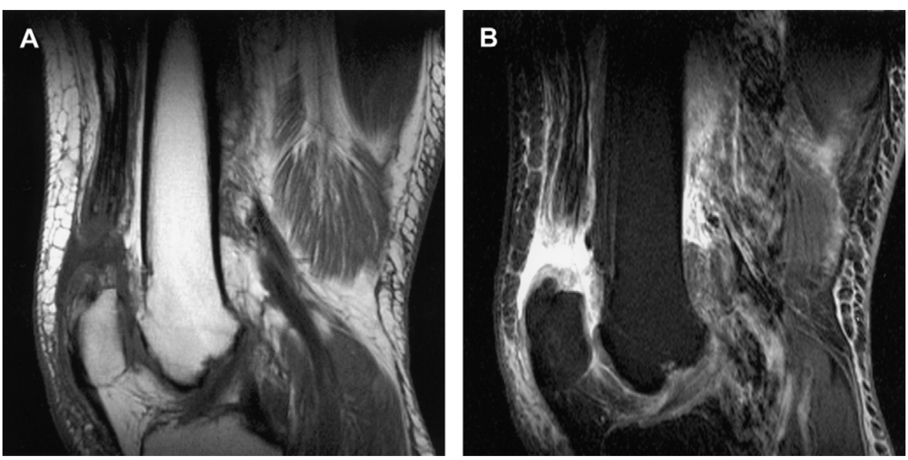

Fig. 14. Third-degree quadriceps strain (complete tear). Sagittal T1- (*A*) and fat-suppressed fast spin-echo T2-weighted (*B*) images demonstrate thickening and high signal intensity through the quadriceps at the patellar attachment.

Fig. 15. Patellar tendonosis. Sagittal T1-weighted image demonstrates marked thickening (*arrows*) of the tendon at the patellar attachment.

layer 1 to form the patellar retinaculum, which inserts on the medial margin of the patella [37,38]. Layer 3 forms the joint capsule. Superiorly in layer 2, the medial patellofemoral ligament arises from the medial condyle or adductor tubercle and takes an oblique course deep to the vastus medialis obliquus to insert on the superior two thirds of the medial patellar margin. On axial MR images, the patellar retinaculum is identified as a low signal intensity structure extending from the medial patellar margin and blending with the vastus medialis obliquus fascia [37–39].

Patellar retinaculum tears are almost always medial (94%) and are part of a spectrum of findings associated with lateral patellar dislocations [36]. MR features include joint effusion (55%–100%), contusions of the anterior lateral femoral condyle (31%–100%), medial patellar facet contusions or osteochondral fractures (41%–61%), patellar tilt (43%), and retinacular complex injuries in 41% to 96% of lateral patellar dislocations (Fig. 17). Tears of the medial patellofemoral ligament occur in up to 96% of patients. Most tears are partial, but up to 40% are complete. Abnormal signal intensity in the vastus medialis obliquus is seen in 45% of cases [38]. Associated injuries include anterior cruciate ligament tears in 18%, and medial collateral ligament and meniscal tears in 11% [36,38]. It is important to detect retinacular complex tears because this indicates surgical repair to avoid the redislocation that occurs in 44% of patients who do not have surgical repair of the retinaculum [37].

Fig. 16. Complete patellar tendon tear. Sagittal T1-weighted image shows a wavy tendon with complete separation (*arrow*) at the patellar attachment and superior displacement of the patella.

Gastrocnemius, soleus, and plantaris injuries

These muscle groups are discussed together because patients are referred commonly to rule out tears of the gastrocnemius when they actually have plantaris muscle tears or associated injuries of the soleus muscle [1,26,40]. The gastrocnemius lies superficially in the calf, with two heads (medial and lateral) arising from the posterior surface of the medial and lateral femoral condyles. The muscle passes distally to join the soleus tendon, forming the Achilles tendon that inserts on the calcaneus [1,26]. Medial gastrocnemius injuries may occur in the mid- or proximal calf, and can be associated with soleus or plantaris strains (Fig. 18). Tears of the lateral gastrocnemius may be associated with popliteus, biceps femoris, and plantaris injury [26].

