Knee and Lower Leg Injuries 84

Christy Hopkins

**Key Points**

- Knee dislocations are associated with a high risk for neurovascular injury and constitute an orthopedic emergency.
- A grossly unstable knee should be assumed to have been dislocated.
- Patients with fractures or dislocations of the knee and lower extremity and neurovascular compromise should undergo emergency reduction or realignment before any radiographic evaluation.
- Patients discharged home in knee immobilizers with stable injuries should be instructed to remove the device several times a day and perform range-of-motion and quadriceps-strengthening exercises.
- The cast or splint should be removed from any patient with increasing pain after a lower leg fracture to allow careful assessment of neurovascular status and evaluation of the lower leg compartments.

**Epidemiology**

Knee and lower leg injuries are common orthopedic problems seen in the emergency department (ED). This chapter divides such injuries into discussions of traumatic injuries (soft tissue and cartilaginous injuries, dislocations, and fractures), overuse injuries, and other disorders of the knee and lower part of the leg.

**Pathophysiology**

**Knee Anatomy**

The knee is the largest and most complex joint in the body. Injuries to this joint are common, so a clear understanding of the anatomy and pathophysiology of the knee is essential for appropriate evaluation, diagnosis, and treatment of disorders in this area.

The knee has a wide range of motion, including flexion, extension, abduction, adduction, and internal and external rotation. Three different articulations are present in the knee: the patellofemoral articulation (anterior) and articulations between the lateral and medial tibial and femoral condyles. In full extension, the stabilizing ligaments of the knee are tight and prevent rotary motion of the knee. Beyond 20 degrees of flexion, the ligaments are relaxed and allow axial rotation of the joint.

Knee stability is provided solely by ligaments and tendons in and around the joint. Knee stability is provided solely by ligaments and tendons in and around the joint (Fig. 84.1). The knee joint is encapsulated by fibrous connective tissue lined by a synovial membrane. The knee capsule is continuous with the suprapatellar bursa, which expands when a joint effusion is present.

The popliteal fossa contains the popliteal artery and vein and the peroneal and tibial nerves. The popliteal fossa is delineated laterally by the biceps femoris muscle, medially by the semimembranosus and semitendinosus muscles, and inferiorly by the gastrocnemius muscle.

The popliteal artery is a continuation of the femoral artery after it leaves the adductor hiatus. It gives rise to the geniculate arteries, which form a rich vascular anastomosis around the knee, and divides to form the anterior and posterior tibial arteries at the level of the tibial tubercle. The popliteal artery is immobilized proximally and distally within the popliteal fossa, which predisposes it to vascular injury in the setting of traumatic knee injuries.

The tibial nerve and common peroneal nerve (a branch of the tibial nerve) innervate the knee. Because the tibial nerve is not immobilized proximally, it is less likely than the popliteal artery to be injured in the setting of joint disruption. The common peroneal nerve travels around the head of the fibula and divides into the deep and superficial peroneal nerves.

**Evaluation**

Key aspects of evaluation of knee are listed in Box 84.1. In general, evaluation of knee complaints should also include an examination of the hip and back to prevent overlooking a source of pain referred to the lower extremity.

During evaluation, the point of maximal tenderness should be assessed last. Specific tests for evaluating ligamentous and meniscal injuries are detailed in Table 84.1. Comparison with the uninjured or normal knee is helpful, especially for assessment of ligamentous laxity.

Joint pain or swelling may limit full evaluation of the knee in the acute setting. Patients with limited evaluations should
undergo immobilization and follow-up examination within 7 days. Key physical findings are listed in discussions of specific disorders later in the chapter.

**Diagnostic Testing**

Because acute injuries to the knee commonly involve soft tissue, plain radiographic examination is not always indicated. The Ottawa Knee Rules¹ (Box 84.2) and the Pittsburgh Knee Rules² (Box 84.3) are useful guides to aid in the decision of whether to order plain radiographs. Both criteria are sensitive for fractures, but the Pittsburgh criteria are more specific and can be applied to both children and adults.

If plain radiographs are indicated, a minimum of an anteroposterior (AP) and a lateral view should be obtained. Oblique radiographs are helpful for detecting subtle tibial plateau fractures. The intercondylar or tunnel view is helpful in evaluating for tibial spine fractures and osteochondral defects (Fig. 84.2). Assessment of the patellofemoral joint and evaluation for the presence of patellar tilt (increased propensity for patellar subluxation or dislocation) can be done with the Merchant or sunrise view (Fig. 84.3). Comparison radiographs of the unaffected extremity are helpful in discerning problems in skeletally immature patients.

When describing the knee radiograph, the examiner should note the alignment and joint spacing of the femoral condyles in relation to the tibial plateau. Narrowing of the joint space (particularly in weight-bearing views) indicates articular cartilaginous and meniscal degeneration. The patella should be examined for possible fractures (in the event of a direct blow to the anterior aspect of the knee) and the presence of a bipartite or tripartite patella. Significant joint effusions are evident as a water-density radiolucency on the lateral view, anterior to the distal end of the femur.³ Effusions seen shortly after injury are suggestive of anterior cruciate ligament (ACL) or posterior cruciate ligament (PCL) tears, tibial plateau fractures, femoral condyle fractures, or patellar fractures.⁴

In the setting of acute injuries, radiographs should be examined for the presence of fractures involving the tibial plateau (depression fracture) or tibial spine (suggesting rupture of the ACL). Segond fractures are avulsion fractures of the lateral tibial plateau at the site of attachment of the lateral capsular ligament. These fractures are associated with ACL and meniscal injuries. The presence of posterior opaque bodies should

