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Part I of this series covered anatomy and injuries to the ankle. This second and final part of this series will focus on injuries to the foot.

—The Editor

Management of Acute Foot and Ankle Disorders in the Emergency Department:

Part II—Fractures of the Foot

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Anatomy of the Foot

Arches. The relationships of the bones, the complex movements, and the significant forces experienced by the foot make it anatomically complicated. In general, the foot has two functions: weight bearing and propulsion. To accomplish these tasks, the foot must be both flexible to adapt to uneven surfaces and highly stable for walking and running. The many bones and joints act to give flexibility, and the arches they form act to support weight. The slight flex of the arches allows them to maintain the shape of the foot and aid in weight transfer to the ground. The arches are formed primarily by the inherent shape of the bones that fit together like blocks and keystones in a classic Roman arch. Thus, the shape of the arches depends more on the position and alignment of the bones rather than the soft tissue. The intrinsic muscles, tendons, and ligaments only help support the arches. There are one transverse and two longitudinal arches. The medial longitudinal arch is the highest and most important of the three. It is formed by the calcaneus, talus, navicular, cuneiforms, and the first three metatarsals. The transverse arch is composed of the cuneiforms, the cuboid, and the five metatarsal bases. The lateral longitudinal arch is lower and flatter than the medial arch. It is composed of the calcaneus, cuboid, and the fourth and fifth metatarsals.

Bones. The foot contains 28 bones and 57 articulations. (*See Figure 1.*) Together, both feet make up nearly 25% of all the bones in the body. The foot is divided into the hindfoot (calcaneous and talus), midfoot (navicular, cuboid, and cuneiforms), and the forefoot (metatarsals, phalanges, and sesamoids). The connection between the hindfoot and midfoot is named Chopart's joint, while Lisfranc's joint connects the midfoot and forefoot. The calcaneus is the largest bone in the foot. The medial part has a shelf-like portion called the sustenaculum tali and acts to support the talus. The talus is the key bone that connects the leg and the foot. It is a relatively small bone, but bears the entire body's weight. The talus is divided into a head, neck, and body. Although a moveable bone, it has no tendon attachments. The subtalar joint refers to the three articulations of the talus with the calcaneus and navicular bone. The subtalar joint is very important, as more than 90% of foot and ankle motion occurs through these articulations. The navicular bone lies in the medial midfoot, and the three cuneiforms are just distal to it. The cuboid lies laterally to the navicular bone. These bones help form the transverse and medial longitudinal arches, and provide a stable connection between the forefoot and hindfoot. The most important midfoot joint is the transverse tarsal joint, formed by the talonavicular and the calcaneocuboid articulations. There is some movement across the cuboid-fourth and fifth metatarsal articulations, and preservation of these joints helps with normal foot movements and ambulation. There is little to no movement in the remaining joints of the midfoot; joint injury is of less concern. In fact, the other joints of the midfoot often are surgically fused to aid in the treatment of other midfoot injuries.[1] Lisfranc's joint is an especially important area to remember. While not a common injury, when it does occur it easily can be missed or underestimated in the ED with devastating consequences for the all involved. (*See the section on Lisfranc Injuries.*) Metatarsophalangeal joints provide flexion and extension of the foot. Two sesamoid bones normally are found inside the flexor hallucis brevis tendon just beneath the first metatarsophalangeal joint. Like all sesamoid bones, they are thought to protect from excessive friction or change the direction of the pull of the tendons for efficiency. There are many (up to one dozen) accessory ossicles that may be present in the foot. They easily can be confused with avulsion fractures on plain films. The os trigonum (talus), os tibiale externum (accessory navicular), os peroneum (cuboid), and os versalianum are the most commonly seen. These accessory ossicles can be associated with pain, with posterior impingement syndrome (os trigonum) as the most well known example. Occasionally surgical removal is required to relieve the symptoms.

Ligaments. Ligaments of the foot are not given the same attention as ankle ligaments. There actually are a larger number—about 132—which are grouped in bundles. They help maintain foot strength and support the arches for balance and integrity in walking and running. Several individual ligaments deserve mention. Lisfranc's ligament is the most well known foot ligament. It joins the medial cuneiform to the second metatarsal base. It is important as the second metatarsal is essential for stability of the entire Lisfranc joint. It acts as the keystone of the transverse arch. (*See Figure 2.*) There are many other dorsal and plantar ligaments around Lisfranc's joint acting to stabilize it. Another important ligament, the calcaneonavicular ligament, runs from the base of the calcaneus to the midfoot and attaches to the navicular bone. It is commonly known as the spring ligament and it helps hold the talus and arches in place. While not actually a ligament, the plantar fascia can act like one. It attaches to the calcaneus and runs out to the metatarsals and toes. It functions like a tension or tie bar so that when the heel is lifted, tension is applied to the forefoot to maintain the arches.

Tendons. Four main tendons run from the leg muscles through the ankle to attach in the foot: Achilles, tibialis anterior, tibialis posterior, and peroneus longus. The Achilles attaches to the calcaneus and acts to lift the heel at the end of a step. Tibialis anterior inserts on the base of the first and acts to invert the foot and dorsiflex the ankle. Tibialis posterior attaches to the medial talus and helps prevent pronation in running. Peroneus longus runs under the foot and attaches at the lateral margin of the first cuneiform and proximal end of first metatarsal, and aids in plantarflexion. Longus, not to be confused with peroneus brevis, which runs along it behind the lateral malleolus, but inserts on the proximal base of the fifth metatarsal. Peroneus brevis everts

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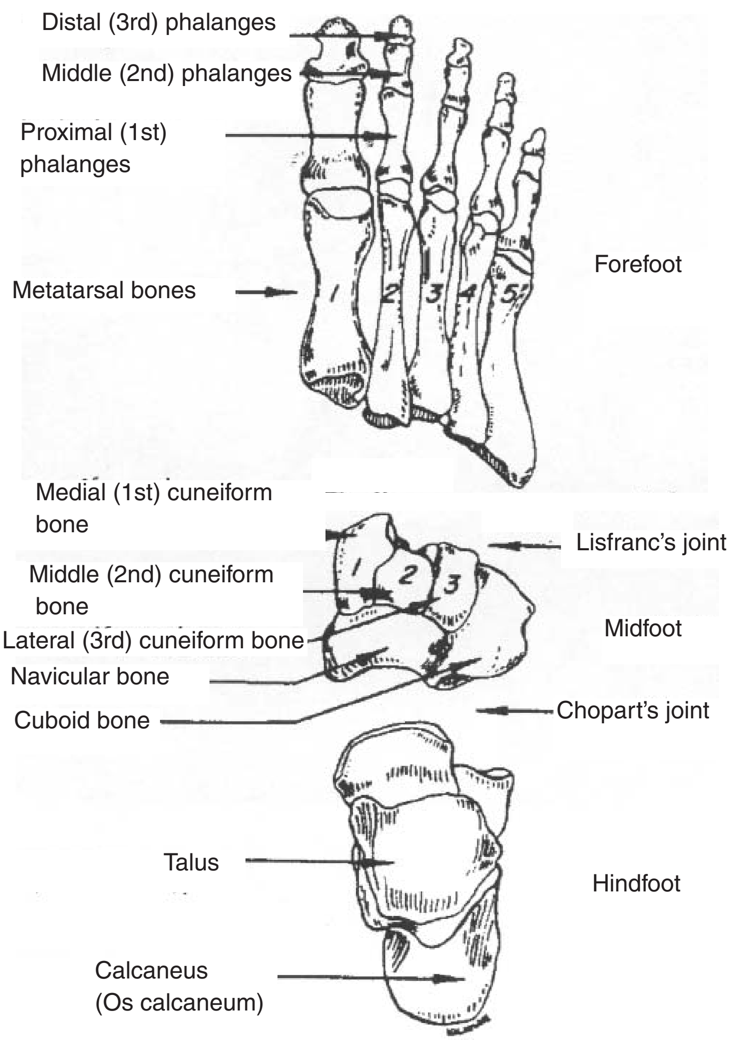
Figure 1. Bones and Joints of the Foot



