Chapter 275: Leg Injuries

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ANATOMY

BONE

The tibia provides primary support for weight bearing. The tibia has a thick cortex, and significant force is required to fracture it. Proximally, the tibia splays out to form the medial and lateral plateaus that articulate with the femoral condyles. The lateral plateau is higher and smaller than the medial and is more susceptible to fracture. The distal tibia articulates with the fibula laterally and the talus inferiorly. A dense interosseous membrane connects the tibia and fibula. The distal tibial articulation is supported by the ankle syndesmosis, a series of ligaments inferior to the interosseous membrane. The fibula has a small diameter and lies lateral and posterior to the tibia. It bears little weight but is more easily fractured than the tibia.

COMPARTMENTS

The lower leg is divided into four compartments, each coursing parallel to the tibia (Figure 275-1). The compartments are enclosed by nonexpandable bones and connective tissue that limit the compartment size and prevent compartment expansion if its volume increases. Each compartment contains muscles and nerves that may sustain permanent damage with elevated tissue compartment pressure (Table 275-1). (See also chapter 278, "Compartment Syndrome.")
TABLE 275-1

Lower Leg Anatomy

<table>
<thead>
<tr>
<th>Compartments</th>
<th>Anterior</th>
<th>Lateral</th>
<th>Superficial Posterior</th>
<th>Deep Posterior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscles</td>
<td>Dorsiflex foot and ankle</td>
<td>Plantarflex and evert foot</td>
<td>Flex knee and ankle</td>
<td>Plantarflex toes, inversion of foot</td>
</tr>
<tr>
<td>Nerve</td>
<td>Deep peroneal</td>
<td>Superficial peroneal</td>
<td>Sural</td>
<td>Posterior tibial</td>
</tr>
<tr>
<td>Sensation</td>
<td>First dorsal web space</td>
<td>Dorsum of foot</td>
<td>Lateral aspect of foot and distal calf</td>
<td>Sole of foot</td>
</tr>
<tr>
<td>Artery</td>
<td>Anterior tibial</td>
<td>—</td>
<td>—</td>
<td>Posterior tibial</td>
</tr>
</tbody>
</table>

A cross-section at the midcalf level shows the anterior compartment enclosed by the tibia, interosseous membrane, and anterior crural septum (Table 275-1 and Figure 275-1). Muscles in the anterior compartment group dorsiflex the foot and ankle. The deep peroneal nerve courses within the anterior compartment and exits to provide sensation to the dorsal web space between the first and second toes.

The lateral compartment is bordered by the anterior crural septum, the fibula, and the posterior crural septum. Its muscles plantarflex and evert the foot. The superficial peroneal nerve in this compartment provides sensation to the dorsum of the foot. The superficial posterior compartment contains muscles that
Flex the knee and the tibiotalar joints. Its sural nerve provides sensation for the lateral aspect of the foot and the distal calf. The muscles of the deep posterior compartment plantarflex the foot and toes and invert the foot. The posterior tibial nerve that exits this compartment provides sensation to the sole of the foot.

**CLINICAL FEATURES**

The history may give clues about the mechanism of injury and nontraumatic soft tissue injuries. Evaluate the nerves by checking sensation in the web space, lateral heel, and sole of the foot. Plantarflex and dorsiflex the foot, and evert the foot to test motor function. Evaluate the extent of soft tissue injury visually and by palpating the compartmental muscle groups. It is often the extent of soft tissue injury, rather than the fracture itself, that determines the outcome. Palpate the knee, and the tibia and fibula along their entire lengths. Palpate the popliteal, dorsal pedal, and posterior tibial pulses. An absent or decreased pulse may indicate the need for urgent fracture reduction and further vascular evaluation.

**DIAGNOSIS**

Anteroposterior and lateral radiographs of the leg that include the knee and ankle are sufficient to evaluate bony injuries. If ankle or knee injuries are suspected, then further imaging is needed. If a tibial shaft fracture is suspected, splint the leg with a radiolucent device to control pain and prevent further soft tissue damage before obtaining films. Check pulses, movement, and sensation before and after splinting the leg.