**BOX 84.1 Evaluation of the Knee**

<table>
<thead>
<tr>
<th>History</th>
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<tbody>
<tr>
<td>Mechanism of injury:</td>
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<tr>
<td>• Direction and type of force (high or low energy)</td>
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<tr>
<td>• Position of the extremity at the time of injury</td>
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<tr>
<td>Nature and duration of symptoms</td>
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<tr>
<td>Previous injuries</td>
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<tr>
<td>Previous surgical procedures</td>
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<td>Associated complaints</td>
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<tr>
<td>Joint effusion</td>
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<tr>
<td>Locking of the joint</td>
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<td>Ability to ambulate</td>
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<tr>
<td>Associated injuries</td>
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<tr>
<td>Physical Examination</td>
</tr>
<tr>
<td>Inspection of the entire limb with the patient sitting or lying and walking (if possible):</td>
</tr>
<tr>
<td>• Deformity, ecchymosis, edema, cutaneous lesions</td>
</tr>
<tr>
<td>• Joint effusions</td>
</tr>
<tr>
<td>• Previous scars</td>
</tr>
<tr>
<td>• Gait and functional range of motion</td>
</tr>
<tr>
<td>• Neurovascular status</td>
</tr>
<tr>
<td>Palpation:</td>
</tr>
<tr>
<td>• Extensor mechanism: quadriceps tendon, patella, patellar tendon, tibial tubercle (tendinitis, prepatellar bursitis, knee effusion, Osgood-Schlatter disease)</td>
</tr>
<tr>
<td>• Femoral or tibial epiphysis in adolescents (physeal fractures)</td>
</tr>
<tr>
<td>• Joint line (meniscal and/or collateral ligament injuries)</td>
</tr>
<tr>
<td>• Posterior aspect of the knee (popliteal cyst or pseudoaneurysm)</td>
</tr>
<tr>
<td>• Neurovascular status</td>
</tr>
<tr>
<td>Range of motion:</td>
</tr>
<tr>
<td>• Flexion or extension</td>
</tr>
<tr>
<td>• Internal or external rotation</td>
</tr>
<tr>
<td>• Active straight leg raise</td>
</tr>
<tr>
<td>Stability testing:</td>
</tr>
<tr>
<td>• Anterior or posterior stability (cruciate ligaments)</td>
</tr>
<tr>
<td>• Medial or lateral stability (collateral ligaments)</td>
</tr>
</tbody>
</table>

![Knee anatomy](image-url)  
Fig. 84.1  
ACL, Anterior cruciate ligament; LCL, lateral collateral ligament; MCL, medial collateral ligament; PCL, posterior cruciate ligament. (From Brown JR, Trojan TH. Anterior and posterior cruciate ligament injuries. Prim Care 2004;31: 925-56.)

![Knee anatomy](image-url)  
Fig. 84.2  
ACL, Anterior cruciate ligament; LCL, lateral collateral ligament; MCL, medial collateral ligament; PCL, posterior cruciate ligament. (From Brown JR, Trojan TH. Anterior and posterior cruciate ligament injuries. Prim Care 2004;31: 925-56.)

![Knee anatomy](image-url)  
Fig. 84.3  
ACL, Anterior cruciate ligament; LCL, lateral collateral ligament; MCL, medial collateral ligament; PCL, posterior cruciate ligament. (From Brown JR, Trojan TH. Anterior and posterior cruciate ligament injuries. Prim Care 2004;31: 925-56.)
**Table 84.1** Stability Testing

<table>
<thead>
<tr>
<th>TEST</th>
<th>HOW PERFORMED</th>
<th>DEFINITION OF A POSITIVE RESULT</th>
<th>COMMENTS</th>
</tr>
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<tbody>
<tr>
<td><strong>Anterior Cruciate Ligament</strong></td>
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<td></td>
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<tr>
<td>Lachman (see Fig. 84.13)</td>
<td>Hold the knee in 15-30 degrees of flexion. Attempt to pull the tibia forward with one hand while holding the femur stationary with the other hand.</td>
<td>Anterior laxity in conjunction with the lack of a firm end point (displacement &gt; 5 mm in comparison with the opposite side).</td>
<td>Most sensitive test for ACL injury.</td>
</tr>
<tr>
<td>Anterior drawer (see Fig. 84.14)</td>
<td>Flex the hip to 45 degrees and the knee to 90 degrees. Stabilize the foot with pressure directed toward the examination table. Grasp the proximal end of the tibia and pull forward. Perform with the knee in neutral and internal and external rotation.</td>
<td>Increased laxity in a neutral position suggests ACL injury (displacement &gt; 6 mm with respect to the opposite side). Increased displacement with external rotation suggests injury to the posteromedial capsule. Increased displacement with internal rotation suggests injury to the posterolateral capsule.</td>
<td>Not a reliable test for acute ACL injuries.</td>
</tr>
<tr>
<td>Pivotal shift (see Fig. 84.15)</td>
<td>Flex the hip to 45 degrees and fully extend the knee while holding the heel. The second hand holds the knee with the thumb behind the fibular head. Internally rotate the ankle and knee. Apply valgus stress to the knee and then flex the knee while maintaining internal and valgus stress.</td>
<td>If anterior subluxation of the knee is present, reduction of the subluxation will occur at 20-40 degrees of flexion.</td>
<td>May be painful. Highest positive predictive value for ACL rupture.</td>
</tr>
<tr>
<td><strong>Posterior Cruciate Ligament</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Posterior drawer (see Fig. 84.16)</td>
<td>Flex the hip to 45 degrees and the knee to 90 degrees. Stabilize the foot with pressure directed toward the examination table. Apply backward force to the tibia.</td>
<td>&gt;5-mm posterior displacement of the tibia or a soft end point.</td>
<td>Best test for evaluation of a PCL injury.</td>
</tr>
<tr>
<td>Posterior sag</td>
<td>Put a pillow under the patient’s thigh so that the knee is flexed to 45-90 degrees. The patient’s heel should be resting on the examination table.</td>
<td>Posterior tibial sag with regard to the femur. The tibia usually sits 10 mm anterior to the femoral condyles in this position.</td>
<td>Assess before performing the posterior drawer test to avoid misinterpreting it.</td>
</tr>
<tr>
<td><strong>Lateral and Medial Collateral Ligaments</strong></td>
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</tr>
<tr>
<td>Collateral ligament</td>
<td>Apply varus and valgus stress to the knee in full extension and at 30 degrees. Assess the joint line opening between the tibia and femur.</td>
<td>Laxity in full extension suggests a complete collateral ligament tear in addition to injury to the secondary stabilizers (ACL, PCL). Laxity at 30 degrees (but not in full extension) isolates injury to the collateral ligament undergoing testing.</td>
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<tr>
<td><strong>Meniscal Tears</strong></td>
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<tr>
<td>McMurray</td>
<td>Hyperflex the knee. Hold the lower part of the leg and flex/extend the knee while simultaneously internally and externally rotating the tibia in relation to the femur.</td>
<td>Clicking sensation felt along the joint line with internal/external rotation or the patient experiences pain. Internal rotation tests the lateral meniscus. External rotation tests the medial meniscus.</td>
<td>Hyperflexion may not be possible in an acutely injured knee. Poor sensitivity.</td>
</tr>
<tr>
<td>Apley</td>
<td>Place the patient in the prone position. Flex the knee to 90 degrees. Internally and externally rotate the leg with pressure on the heel.</td>
<td>Pain while applying downward pressure suggests meniscal injury.</td>
<td></td>
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</tbody>
</table>