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the foot, but is most well know for avulsion fractures of the proximal fifth metatarsal. (*See Metatarsal Fractures.*) Extensor and flexor tendons also are present on the dorsal and plantar surfaces, respectively, and can be lacerated like their counterparts in the hand. Unlike tendons of the hand, they are not as critical for function and may not always be repaired. One can still evaluate their function by testing flexion and extension of the toes similar to testing of finger movement. Unlike the hand, both dorsal (extensor) and plantar (flexor) sides each have a deep (longus) and superficial (brevis) set of tendons.

Nerves. A total of five nerves innervate the foot. Three anterior nerves (superficial peroneal, deep peroneal, and saphenous) and two posterior nerves (posterior tibial and sural): the anterior nerves provide sensation to the dorsal aspect of the foot, while the posterior nerves supply the sole of the foot. The posterior tibial nerve passes behind the medial malleolus next to the posterior tibial artery. The posterior tibial nerve is one of the major nerves for the foot, and supplies most of the volar aspect of the foot and toes. The other posterior nerve, the sural nerve, runs subcutaneously between the lateral malleolus and Achilles tendon. It supplies the lateral aspect of the foot, including the volar and dorsal aspects. The superficial peroneal nerve supplies sensation to the dorsum of the foot. The superficial peroneal nerve runs anterior to the fibula and divides into many branches located superficially between the lateral malleolus and extensor hallucis longus tendon. The deep peroneal nerve passes through the ankle over the interosseus membrane and runs adjacent to the anterior tibial artery and under the extensor hallucis longus tendon. It supplies sensation to the web space between the second and big toes. The saphenous nerve is found superficially with the saphenous vein between the medial malleolus and the tibialis anterior tendon. The saphenous nerve supplies the medial aspect of the foot by the arch.

Arteries. The main arterial supply to the foot is from the anterior and posterior tibial arteries, which arise from the popliteal artery just below the knee. The posterior tibial artery passes behind the medial malleolus and divides into the medial and lateral plantar arteries. The anterior tibial artery runs just over the interosseus membrane and forms the dorsalis pedis on the dorsal surface of the foot. The plantar arch is formed by anstamosis of the lateral plantar artery and the dorsalis pedis.

Evaluation of the Foot

Clinical History. Patients with foot complaints should answer the usual questions on mechanism of injury: time and place of event, activity involved at time of injury, location and quality of pain, ability to bear weight, and if a "pop" or "crack" was felt. Different mechanisms of injury suggest different types of injury patterns. For example, dropping a heavy object onto the foot suggests metatarsal fractures, whereas stepping on a nail should prompt an evaluation for possible plantar foreign body. Any patient presenting with a foot infection and history of previous puncture wound has a retained foreign body until proven otherwise. Crush injuries to the foot are not rare and can result in loss of function and the ability to work. Any significant mechanism of injury should be taken seriously regardless of the initial appearance of the injured foot. Compartment syndrome is relatively common with these injuries, and patients may need to be observed for increased pain and swelling with loss of sensation. The patient's medical conditions also are very important. Diabetes, peripheral vascular disease, etc., all can affect sensation and circulation to the foot and have significant impact on risk and ability to respond to infection. Patients who are no longer ambulatory (i.e., spinal cord injury, elderly, etc.) are at significant risk for decubitus heel ulcers and should have their feet examined when seen in the ED even if there are no apparent complaints related to the feet.

Physical Exam. The patient's gait should be observed if he is able to walk. Next, the physician should observe for obvious deformity, swelling, ecchymosis, and evidence of vascular compromise. As always, obvious deformity, vascular compromise, amputation, etc., should not distract the physician from advanced trauma life support (ATLS) principles. The location of ecchymo-

Figure 2. Diagram of Lisfranc's Ligament

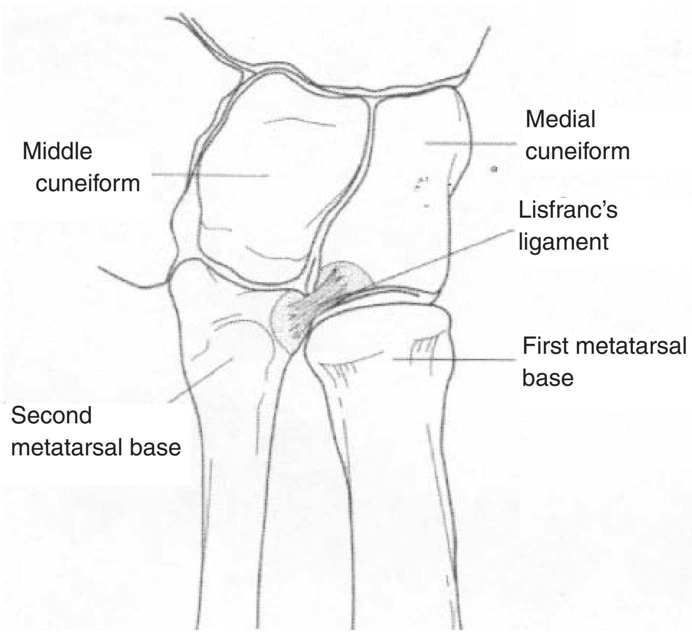

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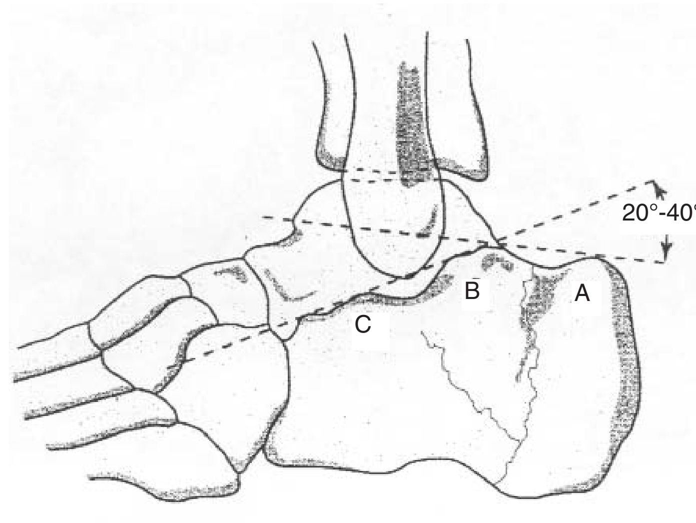
Figure 3. Bohler's Angle



Calculate by drawing two lines, one from the posterior facet (B) and the posterior tuberosity (C), and the other from the posterior facet (B) and the anterior process (A). Normal angles are between 20-40°. An angle lower than the opposite normal side by more than 5° is also considered abnormal.