The plantaris muscle arises from the lateral femur, just above the lateral head of the gastrocnemius. This small muscle has a long tendon that passes distally between the soleus and lateral gastrocnemius to insert on the calcaneus, just anterior to the Achilles tendon [1,26,40]. This muscle is absent in 7% to 10% of patients [40]. Forceful contraction of the plantaris may result in rupture at the myotendinous junction, with possible associated injury to the gastrocnemius, anterior cruciate ligament, and popliteus muscle [26,40].

MR features vary depending on the extent of muscle involvement. Most commonly, there is feathery increased signal intensity in the involved muscle, a common finding in the gastrocnemius. Hematoma formation or fluid collection between the gastrocnemius and soleus also may be evident. The latter is especially common with plantaris tears because the muscle is small and the tendon may not be demonstrated clearly (Fig. 19) [1,40].

Popliteus muscle injuries

The popliteus muscle arises from the posterior medial tibial metaphysis and extends obliquely to

Fig. 17. Lateral patellar dislocations with associated injuries. (*A*) Axial fat-suppressed fast spin-echo T2-weighted image with patellar subluxation and separation at the medial retinacular attachment. (*B*) Sagittal T2-weighted image with an osteochondral fracture (*arrow*) from the superior patella. (*C*) Large effusion with fluid-fluid level and retinacular tear with soft tissue and cartilage debris (*arrow*) in the joint.

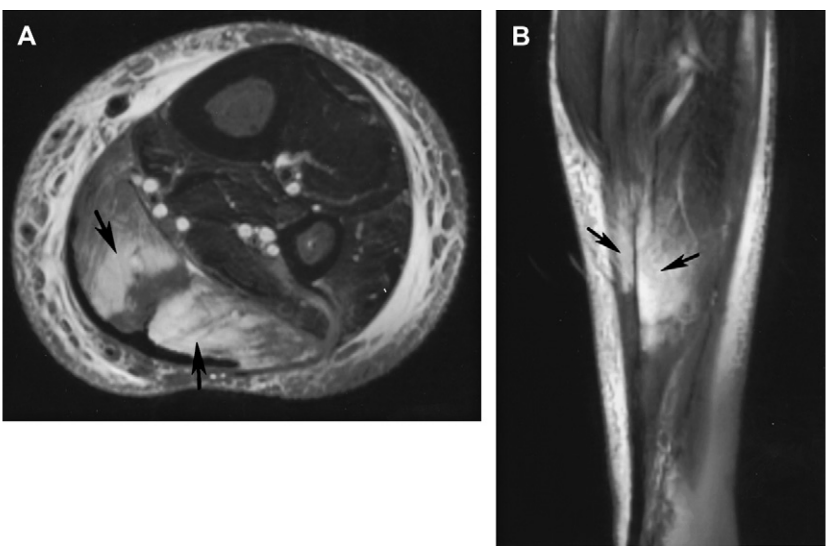

Fig. 18. Gastrocnemius strain. Axial (*A*) and coronal (*B*) images demonstrate increased signal intensity (*arrows*) in the medial and lateral gastrocnemius caused by a first-second degree strain.

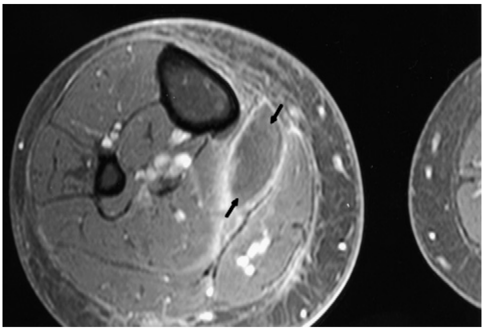

Fig. 19. Plantaris tear. Axial postcontrast fat-suppressed T1-weighed image demonstrates a peripherally enhancing hematoma (*arrows*) between the soleus and gastrocnemius.

insert on the lateral femoral condyle and fibular head. The tendon passes between the capsule and posterior horn of the lateral meniscus [1,26,41]. Once, tears of the popliteus were considered uncommon, but now they are detected more frequently [41]. Tears may involve the body of the muscle or the myotendinous junction. Associated injuries include the posterior cruciate ligament (29%), the anterior cruciate ligament (17%), and bone bruises (33%) [37]. MR features are appreciated most easily on axial and sagittal images, and resemble the injuries described earlier (Fig. 20) [1,41].