ACL, Anterior cruciate ligament; PCL, posterior cruciate ligament.

**BOX 84.2 Ottawa Knee Rules**

Radiographs indicated if any one of the following is present:
- Age 55 years or older
- Tenderness at the head of the fibula
- Isolated tenderness of the patella
- Inability to flex the knee to 90 degrees
- Inability to bear weight for four steps both immediately after the injury and in the emergency department


**BOX 84.3 Pittsburgh Knee Rules**

Radiographs are indicated if the patient sustained a fall or a blunt trauma mechanism and one of the following two conditions is present:
- The patient is younger than 12 or older than 50 years.
- The patient is unable to walk four weight-bearing steps in the emergency department.

also be noted. These may be fabellae (congenital sesamoid) or loose bodies. More than 75% of loose bodies originate from osteochondral lesions. Occult fractures that are commonly missed on plain radiographs include patellar, tibial plateau, fibular head, and Segond fractures.

Musculoskeletal ultrasound techniques can be used to diagnose ACL and PCL tears and may be helpful in the diagnosis of meniscal injuries. Magnetic resonance imaging (MRI) can be used to confirm suspected meniscal injuries, ligamentous disruptions, osteochondral lesions, and occult fractures; however, it is rarely indicated in the acute setting. Computed tomography (CT) is helpful for establishing the extent of certain fractures (e.g., tibial plateau fractures) and is often more readily available than MRI.

**LOWER LEG**

**Anatomy**

The lower part of the leg contains the tibia and fibula. The tibia is the only weight-bearing bone in this part of the leg and is the most commonly fractured long bone in the body. Its superficial course predisposes it to a higher incidence of open fractures. The two bones are bound together by the superior and inferior tibiofibular joint along with an interosseous membrane. The interosseous membrane aids in stability of the ankle mortise.

The thigh muscles attach to the upper part of the tibia and lend stability to the knee joint. The muscles of the lower part of the leg, which are enclosed by fascia, can be divided into four compartments: anterior, posterior, deep posterior, and lateral (Fig. 84.4). Specific motor and sensory nerve distributions are listed by compartment in Table 84.2.

**Evaluation**

A directed history of the traumatic events, duration of symptoms, and exacerbating events or activities is necessary to assess lower leg injuries. Examination of lower leg complaints should include an evaluation of the back, hips, knee, and ankle to assess for pain referred to the lower part of the leg or associated injuries.

Thorough assessment of skin integrity, neurovascular status, and the leg compartments is essential in the evaluation of any traumatic lower leg injury. The point of maximal tenderness should be evaluated last.

**Diagnostic Testing**

Imaging of the lower part of the leg should include the joint above and the joint below the injury. Oblique views are useful for detecting tibial plateau fractures, which may not be seen on routine views.


**DISLOCATIONS AND FRACTURES**

**DISLOCATIONS**

**Knee Dislocations**

Knee dislocations are relatively uncommon and represent, at most, 0.2% of all orthopedic injuries. They require disruption of at least three of the four major ligaments of the knee. Common mechanisms include traffic accidents, sporting injuries, or simple mechanical falls. Dislocations are classified on the basis of the direction of tibial movement in relation to the femur. Anterior and posterior dislocations account for approximately 70% of all knee dislocations. Knee dislocations may also have associated intraarticular fractures involving the tibial plateau or femoral condyles.

Knee dislocations are associated with a high risk for neurovascular injury and should be considered an orthopedic emergency. The neurovascular bundle runs posterior to the bony and ligamentous structures in the popliteal fossa. The popliteal artery and nerve are fixed in the fibrous tunnel of the soleus muscle and interosseous membrane distally. The relative immobility of the neurovascular bundle makes it susceptible to injury. The popliteal artery may be injured in up to 14% of all knee dislocations (Fig. 84.5). Traction injuries to the common peroneal and, less commonly, to the tibial nerve may also be present.

A grossly unstable knee after a traumatic injury should be assumed to have a reduced dislocation until proved otherwise. Any patient suspected of having sustained a knee dislocation should undergo a careful neurovascular examination. Anterior and posterior dislocations have a higher incidence of vascular injury. Vascular compromise in a dislocated knee requires immediate reduction.

Neurovascular status should be documented before and after reduction. All patients with a suspected or confirmed knee dislocation should have the ankle-brachial index (ABI) calculated. An ABI of less than 0.9 has high predictive value for a vascular injury, and such patients should undergo either CT or traditional angiography. Patients with normal findings on vascular examination and an ABI lower than 0.9 should be observed for at least 24 hours with cardiovascular checks every 2 to 3 hours. Prompt diagnosis of vascular injury is essential given the chance of development of progressive distal ischemia. When injury to the popliteal artery has occurred, patient outcome is directly related to the duration of ischemia.