**TREATMENT**

Cleanse wounds and debride loose tissue and foreign material. Administer tetanus immunization as indicated. Splint fractures before obtaining radiographs; this will prevent further damage to soft tissue caused by movement of bone fragments. Irrigate open wounds and administer parenteral antibiotics (such as cefazolin, 1 gram IV) for open fractures. If compartment syndrome is suspected, measure compartment pressure (see chapter 278, "Compartment Syndrome"). Treatment of compartment syndrome is fasciotomy of the involved compartment. Details of suturing pretibial lacerations are provided in the chapter 44, "Leg and Foot Lacerations."

**COMPLICATIONS**

Wounds that are not adequately cleansed and debrided are prone to infection. Patients with compartment syndromes may develop permanent disability if elevated tissue pressures are not suspected or diagnosed in a timely fashion. Fractures that are not adequately aligned or immobilized heal poorly or not at all.

**SPECIFIC INJURIES**

**TIBIAL SHAFT FRACTURES**
The tibia is the most commonly fractured long bone. Fractures often result in open injuries because of the minimal amount of subcutaneous tissue between the tibia and the skin. The fracture pattern seen on radiographs will give a clue to the force that caused the injury. Transverse shaft fractures typically result from a direct blow to the bone. Spiral fractures are the result of rotational forces. A comminuted fracture suggests the mechanism had a very-high-energy impact. A force powerful enough to shatter the dense cortex of the tibial shaft will often be transmitted through the interosseous membrane to the fibula, fracturing that bone as well.

Open tibial shaft fractures have been classified (Table 275-2). A grade 1 injury has minimal soft tissue contusion and a skin laceration that is 1 cm in length or less. A grade 2 injury involves a wound with a >1-cm laceration with moderate soft tissue injury and moderate contamination; the tibia is moderately comminuted. A grade 3 injury can involve segmental injury to the tibia, a vascular injury, a highly contaminated wound, or a >10-cm laceration. This classification system is prognostic in terms of healing time and rate of nonunion. The soft tissue injuries often are determinants of the immediate treatment plan.
<table>
<thead>
<tr>
<th>Gustilo Grade</th>
<th>1</th>
<th>2</th>
<th>3A</th>
<th>3B</th>
<th>3C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy</strong></td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td><strong>Wound size</strong></td>
<td>&lt;1 cm</td>
<td>&gt;1 cm</td>
<td>Often large zone of injury</td>
<td>Often large zone of injury</td>
<td>Often large zone of injury</td>
</tr>
<tr>
<td><strong>Soft tissue damage</strong></td>
<td>None</td>
<td>None</td>
<td>Extensive</td>
<td>Extensive</td>
<td>Extensive</td>
</tr>
<tr>
<td><strong>Contamination</strong></td>
<td>Clean</td>
<td>Moderate</td>
<td>Extensive</td>
<td>Extensive</td>
<td>Extensive</td>
</tr>
<tr>
<td><strong>Fracture pattern</strong></td>
<td>Simple fracture pattern with minimal comminution</td>
<td>Moderate comminution</td>
<td>Severe comminution or segmental fractures</td>
<td>Severe comminution or segmental fractures</td>
<td>Severe comminution or segmental fractures</td>
</tr>
<tr>
<td><strong>Periosteal stripping</strong></td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Skin coverage</strong></td>
<td>Local coverage</td>
<td>Local coverage</td>
<td>Local coverage</td>
<td>Requires replacement of exposed bone with a free flap for coverage</td>
<td>Local coverage</td>
</tr>
<tr>
<td><strong>Neurovascular injury</strong></td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Exposed fracture with arterial damage that requires repair</td>
</tr>
</tbody>
</table>

The initial management of tibial fractures involves administration of analgesics. Promptly splint the leg with radiolucent material to avoid further soft tissue injury from the movement of the bony fragments. Assess for possible compartment syndrome. Some closed injuries may be treated simply by casting if reduction is able
to achieve adequate alignment. Parameters for acceptable reduction include 50% or more of cortical contact, <10 to 15 degrees of angulation on the lateral film, <10 degrees of angulation on the anteroposterior film, and <5 degrees of rotational deformity. Injuries with significant edema and spiral fractures often require surgical fixation. An intact fibula may make obtaining or maintaining reduction of the tibial fracture more difficult.