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sis can be misleading as blood often tracks along tissue planes to pool in dependent areas. The patient's actual injury may be proximal to the location of the visible blood. If no obvious trauma is evident, the patient should identify the sites of maximal pain. As with a good abdominal exam, the physician should begin palpation of the foot away from areas of reported pain and slowly move toward the affected areas. Neurovascular exams should include dorsalis pedis and posterior tibial pulses, evaluation of gross sensation, and motor function. The entire leg from knee to toe should be exposed to ensure adequate exam and detection of associated injuries. The entire foot should be palpated for crepitus both in injury and cases of infection. Particular attention should be given to sites of common injury, such as the proximal end of the fifth metatarsal. The physician also should examine the ankle because, as described in Part I of this article, there may be combined injuries of the foot and ankle. When lacerations are present, one may examine for evidence of tendon injury by performing range of motion tests similar to examination of the injured hand. The uninjured foot may be used for comparison. Keep in mind that presence of motion does not always rule out a significant tendon laceration. While normal strength will not be intact, only 10% of the tendon needs to remain intact for motion to be present.

Foot Imaging

The standard set of plain foot films includes an AP, lateral, and 45° oblique views. The AP view is best for identifying injuries of the forefoot and midfoot. Injuries of the hindfoot and retained foreign bodies are best seen on the lateral view. Calcaneal (Harris) views may be needed in evaluation of suspected calcaneal fracture. Bohler's angle can be calculated from any lateral view of the calcaneus. (*See Figure 3 and the section on Calcaneal Fractures.*)

The Ottawa ankle rules, as described in Part I of this article, can aid in the decision to order films of the foot as well. The third Ottawa rule (*see Table 1*) states a foot x-ray should be ordered for tenderness over the proximal fifth metatarsal or over the navicular bone. One should keep in mind that injuries of the forefoot and hindfoot are not covered by the Ottawa rules, and the foot films should be obtained for suspected injury of these areas.

Unfortunately foot films can be very difficult to read accurately. There are many overlapping bones that can hide fractures, and many foot fractures are minimally or non-displaced. Bone scans are still considered by some as the gold standard for diagnosis of stress fractures, but magnetic resonance imaging (MRI) appears to be taking its place for stress fracture evaluation.[2] Although not routinely ordered in the ED, computed tomography (CT) and MRI scans may be required to fully and accurately define foot injuries. As with the ankle, CT scans in general are better for bony injury and MRI for soft tissue (i.e., tendon or foreign body) evaluation. In most cases, one should contact the consultant who will see the patient at follow-up before ordering CT or MRI as many orthopedists will wait to perform these tests as outpatient

Table 1. Ottawa Ankle Rules

THE RULES

Ankle x-rays are ordered when there is:

- Bony tenderness along the posterior edge or distal 6 cm of either malleolus.
- Inability to bear weight for at least two steps with each foot immediately after the injury and at the time of evaluation.

Foot x-rays are ordered when there is:

- Bony tenderness over the navicular or at the base of the fifth metatarsal.

THE EXCEPTIONS/LIMITATIONS

- Rules were developed only for patients age 18-55 years.
- Does not apply to pediatric patients
- Mechanism of injury only applies to acute blunt trauma.
- Does not apply to subacute or chronic injuries
- Does not apply to injuries of hindfoot, forefoot

studies. It is important to stress (and document) to the patient that the evaluation of the foot is not complete yet at time of ED discharge, and that further testing may uncover undetected and serious injury. One easy way to document this is to write on the patient's discharge instructions to, "See Dr. X as scheduled for further evaluation, diagnosis, and treatment."

Foot Fractures

Foot fractures are neither very common nor especially rare. Fractures of the foot bones account for 10% of all fractures. The calcaneus has the most fractures of the hindfoot, and the navicular is the most commonly fractured bone of the midfoot. The proximal fifth metatarsal is the bone most often fractured in the forefoot. Foot fractures may heal without permanent disability, but many cases can result in prolonged and incomplete recoveries. Foot fractures in industrial workers are second only to hand fractures in length of disability.[3] In some cases, such as Lisfranc fractures, delay of diagnosis and treatment can significantly contribute to poor outcomes.

Avoiding Misdiagnosis. Fractures of the foot can be hard to diagnose by plain film alone in the ED. Many fractures are non-displaced and overlapping bones on x-ray easily can hide them. Further, some extra-articular talar fractures easily can be misdiagnosed in the ED as ankle sprains. (*See sections on Ankle Sprain in Part I and on Talar Fractures in this issue.*) They include talar dome fractures and lateral or posterior process talar fractures. Early detection allows treatment with a short-leg cast and non-weight bearing for four weeks, but early detection in the ED is problematic. Many of these fractures will not be evident on plain films, but require CT or MRI for exact diagnosis. Lisfranc injuries also easily can be misdiagnosed (*see the section on Lisfranc Injury*) because clinical and radiographic signs can be subtle even with substantial damage. Perhaps the biggest clinical clue for Lisfranc injuries is the location of pain (midfoot) and difficulty bearing weight after a twisting injury.

In the end, the ED physician cannot correctly diagnose every foot fracture that presents. The physician should spend a few extra moments with patients who present with significant symptoms (i.e., swelling or inability to walk) or worrisome location of injury (i.e., midfoot). Patients should be informed that further tests and diagnosis may be needed under the care of an orthopedist to fully understand what has happened to the foot. It should be reiterated that the nature of many foot injuries prevents accurate diagnosis in every case on the first try. It is hoped that providing a realistic explanation will help the patient to have realistic expectations about the injury. The importance of follow-up and potential for long-term disability should be mentioned and documented as well.

Open Fractures. Open foot fractures are not as common as open ankle fractures, but still are seen regularly in busy EDs. A small but important source of open fractures is lawn mower injuries. According to the Centers for Disease Control and prevention (CDC), 25,000 people per year are injured by riding lawn mowers alone. Up to 20% of these injuries involve children, and most patients endure multiple surgeries and prolonged treatment often resulting in partial or complete amputation. Making matters worse, when children are injured, usually a parent is running the mower, thereby adding complex social problems to an already devastating situation.

In general, open foot fractures can be treated like other open fractures. Open fractures are true surgical emergencies, and definitive care may be delayed only long enough to treat life-threatening injuries. Care in the ED involves reducing infection risk, reducing fractures producing vascular compromise, and consultation for admission or transfer for definitive care. Gross debris should be cleaned by copious irrigation before any reduction attempts. If there is no evidence of vascular compromise, orthopedic consultation should be obtained before reduction. Patients at high risk for compartment syndrome (i.e., crush injuries) should be monitored for signs of this while in the ED, as the presence of open fractures does not prevent its development. Tetanus coverage is given when indicated, and antibiotics are used based on a general scale that considers the degree of soft-tissue damage and contamination. Type I open fractures have clean wounds less than 1 cm and minimal soft-tissue damage. Type II open fractures have moderately contaminated wounds greater than 1 cm and less than 10 cm with moderate soft-tissue injury. Type III open fractures are grossly contaminated with greater than 10 cm wounds. As the risk of infection increases with the type of open fracture, so does antibiotic coverage. Type I open fractures are given cephalosporin, cefazolin 1-1.5 g IV). Add an aminoglycoside (gentamycin 5 mg/kg IV adult loading dose) for Type II injuries. Penicillin G (4 million units for average adult) should be given for triple coverage in Type III injuries or Type II injuries with soil/farm contamination to treat for *Clostridium perfringens*.[4]