Standard AP and lateral radiographs are adequate for initial evaluation of knee dislocations. After appropriate analgesia and sedation, emergency reduction of the dislocated knee should be attempted. Longitudinal traction on the tibia (to free it from the femur) should be followed with a force in the opposite direction of the dislocation. The rotary components should also be corrected to restore normal leg alignment. After reduction, the knee should be immobilized in 15 to 20 degrees of flexion. Orthopedic consultation in the ED is mandatory for all suspected and confirmed knee dislocations.

**Patellar Dislocation**

The patella normally articulates in the groove between the femoral condyles. The vastus medialis, medial and lateral patellofemoral, and patellotibial ligaments and the medial retinaculum all stabilize the patella (Fig. 84.6).

The overall incidence of patellar dislocations is estimated to be 7 per 100,000 per year and as high as 31 per 100,000 per year in patients between the age of 10 and 19 years. Patellar dislocations most commonly occur when a varus force is applied to a flexed knee or after forced contraction of a flexed quadriceps. Dislocations may be associated with meniscal tears, disruption of the medial collateral ligament, and osteochondral fractures.

The patient may report that the knee “gave out,” followed by pain and swelling. Patients may not be able to bear weight on or flex the knee. An acute hemarthrosis is most commonly seen if an associated osteochondral fracture is present. A patellar apprehension test may be useful in a patient who reports a dislocation that resolved spontaneously. This test is performed by moving a nondisplaced patella laterally. The result is positive if the patient shows apprehension, senses pain, or feels a sensation of impending dislocation when the patella is moved laterally (Fig. 84.7). AP, lateral, and sunrise radiographs are adequate to evaluate for acute dislocations and associated fractures.

After proper sedation, the emergency physician (EP) should reduce a lateral patellar dislocation by flexing the hip and pushing medially on the patella while extending the knee. Postreduction radiographs are mandatory to rule out osteochondral fractures. Intraarticular, horizontal, and superior dislocations typically require open reduction. Dislocations associated with osteochondral fractures are generally treated surgically.

After reduction, the patient should be told to use conservative therapeutic measures, such as ice, elevation, and pain control. The knee should be placed in a straight leg immobilizer, and the patient can start progressive weight bearing when comfortable. Follow-up should be arranged within 1 to

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**Table 84.2 Peripheral Nerve Assessment of the Leg**

<table>
<thead>
<tr>
<th>COMPARTMENT</th>
<th>NERVE</th>
<th>MOTOR FUNCTION</th>
<th>SENSORY FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior</td>
<td>Deep peroneal</td>
<td>Toe dorsiflexion</td>
<td>Dorsal I-II web space</td>
</tr>
<tr>
<td>Lateral</td>
<td>Superficial peroneal</td>
<td>Foot eversion</td>
<td>Lateral dorsum of the foot</td>
</tr>
<tr>
<td>Deep posterior</td>
<td>Tibial</td>
<td>Toe plantar function</td>
<td>Sole of the foot</td>
</tr>
<tr>
<td>Superficial posterior</td>
<td>Sural</td>
<td>Gastrocnemius</td>
<td>Lateral aspect of the heel</td>
</tr>
</tbody>
</table>
2 weeks. Complications include persistent instability, subluxation, repeated dislocation, and osteoarthritis.

**Proximal Tibiofibular Joint Dislocations**

The proximal tibiofibular joint is a small joint between the head of the fibula and the inferior aspect of the lateral tibial condyle. Dislocations can be anterior (most common), posterior, or superior. This rare injury is seen more in adolescents and young adults. It is typically associated with motor vehicle crashes and sports such as skydiving and hang gliding.

Pain and tenderness are felt over the proximal tibiofibular joint. On physical examination the patient has worsening pain with inversion and eversion of the foot or flexion and extension of the ankle. Instability may be present when anterior or posterior pressure is applied to the fibular head. Peroneal nerve injury occurs in approximately 5% of these dislocations.
AP and lateral radiographs are indicated. A comparison view may be helpful to make the diagnosis. Radiographs may demonstrate lateral displacement of the fibular head or diastasis of the proximal ends of the tibia and fibula.

Tibiofibular dislocations are reduced by flexing the knee to 90 degrees and evertting and dorsiflexing the ankle while applying direct pressure to the head of the fibula. General anesthesia may be necessary. After reduction, the knee should be immobilized in extension or partial flexion. Posterior dislocations may be unstable, and recurrent subluxation may be seen. Degenerative joint disease and arthritis can develop after injury to this joint.3

FRAC TURES

Patellar Fracture

The patella, the largest sesamoid bone in the body, is enveloped within the quadriceps tendon and articulates with the trochlear groove of the distal end of the femur. The superficial location of the patella makes it more susceptible to injury.

Patellar fractures account for approximately 1% of skeletal injuries and are the result of either a direct injury (dashboard injury) or an indirect injury (violent flexion). Indirect injuries result in an avulsion injury of the patella as a result of pull of the quadriceps muscle against resistance. Transverse patellar fractures are the most common type of fracture and are more likely to be displaced and be manifested as a disrupted extensor mechanism.

The patient usually has a swollen, painful knee. Patellar evaluation includes palpation for pain and bony disruption and assessment for extensor weakness. AP, lateral, and sunrise views of the knee should be obtained. A bipartite patella may be difficult to distinguish from a patellar fracture and is most often seen in the superolateral part of the patella. A high-riding patella, or a patella alta position, may signify disruption of the distal extensor mechanism; this is best visualized on AP and lateral views.3

Acute treatment of patellar fractures consists of ice, elevation, pain control, and a straight leg knee immobilizer. Nonoperative intervention is considered for nondisplaced fractures (<3 to 4 mm) when the extensor mechanism is intact. Patients with a disrupted extensor mechanism should have immediate orthopedic consultation because these injuries are often repaired within 24 hours.4

Proximal Tibial Fractures

Proximal tibial fractures include fractures above the tibial tuberosity.