A long leg splint from high above the knee with the knee at 5 degrees of flexion and the foot in slight plantarflexion can be applied. Tight-fitting splints or casts may increase the risk of compartment syndrome. Injuries amenable to casting often heal in 4 to 5 months. Initiate weight bearing as soon as possible to facilitate bone union. Patients usually can achieve full weight bearing with crutches in 7 to 14 days.

Patients who can be discharged home after splinting include those who suffered low-energy injuries, have their pain well controlled, and are not at risk of compartment syndrome.

The patient with an open tibial fracture requires orthopedic consultation. Injuries with type 1 soft tissue damage may be cleaned in the operating room and medullary nails inserted to maintain reduction. Those with more extensive injuries may require external fixation or medullary nailing after debridement in the operative room.

SEVERELY INJURED TIBIAL SHAFT

Some patients suffer such extensive damage to their leg that they may be better served by amputation of the leg rather than an attempt to salvage the limb. There are four functional components of the leg: bone, vessels, nerves, and soft tissue. Severe injury to any three of these puts the limb at risk. Most severe injuries are caused by a crushing mechanism. Motor vehicle crashes or farm or industrial accidents are most common, followed by falls. Penetrating injuries caused by gunshot wounds or explosives may also put a limb at risk. There are about 3700 amputations per year performed due to these extensive injuries.

Initial management of the patient with a mangled extremity should include attention to life-threatening injuries, immobilization of the leg, diagnostic imaging, pain control, IV antibiotic administration, and tetanus prophylaxis as needed.

PILON FRACTURES

Pilon is a French word for pestle, a tool used to grind substance in a mortar. In the lower leg, an axial force on the foot can drive the talus into the articular surface of the tibia, grinding or crushing the distal tibia. This injury is also called a tibial plafond fracture (Figure 275-2).

FIGURE 275-2.
Plafond fracture. Tibial plafond fracture (pilon fracture) due to an axial compression force. [Reproduced with permission from Simon RR, Sherman SC, Koenigsknecht SJ: Emergency Orthopedics: The Extremities, 5th ed. © The McGraw-Hill Companies. All rights reserved. Part III: Lower Extremities, chapter 17 Ankle, Fractures, Axial Compression, Imaging, Figure 17-24.]
The amount of energy involved in the accident often predicts the type of injury and is important in planning treatment. A high-energy mechanism (motor vehicle crash) often results in significant soft tissue damage with extensive fragmentation of the bone. By contrast, low-energy injuries (skiing) have minimal surrounding soft tissue damage and less comminution of the bone. Radiographs may show at least one fracture plane that extends proximally from the articular surface of the ankle. There are often several fracture planes present. Obtain a CT scan while the leg is in a splint or cast. The scan will help determine the direction of the fracture planes, reveal the amount of articular surface displacement that exists, and aid in the development of a treatment plan. Pilon fractures may be accompanied by compartment syndrome or by vertebral body fractures, particularly a fracture of the first lumbar vertebrae (L1).3

The goal of treatment is reduction of the fracture fragment and optimal alignment of the articular surfaces. The extent of soft tissue damage may determine when surgical repair occurs. In the setting of significant soft tissue damage, an external fixation device may temporarily be used to allow this tissue time to heal before definitive surgery.
TRIPLANE FRACTURES

The distal tibial growth plate begins to fuse when adolescents are between the ages of 12 and 15 years old. The process takes about 18 months. The medial portion of the growth plate fuses before the lateral. It is this relatively weak lateral growth plate that makes them susceptible to a triplane fracture.