Hindfoot Fractures. *Calcaneal Fractures.* The calcaneus is the largest bone in the foot as it acts as a major foundation during weight-bearing, and as a fulcrum for attachment of the Achilles tendon and calf muscles. It is also the most commonly fractured of the hindfoot and midfoot bones.[5] Calcaneal fractures account for 60% of all foot fractures and are associated with substantial disability. Unfortunately the outcome Cotton and Wilson stated in 1916 “the man who breaks his heel bone is done” was still the norm as late as the 1940s.[6] The reasons for this are that up to 75% of calcaneal fractures are intra-articular,[7] most are comminuted, surgical repair is challenging, and the calcaneus is very important for normal walking. Further, up to 90% of these fractures occur in men in their prime working years,[8] and their overall outcome is poor compared to other intra-articular fractures. Patients routinely take up to two years to return to full activity, and many never return to work at all.[9]

The normal anatomy of the calcaneus contributes to the primary functions of the calcaneus. Intact calcaneal structure and alignment beneath the tibia provide a foundation for transmission of the body’s weight down through the tibia, ankle, and subtalar joints. Displacement of the body of the calcaneus can result in eccentric weight distribution in the foot and deformities about the ankle joint. The calcaneus is a three-dimensionally complex bone and has several articular surfaces or facets with the talus and cuboid. The anterior half of the calcaneus contains four facets. The posterior facet is the largest and is the major weight-bearing surface of the calcaneus. The relationship of the calcaneus to the talus is intricate and changes in positioning of the facets greatly alter subtalar joint mechanics. Thus, some extra-articular fractures that affect the facets may act as intra-articular fractures in terms of complications. Given this intricate relationship, a truly anatomic fracture reduction is difficult and may account for the poor outcome in treating these injuries. Most calcaneal fractures are the result of sudden, forceful axial loading. The calcaneus is situated lateral to the weight-bearing axis of the lower extremity at its point of contact with the subtalar joint. As an axial load is applied to the posterior facet of the calcaneus through the talus, shear forces are directed through the posterior facet, resulting in a fracture line through the medial aspect and the anterolateral wall of the calcaneus. Unlike most other bones, fracture lines are not consistent from patient to patient. Although many have been proposed, classification schemes for calcaneal fractures clinically are not useful due to the infinite number of fracture patterns with varying displacement.

Calcaneal fractures should be grouped into those caused by either high energy injuries or by repetitive weight-bearing activities (stress fractures). Stress fractures are less common in the general population, but commonly are seen in military recruits. The patient may present with persistent heel pain, swelling, and tenderness to palpation but be able to bear weight. Like all stress fractures, they may be difficult to see with plain films. Patients should be discharged for follow-up with a bulky soft dressing, crutches, and RICE (rest, ice, compression, elevation) guidelines. Treatment is conservative, and most stress fractures resolve several weeks after cessation of the precipitating activity.

In contrast, presentation of high energy fractures is much more dramatic. Most patients will present with history of a fall or motor vehicle accident (MVA) combined with immediate heel pain, swelling, and ecchymosis on physical exam. Weight-bearing is usually unbearable. When a calcaneal fracture is diagnosed, the physician should remember to search for associated injuries. Up to 7% of patients have contralateral calcaneal fractures, and 10% have vertebral compression fractures.[10] Another 26% have other injuries of the lower extremity such as ankle or tibia fractures.[10] Forearm, femur, and elbow fractures also are common, as are internal injuries such as aortic rupture, etc.

It is clinically important to distinguish between extra-articular and intra-articular subtalar joint involvement. Non-displaced extra-articular fractures have a better prognosis and generally will heal well with bulky compression dressings, rest, ice, elevation, nonsteroidal anti-inflammatory drugs (NSAIDs), and orthopedic follow-up. However, the more common intra-articular fractures, accounting for 70-75% of calcaneal fractures, have an increased incidence of posttraumatic arthritis, nerve entrapment syndromes, long-term pain, loss of mobility, and functional disability.[10] Plain foot or ankle series usually show intra-articular fractures best on lateral views, but some fractures may be difficult to see without CT. When the patient can tolerate it, calcaneal (Harris) views also should be obtained as they show the subtalar joint in more detail. Bohler’s angle is measured on the plain lateral foot (or ankle) film, and can be helpful to identify subtle intra-articular fractures. To calculate Bohler’s angle, draw a line between the posterior facet and the posterior tuberosity and another through the posterior facet and the anterior process. (*See Figure 3.*) The angle of these intersecting lines is normally between 20-40°. If the angle is less than 20°, or more than 5° smaller than that of uninjured side, a depressed fracture is present. Given the limits of plain films for assessing calcaneal fractures, CT quickly has become the gold standard for imaging. While plain films may underestimate damage, the three-dimensional features of the calcaneus are more fully apparent on CT. Thus, CT scanning has become essential for pre-operative planning.

Urgent orthopedic consultation is required for all intra-articular calcaneal fractures and displaced extra-articular fractures. Treatment of these fractures used to be conservative, but recent data has suggested that open reduction with internal fixation (ORIF) improves outcome.[11] Improvement with surgery in patients with bilateral fractures is reported as patients with non-operative treatment were six times more likely to undergo subtalar fusion.[12] Controversy still exists, as other authors suggest that clear benefit for ORIF has not been established.[13] The most recent studies suggest that unless good anatomic reduction is obtained through surgery, the outcome may not be improved over non-operative treatment.[8] Current orthopedic texts state that regardless of whether treatment with immobilization and casting or ORIF is chosen, there remains a 50% incidence of long-term pain and functional disability after an intra-articular calcaneus fracture.[13] Ultimately, whatever treatment is employed, it appears that the more severe the fracture (more comminuted, lower Bohler’s angle, higher energy mechanism) the worse the prognosis. Common complications include infection from surgery or open fractures, chronic pain, swelling, deformity, subtalar arthritis, and compartment syndrome. Compartment syndrome is relatively common with calcaneal fractures and occurs in up to 10% of displaced fractures.[8] Any patient diagnosed with a calcaneal fracture should be given warning signs to watch out for, and any patient presenting with increasing pain after a fracture should be evaluated for compartment syndrome. Only rapid diagnosis and emergent surgery will prevent the sequelae of clawed toes and painful nerve dysfunction.

Talar Fractures. The word "talus" is derived from the Latin word taxillus (dice) which dates back to the Roman Empire when soldiers used ankle bones of horses for dice.[14] The talus is a unique bone for several reasons. It acts as the link between the leg and the foot with critical articulations between the tibial plafond above, the distal calcaneus and anterior navicular below, and the malleoli laterally. More than 90% of the motion of the foot and ankle occur through these articulations. The talar dome makes up the distal half of the ankle joint, and injuries to it can appear as a simple sprain in the ED. Although a small bone, the talus bears the entire body's weight. In fact, it supports more weight per unit area than any other bone. Due to the high stress load, the talus frequently is injured. It is the second most common tarsal fracture,[15] and fractures often involve multiple joint surfaces.[10] Articular cartilage covers 60% of its surface and nearly 100% of the body, yet the talus has no tendinous originations or insertions. It is held in place only by its ligaments and the malleoli. The neck is the only part with little cartilage or articulations so the blood supply for the entire bone enters primarily through the neck region. Since 50% of major talar fractures occur here, blood supply is disrupted frequently and easily, giving a high incidence of avascular necrosis (AVN) with talar injuries.[16] The anterolateral talar dome is the area with the most tenuous blood supply, and injuries here also have a high incidence of osteonecrosis.