TIBIAL PLATEAU FRACTURES The proximal end of the tibia comprises the medial and lateral condyles, which make up approximately three fourths of the proximal tibial surface. The condyles ensure appropriate knee alignment, stability, and motion. Tibial plateau fractures account for about 1% of all proximal tibial fractures.9

Tibial plateau fractures are caused by side loading secondary to either a varus or a valgus force combined with axial compression, which results in the femoral condyle impacting on the tibia. Common mechanisms are motor vehicle crashes, falls, and athletic activities such as skiing (Fig. 84.8). A Segond fracture is bony avulsion of the lateral tibial plateau at the site of attachment of the lateral capsular ligament. This fracture is an important marker for ACL disruption and anterolateral rotary instability. Associated soft tissue injuries to the collateral ligaments, menisci, and neurovascular structures are common, although low-energy injuries (from athletic activities) usually result in less soft tissue damage.9

Patients with tibial plateau fractures exhibit pain and swelling of the knee and their knee in a slightly flexed position. A valgus or varus deformity of the knee generally indicates a depressed fracture. Careful assessment of associated ipsilateral bony, soft tissue, and neurovascular status is essential given the high rate of association of such injuries with tibial plateau fractures.9

AP, lateral, and oblique radiographs are necessary to evaluate tibial plateau fractures. In addition, a tibial plateau view is helpful in assessing the amount of depression present. CT with 2-mm cuts and three-dimensional reconstruction is useful to further investigate indeterminate plain films, evaluate fracture patterns, show the precise extent of articular depression, and assist in planning for optimal operative treatment.4

Nonoperative treatment is indicated for minimal or nondisplaced fractures (<2 to 3 mm of articular incongruity), peripheral (submeniscal) fractures, and fractures in elderly, low-demand, or osteoporotic patients. Patients should not bear weight on the affected leg for 4 to 6 weeks.

Absolute indications for surgery are open fractures, arterial injuries, and compartment syndrome. Relative indications for surgery are displaced fractures leading to joint instability and depression of the plateau. The amount of depression that requires operative intervention is controversial and ranges from 3 to 10 mm; however, 3 mm is the usual cutoff in athletic patients.9

Fig. 84.8 Lateral tibial plateau fracture. (From Browner BD, Jupiter JB, Levine AM, et al. Skeletal trauma: basic science, management, and reconstruction. 3rd ed. Philadelphia: Saunders; 2003.)
TIBIAL SPINE FRACTURES  Tibial eminence avulsion fractures occur most often in children 8 to 14 years of age but can be seen in skeletally mature patients as well. A fracture of the anterior tibial spine in children is equivalent to an ACL rupture in adults.

The intercondylar eminence, or tibial spine, is the central portion of the proximal tibial surface. Tibial spine injuries usually result from a hyperextension force with or without a varus or rotational moment about the knee. The fracture may also occur after a direct blow to the distal end of the femur while the knee is flexed (Fig. 84.9).

Affected patients have a suggestive history and a painful, swollen knee. In most cases, patients are unable to fully extend the knee and exhibit an effusion, and findings on stability tests (Lachman, anterior drawer) are abnormal. The examiner should carefully evaluate such patients for associated ligamentous injuries.

Routine AP and lateral radiographs are adequate to define these fractures. CT is helpful for evaluating displacement, whereas MRI is superior in assessing any accompanying soft tissue injuries.

Fractures with little or no displacement should be immobilized in a long leg splint with the knee flexed at approximately 10 to 20 degrees. Displaced fractures necessitate orthopedic consultation because they may require closed reduction (if no ligamentous damage is present) or open or arthroscopic reduction with fixation of the fragments.10

SUBCONDYLANAR FRACTURES  Subcondylar fractures involve the proximal tibial metaphysis and are usually transverse or oblique. Isolated subcondylar fractures are rare, and such fractures are generally associated with tibial plateau fractures.

Routine AP and lateral radiographs are adequate for evaluation of subcondylar fractures. Acute management of these injuries involves ice, elevation, and immobilization in a long leg splint. Stable extraarticular nondisplaced transverse fractures are treated with a long leg cast for 8 weeks. Fractures that are comminuted or associated with a condylar component require open reduction and internal fixation.5

**Tibial Shaft Fractures**

Tibial shaft fractures are the most common long-bone fractures, as well as the most common open long-bone fracture. They are commonly associated with a fibular fracture or ligamentous injury. The fibula remains intact in only 15% to 25% of tibial shaft fractures. These fractures are associated with a high incidence of infection, delayed union, nonunion, and malunion.

Tibial shaft fractures result from either direct (motor vehicle accidents) or indirect (rotary or compressive forces) trauma. High-energy direct injuries usually cause transverse or comminuted fractures (most common). Indirect trauma commonly results in spiral or oblique fractures (Fig. 84.10).

A good neurovascular examination is essential. Skin integrity should be noted, and documentation of the integrity of the peroneal nerve is mandatory, as is a thorough examination of the knee and ankle.

AP and lateral radiographs should be obtained and must include the knee and ankle in both views. Closed tibial shaft fractures are immobilized in a long leg posterior splint with 10 to 20 degrees of knee flexion. Closed tibial and fibula shaft fractures, especially if displaced, are at risk for the development of compartment syndrome. Such injuries may necessitate observation in the hospital. It is estimated that compartment syndrome may develop in approximately 8% of tibial diaphyseal fractures. Any patient discharged home from the ED with a closed tibial fracture should be educated about the signs of compartment syndrome.

Open fractures should be gently cleaned, dressed with sterile dressings, and placed in a splint while awaiting orthopedic consultation. Patients should receive prophylactic antibiotics and tetanus prophylaxis. Emergency reduction is necessary for injuries accompanied by neurovascular compromise. Nonunion or delayed union is more likely with fractures that are open, severely displaced, or comminuted or with fractures associated with severe soft tissue injuries or infections.11

**Proximal Fibular Fractures**

Proximal fibular fractures are often seen in conjunction with tibial fractures. Isolated proximal fibular fractures are rare given that the fibula runs parallel to the tibia and is bound to the tibia via ligaments. These fractures may be associated with significant knee injuries.