An external rotational force applied to the foot causes stress and a fracture of the tibia. The fracture plane extends from the lateral side of the tibia through the growth plate until it reaches the already fused medial aspect of the physis. At that point, the fracture planes are redirected into sagittal and coronal planes. The resulting injuries can appear to be a Salter III fracture on the anteroposterior radiographic view and a Salter II injury on the lateral view. Evaluate this injury with a CT scan, which often can reveal further deformity of the articular surface.

The treatment goal is producing good articular surface alignment, which can be obtained with closed reduction in most cases. With a complex fracture pattern, some patients will require surgery to attain optimal joint surface alignment.

PROXIMAL FIBULA FRACTURE (MAISONNEUVE'S FRACTURE)

Maisonneuve's fracture results from an external rotation force applied to the foot. This creates a plane of injury that starts at the medial ankle as either a deltoid ligament rupture or a medial malleolus injury. The injury is then directed upward and laterally, tearing the interosseous membrane that tethers the distal tibia to the fibula. The third component of this injury is a fracture of the proximal fibula. The word *proximal* is relative; the fibula may be fractured at its head or as far down as 6 cm above the ankle joint (a Weber C ankle fracture).

The surgical treatment for this injury is to reduce and stabilize the fractured medial malleolus and to secure the fibula to the distal tibia, allowing the ruptured interosseous membrane to heal.

MIDSHAFT FIBULA FRACTURES

The shaft of the fibula is most often fractured by a force that has also fractured the tibia; in these cases, treatment is directed by the tibial injury. A direct blow to the fibula can result in an isolated injury to this bone. The patient typically presents with pain or tenderness over the fracture site. With the tibia intact, the patient is often able to bear weight and should be treated with a short leg cast and crutches. Patients with less intense pain may be immobilized with a knee immobilizer (proximal fibula) or elastic wrap (distal fibula) and directed to bear weight as tolerated.

STRESS FRACTURE

Stress fracture occurs when there is increased muscle activity on bones that are not able to tolerate the additional forces. Extrinsic causes may include a recent increase in activity, running over hard surfaces, or excessive wear on the athlete's shoes. Adolescent female athletes with eating disorders and military recruits...
are at high risk for stress fractures. As our population ages, the elderly are taking up activities that may result in stress fractures. The prototypical patient is the Caucasian woman with demineralized bone. Stress fractures are twice as common in women compared with men. About half of stress fractures in athletes occur in the tibia. Less common sites are the tarsals and fibula. Stress fractures may be bilateral. In adolescents, the site is often the proximal third of the tibia. Runners typically sustain fractures at the junction of the middle and distal third of the tibia. The distal fibula is another common site.

The history typically involves a change in the patient's training pattern. In an early stage of stress fracture, the patient notices activity-induced pain that is relieved by rest. This can progress to constant pain. On examination, there is pain on palpation over the fracture site, and there may be edema. The pain may be intensified by load bearing on the affected bone.

The radiographs of the site are often normal on initial presentation. They may reveal the fracture, which can have the appearance of sclerosed areas oriented linearly. Radiographs obtained 10 to 15 days later may show periosteal elevation or demineralization at the fracture line. Plain films that are initially normal do not exclude the diagnosis. More sensitive tests for stress fracture are the bone scan and MRI. Although these studies are typically ordered at follow-up and not in the ED setting, they can demonstrate the severity of the change and can be used to predict time to recovery.  

Treatment of a suspected stress fracture includes discontinuation of the activity. A cast can be applied if significant pain continues. It is not unusual to have pain lasting up to a year despite treatment.