Minor Talar Fractures. Talar fractures can be thought of as minor or major. All talar fractures require consultation with an orthopedist in the ED or discussion for early follow up as an outpatient. Minor fractures are low energy injuries and include talar dome fractures and chip fractures of lateral or posterior process. Major fractures are high energy injuries and include obvious fractures of the neck, body and head. Minor fractures account for 80% of all talar fractures[17] and easily can be misdiagnosed as "just an ankle sprain."

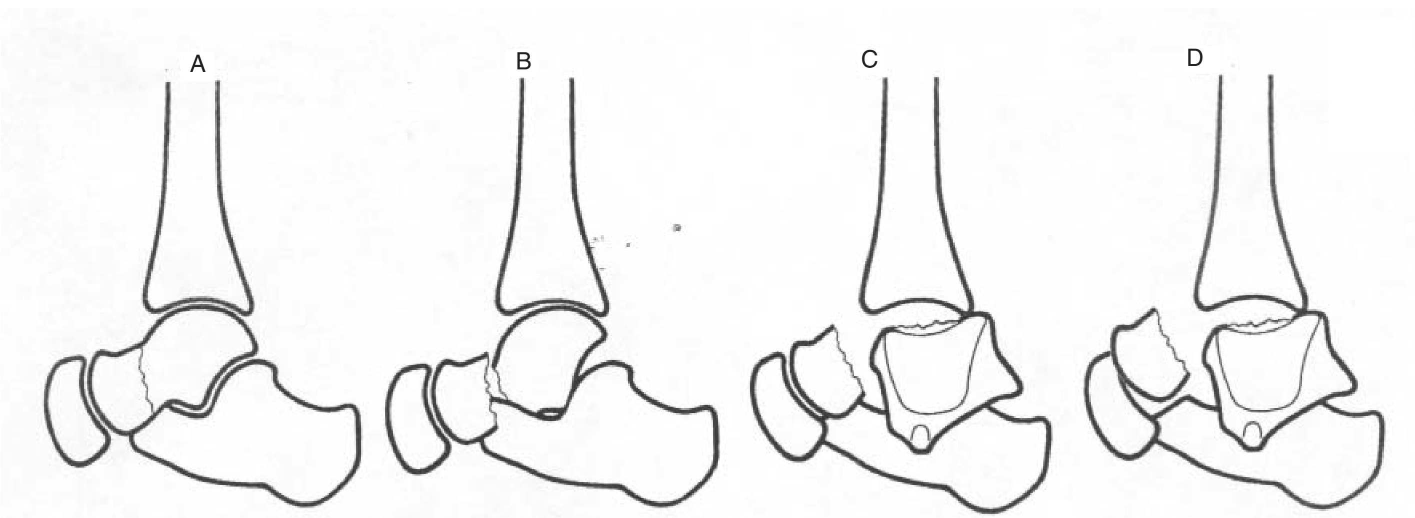
There are several reasons why minor talar fractures easily are missed in the ED. They result from forced inversion or, less commonly, eversion of a dorsiflexed ankle. This is exactly the same mechanism that produces the much more common lateral ankle ligament sprain. As a result, patients with minor talar fractures also may have a lateral ligament injury, which may confuse the ED physician. Further, radiographs usually are unremarkable. Most of these fractures will be diagnosed only on CT/MRI or on plain film after bony degeneration is evident. As uncomplicated lateral ligament sprains are much more common than minor talar fractures, the physician may feel that he or she essentially is looking for the proverbial needle in the haystack trying to diagnose these fractures. Thus the question arises, "How can one find these fractures if plain films usually are negative?" The answer is that one cannot, but in the end just being aware of them and looking for the patients who can be diagnosed by plain film in the ED can be a good first step. Next, consider the clinical findings. While one cannot CT every ankle sprain, it could be considered in patients who present with dramatic physical findings (i.e., Grade III ankle sprain) strongly suggesting fracture who have no fracture evident on plain films. Severity of pain also can be used. Mayer described an interesting clinical feature of talar fractures in a series of five patients, all with relatively minor trauma. He observed that pain out of proportion to that expected based on the mechanism of the injury, physical exam findings, and radiographs was highly associated with talar fractures.[18] The physician should pay close attention to the degree of the patient's pain and have a high index of suspicion for possible occult fractures of the talus. It also is important to consider these diagnoses in patients who have suffered a severe ankle sprain and have persistent pain after several weeks of conservative treatment.

Talar dome fractures are divided into four classes by severity. Class I injuries are small compression fractures seen only on MRI. Class II injuries have a partially detached bony fragment, while in Class III injuries the fragment is fully detached but nondisplaced. Class IV fractures produce a completely displaced bone fragment loose in the joint. Class I-III fractures usually are treated using a below-the-knee cast or posterior splint. Currently, no evidence supports that the avoidance of weight bearing holds any advantages over weight-bearing while casted. Class IV fractures are associated with an increased risk of nonunion, malunion, and avascular necrosis of the displaced fragment secondary to vascular disruption.[18] Displaced fragments 5 mm in diameter or larger may require excision or reattachment.[19]

Lateral (and posterior) process fractures, like talar dome fractures, easily are confused with a simple ankle sprain. They are caused by inversion injuries, can have associated ligament injuries and are not easily seen on plain films. CT or MRI may be needed to actually diagnose these fractures. The lateral process projects from the lateral talar body just beneath the lateral malleolus. It articulates with the distal fibula (lateral malleolus) and also helps compose part of the subtalar joint. The anterior talofibular (ATFL) and talocalcaneal ligaments originate here explaining why injury can be confused with a lateral ankle sprain. The ATFL is the most commonly injured ankle ligament, and a lateral process fracture is simply an avulsion injury of this ligament. CT scan allows accurate sizing of the fracture fragment, and sizing determines treatment. Larger fractures are more likely to involve the posterior facet and are treated more aggressively. Fractures larger than 1 cm and displaced greater than 2 mm usually are treated surgically.[20] Displaced fractures have a high frequency of non-union unless surgically repaired. Small comminuted fractures can be excised. Non-displaced fractures can be treated with non-weight bearing casts for 4-6 weeks. Note that this is a much longer and more aggressive treatment than for simple lateral ankle sprain. This underscores the importance of identifying these fractures when they present the first time.

The posterior process is found on the posteroinferior aspect of the talar body and, unlike the lateral process, is non-articular. It actually has two tubercles, the medial and lateral. The flexor hallucis longus tendon runs between the two tubercles, and fractures

Figure 4. Hawkins Classification of Talar Neck Fractures



Type 1 are the only fractures routinely treated without surgery and the only ones with low incidence of AVN (< 10%).
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can injure the tendon. Synovitis in this area is common in ballet dancers because of repetitive toe-pointing. The os trigonum, a relatively common accessory bone, is located just over the process and can be considered an unfused portion of the lateral tubercle. Nearly 60% of people will have a second os trigonum on the other foot, and films of the uninjured foot may be helpful. The posterior talofibular ligament (PTFL) attaches to the lateral tubercle, and the medial tubercle has attachments of the talocalcaneal and posterior deltoid ligaments. Avulsion of the posterior process by the PTFL (also called a Sheppard's fracture) occurs from inversion injuries of the ankle and can be a difficult diagnosis for all the same reasons as lateral process avulsions. Pain with flexion of the great toe can clinically help identify fractures as tendon movement over the fracture site is irritating. As with lateral process fractures, minimally displaced fractures will be treated with 4-6 weeks of casting with non-weight bearing. Unlike lateral process fractures, they are non-articular and surgery is only done for persistent pain.