Isolated proximal fibular fractures are treated with protected weight bearing. The EP must rule out other associated injuries, such as lateral collateral ligament injury, common peroneal nerve injury, arterial injuries, and Maisonneuve fractures.11

**Tibial Tuberosity Fractures**

The tibial tubercle is a bony prominence that is found approximately 3 cm distal to the proximal articular surface of
the tibia and in line with the medial half of the patella. It is
the insertion point of the extensor mechanism, and thus accu-
rate reduction and healing of this structure are essential.

Tibial tubercle avulsion fractures are rare injuries. Although
they can occur in adults, these fractures are more commonly
seen in adolescents undergoing a growth spurt. Most fractures
are the result of an indirect force delivered by an eccentric
load.12 A sudden flexion force is applied while the knee is in
flexion and the quadriceps is tightly contracted. The quadri-
ceps resists the force, which causes avulsion of the tibial
tubercle.

The physical findings depend on the extent of the injury.
Swelling and tenderness are present over the anterior aspect
of the tibia. A joint effusion may result from associated
intraarticular injuries. The injured knee is usually held in 20
to 40 degrees of flexion secondary to hamstring spasm. In
addition, the patient may not be able to extend the knee
because of either pain or loss of the extensor mechanism.13

Routine AP and lateral radiographs are useful for ruling out
associated fractures (Fig. 84.11). Initial treatment is similar
to that for both quadriceps and patellar tendon injuries. Minim-
ally displaced fractures are treated conservatively. Displaced
fractures frequently require open reduction and internal
fixation.12

Fig. 84.10 Radiographic examples of the three grades of severity of tibial fractures. A, Minor: spiral fracture caused by a simple slip
and fall. B, Moderate: fracture in a pedestrian struck by a slowly moving vehicle. C, Major: fracture caused by a high-velocity motorcycle
Philadelphia: Saunders; 2003.)

SOFT TISSUE AND CARTILAGINOUS
INJURIES

EXTENSOR MECHANISM INJURIES

The extensor mechanism of the knee is composed of the
quadriceps muscles and tendon, the patella, the patellar
tendon, and the tibial tubercle. Injuries can result from direct
trauma (direct blow or laceration) or an indirect force (forced
flexion of the knee). Rupture of the extensor mechanism is
relatively uncommon in comparison with other injuries involv-
ing the knee joint.12

QUADRICEPS AND PATELLAR TENDON
INJURIES

The quadriceps tendon represents the convergence of the
rectus femoris, vastus intermedius, vastus lateralis, and vastus
medialis muscles. It inserts on the superior pole of the patella.
The patellar tendon travels from the inferior pole of the patella
to the tibial tubercle.

Quadriceps ruptures typically occur in patients older than
40 years. Rupture is usually the result of forced quadriceps
contraction with a flexed knee, which loads the tendon. Direct
blows and lacerations can also cause disruption of the tendon.
The most common site of rupture is at or near its insertion on the patella. Predisposing factors are listed in Box 84.4.

Patellar tendon ruptures are less common. Risk factors for patellar tendon rupture are similar to those for quadriceps rupture, with the exception that they generally occur in patients younger than 40 years. Most patellar tendon ruptures occur along the inferior pole of the patella.

Pain, swelling, and ecchymosis are usually localized to the superior pole (quadriceps tendon) or inferior pole (patellar tendon) of the patella. A defect in the patella or quadriceps tendon may be palpable on physical examination. Other physical findings include a low-riding patella (patella baja) with inferior retraction of the patella (quadriceps tendon rupture) or a high-riding patella (patella alta) with superior retraction of the patella (patellar tendon rupture). The integrity of the extensor mechanism should always be evaluated.

AP and lateral radiographs help define the patellar position (alta or baja) and rule out associated fractures. Ultrasound has also been shown to be useful in diagnosing quadriceps tears. MRI is helpful in the diagnosis of partial tears.

Orthopedic consultation in the ED is indicated for suspected injuries and complete ruptures. Initial treatment consists of ice, elevation, and a straight leg immobilizer. Partial tears are treated by immobilization for 4 to 6 weeks, whereas complete tears are treated surgically. Diagnosis is essential given the better outcomes with prompt referral and repair.

**LIGAMENTOUS AND MENISCAL INJURIES**

Knee stability depends on the static stability of the ligaments and the dynamic stability of the muscles. Injuries to the knee involve the following six common mechanisms: (1) valgus stress (laterally directed), (2) varus stress (medially directed), (3) hyperextension, (4) rotational stress, (5) direct anterior stress, and (6) direct posterior stress. These stressors, working in isolation or combination, may result in myriad of ligamentous, meniscal, or chondral injuries.

Common mechanisms of ligamentous knee injuries are shown in Figure 84.12. Diagnosis is based on clinical

**BOX 84.4 Risk Factors for Quadriceps Tendon Rupture**

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt; 40 years</td>
<td>Chronic systemic conditions (rheumatoid arthritis, systemic lupus erythematosus, gout)</td>
</tr>
<tr>
<td>Steroid use</td>
<td>Insertional tendinopathy</td>
</tr>
<tr>
<td>Chronic metabolic disorders</td>
<td></td>
</tr>
</tbody>
</table>


Fig. 84.11 Lateral knee radiograph in a 14-year-old boy with a displaced fracture of the tibial tubercle. (From Green NE, Swiontkowski MF. Skeletal trauma in children, vol 3. 3rd ed. Philadelphia: Saunders; 2003.)

Fig. 84.12 Common mechanisms of knee injuries. ACL, Anterior cruciate ligament; LCL, lateral collateral ligament; MCL, medial collateral ligament; PCL, posterior cruciate ligament. (From Browner BD, Jupiter JB, Levine AM, et al. Skeletal trauma: basic science, management, and reconstruction. 3rd ed. Philadelphia: Saunders; 2003.)
examination; plain radiographs are indicated if a fracture is suspected. MRI offers a direct, noninvasive view of the knee ligaments, menisci, and other soft tissue structures; however, it is rarely indicated in the ED setting.