Iliotibial band syndrome

The iliotibial band or tract is formed proximally by the fascia of the gluteus maximus and medius and tensor fascia lata. Distally, the iliotibial band attaches to the supracondylar tubercle of the lateral femoral condyle and extends below the joint to insert on Gerdy's tubercle of the tibia [1,26,42,43]. Iliotibial band syndrome, or friction syndrome, is seen in long-distance runners, cyclists, and football players. This syndrome is a common cause of lateral knee pain that may be confused with lateral meniscal tears, lateral collateral ligament injuries, or injuries to the biceps femoris insertion or popliteus muscle [43–46].

MR images demonstrate increased signal intensity deep to the iliotibial band or organized fluid collections. Frequently, the band is thickened, with intermediate signal intensity related to chronic microtrauma (Fig. 21) [1,39–42].

Other myotendinous injuries

The other muscles and tendons about the knee are injured less commonly, especially as isolated strains. The medial tendons (sartorius, gracilis, and semitendinosus) are associated closely because they insert on the anterior tibia forming the pes anserinus. In this group, the sartorius is most prone to injury [26]. In the author's experience, pes anserine bursitis is more common than tendon strain [1].

The semimembranosus also attaches medially at the infraglenoid tubercle of the posterior medial tibia. This tendon may be injured in association with medial gastrocnemius tears. Laterally, the biceps femoris inserts on the head and styloid of the fibula. The biceps femoris is injured commonly in patients who have arcuate ligament tears [47]. MR features are similar to those of other tendon strains. Commonly, biceps femoris strain or

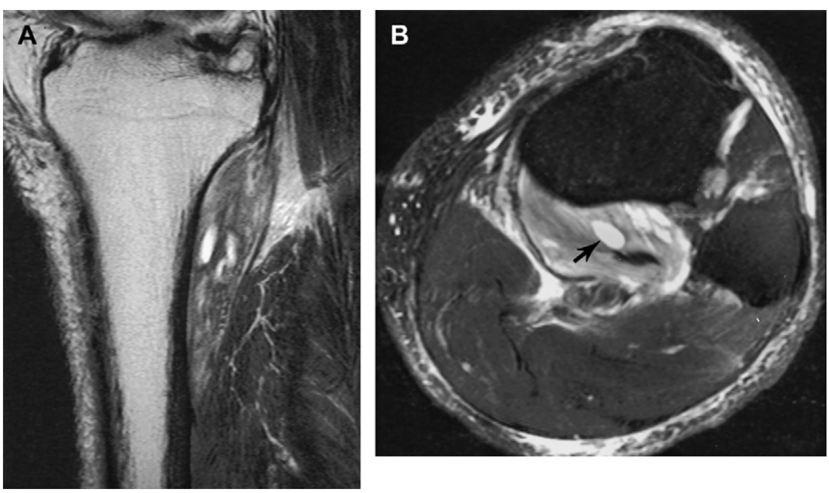

Fig. 20. Popliteus muscle tear. Sagittal T1- (*A*) and axial fat-suppressed fast spin-echo T2-weighted (*B*) images demonstrate diffuse abnormal signal intensity in the popliteus muscle, with a small central hematoma (*arrow in B*).

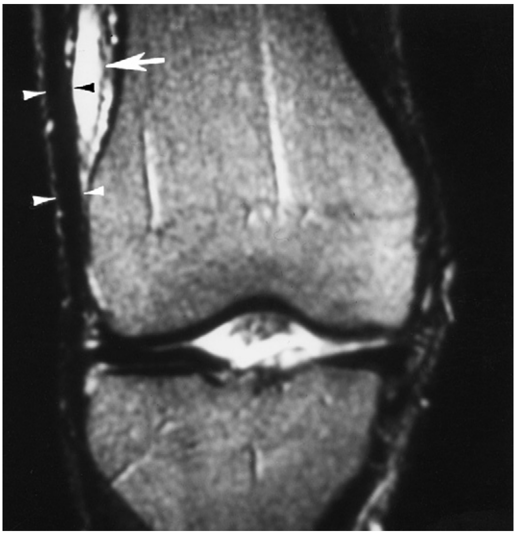

Fig. 21. Iliotibial band friction syndrome. Coronal T2-weighted image shows a fluid collection between the iliotibial band and the femur (*arrow*). Also, the iliotibial band is thickened markedly (*arrowheads*).

avulsion is associated with bone contusion involving the anterior medial femoral condyle [48].

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