Major Talar Fractures. Major fractures of the talus usually are seen on initial radiographs and can be divided into three classes based on the location of the fracture: neck, body, and head fractures. Talar neck fractures are the most common, accounting for 50% of all major talar fractures.[10] Talar neck fractures were first described in the 1600s, and their management was fraught with complications. In the early 1900s the term "aviator's astragalus" described a then common talar (formerly referred to as the astragalus) fracture seen in pilots that crashed World War I planes with their feet applying pressure to the rudder pedals.[21] Currently, forceful braking in high speed MVAs or falls from a height are the most common mechanism for fracture. The talar neck is fractured as a sudden axial load is applied to the foot in extreme plantarflexion.

Hawkins first described a classification of talar neck fractures in 1970.[22] (*See Figure 4.*) His system is still used today as it accurately predicts the treatment indicated and the prognosis (risk of AVN) for each fracture class. Of further note, he found a 26% incidence of associated medial malleolar fractures. Diagnosis of a medial malleolar fracture should prompt a closer look at the talus, as well as the proximal fibula (Maisonneuve fracture). Type I fractures are vertical neck fractures without displacement. Type II fractures are vertical neck fractures with displacement (no matter how small), but the body of the talus is still in the ankle joint. Type III fractures are vertical neck fractures associated with dislocation of the talus from the ankle joint (tibiotalar dislocation). The Type IV fracture is a type III fracture plus disruption of the talonavicular joint and talocalcaneal joint (i.e., total talar dislocation), and is fortunately very uncommon.

Treatment of talar neck fractures is also based on the Hawkins classification. The majority of fractures are treated with ORIF. Only stable, non-displaced Type I fractures in compliant patients are treated without surgery. The patient is non-weight bearing for 4 weeks, and then placed in a walking cast for another eight weeks. CT is required to diagnose Type I fractures, as only those with less than 1 mm displacement and no incongruity of the subtalar joint are considered Type I. These subtle changes cannot be excluded with plain films.

AVN is a major complication of talar neck fractures and also is predicted by the Hawkins classification. All talar neck fractures can be associated with disturbances of the vasculature, and therefore any talar neck fracture can result in AVN. It is more likely with more severe fractures, as disruption of the talar articulations virtually ensures loss of blood supply. Thus the risk of AVN increases with each type of fracture. Type I fractures carry a risk of 0-13%; Type II 20-50%; Type III 40-80 %; and Type IV the highest risk of nearly 100%.[23] Appearance of the Hawkins sign, or patch subchondral osteoporosis under the talar dome at 6-8 weeks of healing is a good prognostic indicator. This is evidence enough blood supply has survived to allow normal bone healing. Patients with this sign have very little subsequent AVN. Even without AVN, many patients still suffer from subtalar arthritis as a later complication.

Talar body fractures make up 15-20% of talus fractures, and talar head fractures make up an additional 5-10%.[14] Although less common than neck fractures, they are caused by the same mechanisms. Talar body fractures can be simple shear fractures (horizontal, coronal, or sagittal) through the body of the talus or comminuted. They may be difficult to diagnose adequately without CT imaging. Body fractures carry an even higher incidence of AVN than neck fractures as there is greater likelihood of vascular disruption. Horizontal fractures carry a 100% risk of AVN of the talar dome.[24] Body fractures also carry a high risk of subtalar arthritis from displacement of the posterior facet from the subtalar joint. Treatment is with ORIF. Talar head fractures result from axial compression of a plantar flexed foot, or from talonavicular joint dislocation. They can be associated with other fractures of the foot, and tenderness in the talonavicular area is the best clinical clue. The talar head is best seen on the mortise view. Unlike other talar fractures, the incidence of AVN is low with these injuries. Orthopedic consultation is required as some head fractures are treated with casting and others with ORIF.

Talar Dislocations. Talar dislocations are usually only subtalar and less often total (i.e., including both subtalar and tibiotalar joints). Total dislocations are often open, devastating injuries fraught with complications, including AVN, infection, and arthritis. Subtalar dislocations leave the ankle joint intact but have disruptions of both talonavicular and talocalcaneal joints. Subtalar dislocations are not common overall and only account for about 1% of all dislocations and 15% of talar injuries.[14] However, the incidence of subtalar dislocations has been increasing during the last decade.[25] Subtalar dislocations can be anterior or posterior, but these are rare. Lateral dislocations account for 15% of cases and medial dislocations for 85%. Falls and MVAs account for many of these injuries, but basketball also causes enough cases for medial dislocations to be known as basketball foot. About 10% of dislocations will be open, and fractures are seen in nearly 50% of cases.[14] The deformity is obvious on physical exam, but neurovascular compromise is unusual. Plain films are recommended as most ED physicians cannot define the type of dislocation (subtalar vs talar) just by physical exam. Reduction should not be delayed, however, as skin tenting is common and can complicate treatment for the orthopedist if not corrected. Closed reduction is possible with 90% of medial and 80% of lateral dislocations. Cases requiring open reduction usually are due to entrapment of soft tissue (i.e., joint capsule, tendons) which prevent reduction. With either conscious sedation or general anesthesia, the knee is flexed, and longitudinal traction applied to the foot. First accentuate the deformity, then apply force in the opposite direction. CT imaging is recommended after reduction to assess reduction and further identify associated injuries. One study found that while plain films identified the dislocation in all patients, 100% had new injuries found on post-reduction CT, with 44% of these injuries altering patient management.[26] Patients will be in short leg casts from 3-4 weeks. AVN is rare after subtalar dislocation as some of the blood supply remains intact, but infection complicates 30% of open dislocations despite aggressive early treatment. Unfortunately the majority of patients will experience chronic problems, with subtalar stiffness being the most common complaint.[25] This is not a minor complication as 90% of the motion of the foot and ankle involves the subtalar joint.

Midfoot Injuries

The midfoot is made of five small bones—the navicular, the cuboid, and three cuneiforms. These bones help form the transverse arch and medial longitudinal arch of the foot and provide a stable connection between the forefoot and the mobile hindfoot. The inherent stability of the midfoot makes injury less common than for the hindfoot or forefoot. In fact, joints of the midfoot often are fused surgically to aid in the treatment of other midfoot injuries.[1] Midfoot injuries can be especially difficult to diagnose for several reasons. Besides being infrequent, pain from these injuries is poorly localized, and fractures are difficult to see on plain films. This leads to a delay in diagnosis of 41% of midfoot injuries.[14] Although each bone in the midfoot will be discussed, the two most important injuries to identify are navicular fractures and Lisfranc injuries.

Navicular. The navicular is the most commonly fractured midfoot bone. It is a disc-shaped bone that articulates with the three cuneiforms distally and the talus proximally. So much of the navicular surface is articular and therefore covered in cartilage so that its blood supply enters through a relatively small area. The middle third of the navicular is relatively avascular and at high risk of AVN as a fracture complication. The navicular bone can be problematic for ED physicians because it is the keystone of the medial longitudinal arch, but navicular injury is difficult to diagnose as fractures are not easily seen on plain films in the ED. Unfortunately, a delay in diagnosis and treatment can lead to prolonged recovery and potentially disabling chronic pain.