Stability testing for ligamentous and meniscal injuries is outlined in Table 84.1 and Figures 84.13 to 84.16. Ligament function, mechanism of injury, diagnosis, and treatment are outlined in Table 84.3. Most ligamentous and meniscal injuries should be reevaluated by an orthopedist in 3 to 5 days.

**Fig. 84.13  Lachman test for anterior drawer instability.** The test is done at 20 to 30 degrees of flexion. The examiner stabilizes the femur with one hand and draws the tibia anteriorly with the other hand. (From Browner BD, Jupiter JB, Levine AM, et al. Skeletal trauma: basic science, management, and reconstruction. 3rd ed. Philadelphia: Saunders; 2003.)

**Fig. 84.14  Anterior drawer test.** The knee is placed in 90 degrees of flexion, the foot is stabilized with pressure toward the examination table, and the proximal end of the tibia is grasped and pulled forward. (From Brown JR, Trojan TH. Anterior and posterior cruciate ligament injuries. Prim Care 2004;31:925-56.)

**Fig. 84.15  Pivot shift test.** With one hand the examiner flexes the hip to 45 degrees, extends the knee, and holds the heel. With the other hand the examiner holds the knee with the thumb behind the fibular head. The examiner then internally rotates the leg at the heel and applies valgus stress and flexion at the knee. (From Brown JR, Trojan TH. Anterior and posterior cruciate ligament injuries. Prim Care 2004;31:925-56.)

**Fig. 84.16  Posterior drawer test.** The knee is placed in 90 degrees of flexion and the foot is stabilized with pressure toward the examination table. The proximal end of the tibia is then grasped and a posterior force applied to it. (From Brown JR, Trojan TH. Anterior and posterior cruciate ligament injuries. Prim Care 2004;31:925-56.)

**Table 84.3**

<table>
<thead>
<tr>
<th>Table 84.3</th>
<th>Chapter 84 - Knee and Lower Leg Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Muscle Strains</strong></td>
<td>Gastrocnemius Muscle Strain</td>
</tr>
<tr>
<td>The gastrocnemius, soleus, and plantaris muscles form the posterior muscles of the calf. The tendon of the gastrocnemius muscle has two heads that arise from the posterior surfaces of the medial and lateral femoral condyles. The tendons of the gastrocnemius and soleus muscles form the Achilles tendon, which inserts on the posterior tubercle of the calcaneus. The gastrocnemius muscle acts primarily as a plantar flexor but also provides some passive support to the...</td>
<td></td>
</tr>
</tbody>
</table>
posterior joint capsule. The most common mechanism of injury to this muscle is hyperextension of the knee. Posterior dislocation of the tibia during knee flexion may also injure this muscle.

Patients may describe sudden calf pain while running or making a sudden stop or cut. Pain and swelling of the calf develop over the next day, and tenderness is typically found at the musculotendinous junction of the medial (more common) or lateral head of the gastrocnemius muscle. Complete rupture of the head of the gastrocnemius muscle is associated with retraction of the muscle belly. Acute posterior compartment syndrome has been associated with rupture of the medial head of the gastrocnemius muscle.14

Plain radiographs are not indicated. MRI may be helpful if a soft tissue injury is in doubt. Acute strains of the gastrocnemius muscle are treated conservatively with ice, compression wraps, and antiinflammatory medications. Gentle passive and active stretching exercises are begun early.

**Strain or Rupture of the Plantaris Muscle**

The plantaris is a pencil-shaped muscle that originates at the lateral condyle of the femur and passes below the soleus to attach to the Achilles tendon. Strain of the proximal plantaris muscle may occur with an injury to the ACL.

Patients with plantaris muscle rupture may experience a deep, disabling pain in the calf followed by a dull, deep ache. On examination, tenderness is greatest just lateral to the midline of the posterior aspect of the calf. No diagnostic testing is indicated. Plantaris muscle strains and ruptures are treated conservatively.

**Shin Splints**

Shin splints are also known as the medial tibial stress syndrome, which is characterized by diffuse tenderness over the posteromedial aspect of the distal third of the tibia. It is believed to represent a periostalgia or tendinopathy along the tibial attachment of the tibialis posterior or soleus muscle. It may be confused with a stress fracture.

Common contributing factors are improper shoe wear, rapid transition in training, inadequate warm-up, running on uneven or hard surfaces, running in cold weather, and anatomic considerations. Patients with mild cases of shin splints have pain during exercise, whereas those with more severe cases have pain at rest.

Diagnostic tests are not indicated for shin splints unless a tibial stress fracture is a consideration. Treatment of shin splints involves relative rest, training adjustment, and antiinflammatory medications. Runners should be instructed to avoid running on hills and uneven surfaces.15

### OVERUSE INJURIES

Common tendinopathies and bursitis of the knee are described in Chapter 86.

**OSGOOD-SCHLATTER DISEASE**

Osgood-Schlatter disease is an overuse injury that involves traction apophysitis at the tibial tubercle. It is often seen in adolescents during a growth spurt, when the apophysis in this region becomes weaker than the surrounding bony and tendinous tissues. The condition is bilateral in 20% to 30% of cases. Its cause is unknown.

Patients with Osgood-Schlatter disease complain of pain and swelling over the tibial tuberosity. They may describe worsening of the pain with jumping, squatting, or kneeling. The pain may be intermittent and is rarely severe enough to interrupt daily activity. Physical examination demonstrates localized pain and swelling over the tibial tuberosity.