ACHILLES TENDON RUPTURE

The Achilles tendon is the largest and strongest tendon in the human body. The gastrocnemius and soleus muscles of the calf have tendinous complexes that coalesce to the Achilles tendon that extends about 15 cm to where it inserts on the calcaneus. Its vascular supply is the weakest in the area 2 to 6 cm above the calcaneus, and this is the area that is most frequently ruptured. A typical patient is a 30- to 50-year-old man who participates in strenuous activities on an occasional basis ("weekend warrior"). Risk factors for rupture include older age, prior quinolone use, and prior steroid injection. The injury often occurs when eccentric force is suddenly applied to a dorsiflexed foot. The patient suffers sudden severe pain and is unable to run, stand on toes, or climb stairs. The most notable finding on examination is a palpable gap in the Achilles tendon 2 to 6 cm proximal to the calcaneus. The calf may be swollen. The patient will be unable to stand on toes. The Thompson test (see Figure 44-6 in chapter titled "Leg and Foot Lacerations") will help demonstrate the tendon rupture. The patient lays prone with the knee bent at 90 degrees. The examiner squeezes the calf: an intact Achilles tendon will transmit this force to the foot resulting in its plantarflexion. If the Achilles tendon is ruptured, the foot will not plantarflex when the calf is squeezed. The diagnosis of Achilles tendon rupture can be made without radiographs. When the diagnosis is not clear, an US or MRI of the Achilles tendon may be obtained. The reliability of US is largely dependent on the operator's skill. Initial care for Achilles tendon rupture involves immobilization from just below the knee to the metatarsals with the ankle in some plantarflexion. Crutches are necessary for non–weight-bearing status. Ice and analgesics are also used.
Subsequent therapy may involve either surgical repair of the ruptured tendon or immobilization and gradual physical therapy to regain range of motion. There has been controversy about whether surgery is superior to conservative management. In both treatment modalities, the rerupture rate is less than 5%, but there was some suggestion that conservative care was associated with a slightly higher rate of rerupture. Two studies have shown equivalent rates of rerupture in those treated surgically versus conservatively. Refer patients with Achilles tendon rupture to an orthopedist or sports medicine specialist. They will typically be immobilized for 2 to 3 months and be able to return to their sport in 3 to 6 months.

MEDIAL GASTROCNEMIUS MUSCLE STRAIN

The medial gastrocnemius originates from the medial femoral condyle, crosses the knee, and joins the lateral gastrocnemius. The tendon complex of this muscle merges with that of the soleus muscle to form the Achilles tendon, which inserts on the calcaneus to act in plantarflexion of the foot. Injury to the medial gastrocnemius muscle usually occurs when a person forcefully plantarflexes the foot while the knee is extended, occurring when the gastrocnemius is at its maximal length. The typical patient is 40 to 60 years old and an intermittently active athlete. A sharp pain is suddenly felt in the calf as if a stick had struck the person. An audible "pop" may be heard. The pain is severe enough to cause an immediate cessation of the activity, as plantarflexion of the ankle is too painful.

On examination, there may be asymmetric calf swelling and tenderness of the calf. The Achilles tendon is intact. The patient's pain can be elicited by passive dorsiflexion of the ankle. Differential diagnosis can include deep vein thrombosis, ruptured Baker's cyst, and compartment syndrome. Radiographs are not necessary for making the diagnosis. Nonurgent MRI can be obtained to confirm the diagnosis. Treatment includes immobilization with the foot maximally plantarflexed. Rest, ice, and elevation may decrease swelling.

SHIN SPLINTS

Shin splints is a complex syndrome that may eventually be found to include several different injuries. The patient presents with exercise-induced pain over the medial aspect of the tibia. This is also referred to as a medial tibial stress syndrome. It may be caused by a repetitive trauma–induced periostitis of the tibia.

The population at risk includes runners, military recruits, and those with flat feet. It is uncommon before the age of 15 years old. The condition typically starts after a sudden increase in training, particularly running on hard surfaces. Physical examination findings may include tenderness over the medial or posterior tibia. Radiographs are normal. A bone scan may be needed to exclude the possibility of a stress fracture. The diagnosis is primarily a clinical one based on history and an examination that excludes other pathology. The mainstay of treatment is a several-week cessation of the activity that precipitated the pain.

REFERENCES