Navicular fractures are divided into dorsal avulsion, tuberosity, and body fractures. Dorsal avulsion fractures are the most common type, accounting for 47% of navicular fractures.[14] Both avulsion and tuberosity fractures result from eversion injury, and can be misdiagnosed as simple ankle sprains. Tenderness over the navicular area is not expected in simple ankle sprain and should be a clue to the ED physician that navicular injury may be present. Tension on the deltoid ligament can cause an avulsion fracture, and the tuberosity can be fractured by tension on the posterior tibial tendon attachment. Both avulsion and tuberosity fractures are treated conservatively with a short leg walking cast with good arch support for 4-6 weeks. The exception is when a tuberosity fracture is displaced by greater than 1 cm, which requires operative repair. While tuberosity fractures can be complicated by non-union, avulsion and tuberosity fractures do not result in AVN and are less serious fractures than navicular body fractures.

Navicular body fractures can be occult stress fractures or obvious displaced fractures. Stress fractures are seen most commonly in athletes, where they make up 28% of stress fractures.[27] Stress fractures have been notoriously difficult to diagnose, and navicular stress fractures are no exception. One study found an average delay of seven months between occurrence of the fracture and its diagnosis.[27] Sports that require rapid changes in direction or sudden explosive movements are risk factors for navicular stress fractures, with the highest incidence seen in jumping and sprinting events. Patients usually give a history of weeks to months of vague midfoot pain that gets better with rest, but resumes with return of activity. Sudden movements requiring forceful push-off from the ground seem to cause the worst pain, as they maximize axial loading on the navicular bone. Physical exam will reveal point tenderness over the lateral half of the navicular bone and mild swelling in some cases. Plain films as a rule do not show the fracture, and bone scan, CT, or MRI are required to make the diagnosis. Stress fractures are treated with strict non-weight bearing casts for six weeks, followed by gradual return to activities. Persistent pain and the appearance of bone cysts after this course suggest delayed or non-union, or AVN. Surgical treatment then may be needed, including a combination of internal fixation, curettage, and bone grafting.

Obvious, comminuted body fractures are the worst kind of navicular fracture, but fortunately the least common as well. They result from hyperextension, extreme flexion and rotation, or axial loading. Common mechanisms include motor vehicle accidents, falls, or direct crush injuries. Other midfoot injuries (midtarsal or Chopart's joint dislocations) are found commonly in combination with a severe body fracture. Non-displaced fractures can be managed with casting alone, but all navicular body fractures with 1 mm or more of displacement require open reduction and internal fixation. AVN is a common complication, and all body fractures seen in the ED should have urgent orthopedic consultation.

Cuboid and Cuneiform Fractures. Cuboid fractures are especially rare, and physicians must have a high index of suspicion to make the diagnosis. The most common mechanism of cuboid fracture is direct trauma from a crush injury. One should consider cuboid fracture in the patient who sustains a foot injury involving a moderate to severe amount of force, such as a fall from height or a motor vehicle collision, associated with lateral midfoot tenderness and difficulty bearing weight. The classic cuboid fracture is known as the nutcracker fracture. The cuboid is crushed like a nut between the superior part of the calcaneus and the base of the fourth and fifth metatarsals when the forefoot is violently everted on the hindfoot. The nutcracker fracture is often associated with injury to the peroneus longus tendon. Lisfranc injury (see next section) also commonly is associated with cuboid fracture and should be considered present until proven otherwise (usually by the consultant). Non-displaced cuboid fractures are treated with a short leg walking cast with good arch support for six weeks. Afterward, arch support should be maintained with an orthotic for up to six months. All displaced cuboid fractures or dislocations need reduction because the cuboid has a critical role in maintaining the integrity of the lateral column of the foot. Surgery often is required to obtain adequate reduction, and all displaced fractures should be referred for orthopedic management.[1,10]

Cuneiform fractures are extremely uncommon and usually result from a crushing type injury or other direct trauma. Again as with cuboid fractures, Lisfranc injury is a common associated injury. Treatment usually consists of immobilization with a short leg walking cast for six weeks. Early orthopedic involvement is warranted in any displaced fracture or fracture dislocation.[1]

Lisfranc Injury. Lisfranc's joint, or the tarsometatarsal (TMT) joint, separates the midfoot and forefoot. Jacques Lisfranc was a field surgeon for Napoleon's army in the early 1800s. The joint now bears his name, as he was the first surgeon to describe amputations through it. His approach saved time, as previously surgeons cut through the metatarsals. He used this technique to treat gangrene from frostbite, but more importantly he also treated midfoot dislocations that soldiers developed after falling from their horses and twisting their feet in the stirrups. Although Lisfranc did not describe the injury pattern his name now describes, he undoubtedly encountered them.

Lisfranc injury is a broad term that refers to fractures, fracture/dislocations, and sprains of the TMT joint. These injuries are particularly challenging for the ED physician. They are not very common, accounting for less than 1% of all orthopedic trauma cases, or 1 in 55,000 persons per year.[28] About 20% of cases are missed on first presentation to the ED.[29] While severe injuries are more obvious on plain films, many Lisfranc injuries, especially spontaneously reduced dislocations, can be very difficult to see on ED films. Finally, early diagnosis and good anatomic reduction are essential for optimizing outcome for these patients. Delay in treatment can dramatically increase disability.

Understanding the complex anatomy of the TMT (Lisfranc's) joint is crucial for appreciation of Lisfranc injuries. Lisfranc's joint joins the relatively rigid midfoot to the more flexible forefoot. The proximal ends of the metatarsals are trapezoid shaped and form the transverse arch of the foot much like a classic Roman arch. The second MT is the longest of the five MTs and is the keystone of the arch. Strong ligaments join the bases of the second through fifth metatarsals to help support the arch. The tibialis anterior and peroneus longus tendons, plantar fascia, and dorsal and plantar ligaments also stabilize the joint. The actual Lisfranc ligament attaches the second metatarsal base to the medial cuneiform. (*See Figure 2.*) At 1 cm wide, the Lisfranc ligament is the broadest and thickest of the TMT ligaments. The combination of the strength of the Lisfranc ligament and the keystone placement of the second MT make this area the essential component of Lisfranc's joint. Injury here will disrupt the entire transverse arch's shape, produce a flat foot, and dramatically alter the patient's biomechanics of walking.