A lateral knee radiograph is the most useful view and may show separation of the apophysis or fragmentation of

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**Table 84.3 Static Knee Stabilizers: Function, Mechanism of Injury, and Treatment**

<table>
<thead>
<tr>
<th>STRUCTURE</th>
<th>FUNCTION</th>
<th>MECHANISM OF INJURY</th>
<th>TEST</th>
<th>INITIAL TREATMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior cruciate ligament</td>
<td>Prevents forward displacement of the tibia on the femur</td>
<td>Deceleration, hyperextension, or twisting</td>
<td>Lachman, anterior drawer, pivot shift (see Figs. 84.13 to 84.15)</td>
<td>Ice, elevation, pain control, hinged knee brace (unlocked)</td>
</tr>
<tr>
<td>Posterior cruciate ligament</td>
<td>Primary restraint against posterior tibial displacement</td>
<td>Forced hyperflexion, direct blow to the proximal end of the tibia</td>
<td>Posterior drawer (see Fig. 84-16), posterior sag</td>
<td>Ice, elevation, pain control, hinged knee brace (unlocked)</td>
</tr>
<tr>
<td>Lateral collateral ligament</td>
<td>Lateral joint stability</td>
<td>Direct force to the anteromedial aspect of the knee when extended</td>
<td>Varus stress testing in extension and 30 degrees of flexion</td>
<td>Ice, elevation, pain control, hinged knee brace (unlocked)</td>
</tr>
<tr>
<td>Medial collateral ligament</td>
<td>Medial joint stability</td>
<td>Direct force to the lateral aspect of a partially flexed knee</td>
<td>Valgus stress testing in extension and 30 degrees of flexion</td>
<td>Ice, elevation, pain control, hinged knee brace (unlocked)</td>
</tr>
<tr>
<td>Meniscal injuries</td>
<td>Load-share and reduce contact stress across the joint</td>
<td>Cutting, deceleration, landing from a jump</td>
<td>McMurray test, Apley test</td>
<td>Partial weight bearing or hinged knee brace (unlocked). A “locked” knee requires attempted reduction and orthopedic consultation</td>
</tr>
</tbody>
</table>
a portion of the tibial tubercle. The appearance of tibial tubercle fragmentation may represent a normal variant in ossification of the tibial tubercle. Radiographic findings without associated clinical symptoms should be interpreted with caution.

Osgood-Schlatter disease is generally a self-limited condition. In most cases, treatment is nonoperative and consists of modification of activity, nonsteroidal antiinflammatory drugs (NSAIDs), and physical therapy. The family of an adolescent with this disorder should be counseled that the symptoms may take up to 12 to 18 months to resolve.

**OSTEONECROSIS**

Osteonecrosis of the knee is usually idiopathic and is most commonly located on the medial femoral condyle. It may be associated with steroids, irradiation, and systemic diseases such as sickle cell anemia and rheumatologic disorders. Osteonecrosis occurs when the blood supply to the bone is disrupted, which results in bone infarction. The patient has a sudden onset of pain over the anteromedial (most common) aspect of the knee. The pain may become worse at night or increase with activity. Idiopathic osteonecrosis is typically seen in women older than 60 years. The patient may have a joint effusion or decreased range of motion of the knee joint.

Radionuclide scintigraphy or CT may be required to detect the disease in its early stages. Plain radiographic findings in patients with early disease are usually normal.

Patients with early stages of osteonecrosis are treated conservatively with partial weight bearing and antiinflammatory medications. Patients with advanced disease may require surgery to restore the articular surface. Total knee arthroplasty is reserved for disease that has expanded to the lateral compartment.

**PATELLOFEMORAL PAIN SYNDROME**

Patellofemoral pain syndrome refers to the clinical manifestation of anterior knee pain related to changes in the patellofemoral articulation. Patients are generally between the ages...
of 10 and 20 years and usually have complaints of nonspecific anterior knee pain that is not related to trauma. Athletes may experience symptoms after periods of overactivity. Elderly patients may exhibit symptoms if they have arthritis that affects the patellofemoral joint. The most important risk factors are overuse, quadriceps weakness, and soft tissue tightness. In most cases the etiology is multifactorial.¹⁸

The patient has a history of mild to moderate anterior knee pain. The knee may be more painful with prolonged flexion, stair climbing, or kneeling. Physical examination may show a slight effusion, along with patellar crepitus on range of motion. Applying direct pressure to the anterior aspect of the patella may reproduce the patient’s pain.²⁰

Plain radiographs are not indicated. CT or MRI can detect abnormalities in the articular surface of the patella. In most cases, a physical therapy program that strengthens the quadriceps muscle can successfully reduce the symptoms. Surgery may be required for the minority of patients who do not respond to conservative management.¹⁹

**POPLITEAL CYST**

A popliteal cyst, or Baker cyst, is an inflammation of the semimembranosus or medial gastrocnemius bursa. A Baker cyst is produced by herniation of the synovial membrane through the posterior knee capsule. It is usually the result of synovitis, arthritis, or an internal derangement of the knee that results in excess synovial fluid in the bursa.

Intermittent swelling can develop behind the knee. If the bursa ruptures, the patient may complain of calf pain, and the findings may be similar to those in patients with thrombophlebitis.

Ultrasoundography is helpful to distinguish Baker cysts from other disorders, such as popliteal artery aneurysms, neoplasms, and thrombophlebitis. Treatment is based on the underlying cause. Asymptomatic cysts found incidentally need no further treatment.¹⁹

### PATIENT TEACHING TIPS

A patient in whom a strain, sprain or stable injury of the knee is diagnosed should be discharged home in a hinged brace (fully unlocked). If discharged in a knee immobilizer, the patient should be instructed to perform gentle range-of-motion exercises multiple times per day to prevent joint stiffness.

A patient with a tibia fracture who is sent home should be educated about compartment syndrome and told to return to the emergency department if either severe pain or numbness in the foot or leg develops within the first 48 hours.

A patient with an acute injury should be instructed to:

- Elevate the injured area above the level of the heart for the first 48 hours after the injury.
- Apply ice to the injured area while avoiding direct contact of ice with bare skin and getting the splint moist.

In a patient discharged from the emergency department on crutches:

- Crutch training should be given.
- The ability of the patient to safely use crutches should be observed before discharge.

### SUGGESTED READINGS


### REFERENCES

References can be found on Expert Consult @ www.expertconsult.com.
REFERENCES