Lisfranc injuries can be caused by low-energy or high-energy mechanisms. Low-energy injury tends to occur during sports while high-energy injury results from MVAs and industrial accidents. Sports where the forefoot is fixed (i.e., horse riding stirrups or windsurfing) increase risk of twisting or rotational forces around the Lisfranc joint. High-energy Lisfranc injuries are more common, and 80% will have associated injuries to the MTs, cuneiforms, or the cuboid.[28] Any foot injury that produces a fracture of the second MT base or multiple fractures of the MT bases should be considered a Lisfranc injury and referred to the orthopedist for confirmation. Even though most authors state that great energy is required to injury Lisfranc's joint, up to one-third of Lisfranc injuries seem to occur from apparently insignificant mechanisms such as slips and minor falls.[30]

Clinical presentation is highly variable from an obviously deformed foot to a minimally injured foot. In general, physical exam will reveal severe midfoot pain, inability to bear weight, pain with pronation and passive abduction of the forefoot, and tenderness along the TMT joints.[10] Ecchymosis of the plantar midfoot is a significant physical sign of Lisfranc injury and should heighten suspicion. Plain films also can vary from dramatically apparent injury to damage that only is evident on weight-bearing films. As plantar ligaments are stronger than the dorsal ligaments dislocations of the TMT joint usually occur dorsally, and are best seen on lateral views. Key findings to notice on plain films include: any widening of the space between the first and second or second and third MT bases, cuboid or cuneiform fractures, navicular compression fractures, or lateral shift of the fifth MT. Again, fracture of the base of the second MT should be considered pathonogmonic of Lisfranc injury. To help diagnose more subtle injuries, Stein[31] reported a method of reviewing radiographs suspicious for Lisfranc's injury. His criteria are based on preservation of normal anatomic alignments. A Lisfranc injury has occurred if any of the following are present:

1) The medial border of the fourth metatarsal does not form a continuous line with the medial border of the cuboid.

2) The lateral border of the third metatarsal does not form a straight line with the lateral border of the lateral cuneiform.

3) On AP view, the medial border of the second metatarsal does not form a continuous straight line with the medial border of the middle cuneiform.

4) The first metatarsal does not align itself medially and laterally with the medial cuneiform.

Ultimately, as with many other foot injuries, CT may be required to accurately diagnose Lisfranc injuries.

Classification schemes for Lisfranc injury are not essential for the ED physician, but are based on the direction of the MT base displacement in the horizontal plane. Homolateral injuries occur when all five MTs are displaced in the same direction. Divergent injuries occur when the first MT is displaced medially and the remaining MTs laterally. Isolated injuries occur when one or more MTs are displaced; usually only the first MT is displaced medially while the remaining are in normal position.

As the normal anatomic relationship of Lisfranc's joint is essential for proper function, it follows that altering such a stable joint has very serious consequences. Acutely, compartment syndrome can be common for crush injuries. Lisfranc injuries are prone to many delayed complications, including degenerative arthritis, biomechanical disruption of gait from acquired flat-foot deformity, chronic pain, and reflex sympathetic dystrophy. Recently the literature supports that in cases with little soft-tissue injury there is no correlation as one might expect with the degree of diastasis, pattern of displacement, etc., and outcome.[32] The outcome seemed to be determined solely by the accuracy of reduction. Thus, except for Lisfranc sprains (clinical findings or suspicion of injury with normal imaging) which are treated with six weeks of casting, nearly all Lisfranc injuries are treated with surgical repair. Percutaneous pinning or aggressive ORIF approaches seem to produce the best results when applied early[33] rather than later. Thus, accurate diagnosis of Lisfranc injuries in the ED is essential to help improve patient outcome. Orthopedic consultation, in the ED or by phone, is required for any suspicion of Lisfranc injury.

Forefoot Fractures

The forefoot is a common site for fractures and other injuries. It plays an essential role in the biomechanics of walking/running and injury here can produce permanent disability.

Metatarsal Fractures. MT fractures account for 35% of all foot fractures,[34] with most fractures resulting from either indirect twisting or direct crushing. MT fractures tend to be multiple in nature. Swelling, ecchymosis, tenderness over the involved metatarsal, and pain with weight bearing are common. Most fractures are well visualized with standard AP, lateral, and oblique radiographs. The first MT bears twice the weight of the others and fractures here are treated more aggressively. MT fractures can be divided into head/neck, shaft, base, and stress fractures.

MT head and neck fractures often result from direct trauma, usually are displaced, and are treated in a similar fashion as shaft fractures. They tend to displace in a plantar direction from the stronger pull of flexor tendons. Like shaft fractures, preservation of anatomic positioning is essential to maintain the transverse arch. Treatment with ORIF is needed more often than with shaft fractures to maintain reduction.

MT shaft fractures are treated based on their location and displacement. First MT shaft fractures are least commonly seen and produce the most severe consequences. Accordingly, non-displaced fractures are treated with a non-weight bearing cast for 3-6 weeks compared to weight bearing as tolerated with second through fifth shaft fractures. Any displacement of first MT shaft fractures is often treated surgically as well, and should have ED orthopedic consultation when diagnosed. Fractures of the second through fifth shafts that are more than 3 mm displaced or 10° angulated also require ED consultation for reduction.[14] Treatment of non-displaced or minimally displaced fractures of the MT neck and shaft of the second through fifth metatarsals are treated with stiff shoe, casting, or fracture brace. Prolonged immobilization should be avoided because it may be associated with reflex sympathetic dystrophy.

MT base fractures deserve special attention by ED physicians for several reasons. First, as mentioned above, any fracture to the second MT base or fractures to multiple MT bases should be considered a Lisfranc injury until proven otherwise by the orthopedist.

Orthopedic consultation (by phone or in person) is required while the patient is in the ED to ensure proper treatment and follow-up. The severe consequences of these injuries should be stressed to the patient. Secondly, fractures of the fifth MT base commonly are seen in the ED and also commonly are misdiagnosed. Two distinctly different fractures occur and often are both labeled as "Jones fractures." The distinction between a true Jones fracture and a pseudo-Jones fracture is very important for ED physicians to appreciate as treatment of fifth MT base fractures is based on the exact location of the fracture and differs dramatically.

In 1902, Jones originally described his own and a series of fractures to the fifth MT base obtained while dancing,[35] but it is unclear from which fracture he actually suffered. Currently, true Jones fractures are transverse fractures of the fifth MT base where the fracture line is 1.5 cm or more distal to the proximal tuberosity. Pseudo-Jones fractures are the more common avulsion fracture of the peroneus brevis tendon attachment. The fracture line for pseudo-Jones fractures is in the proximal 1.5 cm of the fifth MT base. The accurate diagnosis of these two fractures is very important as pseudo-Jones fractures can be treated with a hard sole shoe and weight bearing as tolerated, but true Jones fractures tend to displace with weight bearing and are treated with non-weight bearing for 5-6 weeks. As a result of the confusion, true Jones fractures go on to displace or develop non-union in up to 50% of patients.[14] Non-union is treated with ORIF and bone grafting. Thus, accurate diagnosis by the ED physician is crucial so that the patient receives the proper treatment for the type of fracture, and the consultant is not confused by misuse of these potentially confusing terms.

MT stress fractures are the most common type of stress fracture. Although the literature describes these primarily in military recruits and high-level athletes, they are seen in all types of runners, ballet dancers, and gymnasts. Disease such as rheumatoid arthritis, osteoporosis, renal disease, and chronic steroid use also predispose for MT stress fractures. Pain is dull and poorly localized at first, progressing to sharp pain over the fracture site. Pain usually is associated only with activity but worsens to constant pain. Initially plain films are normal, and signs of healing usually take three months to appear. Up to 50% of stress fractures are never visualized on plain films. Bone scans remain the imaging modality of choice for MT stress fractures. Treatment consists of avoiding any activity which causes pain, and immobilizing for comfort. Surgical intervention is typically not needed and is reserved for those who progress to painful non-union. ED physicians usually will not make the diagnosis of stress fractures but need to recognize the clinical history, educate and refer the patient appropriately.

Phalangeal Fractures and Dislocations

Phalageal or toe fractures are the most common of the forefoot fractures. Most are caused by direct blows either by hitting the foot accidentally while walking (often in the dark) or by dropping a heavy object. The proximal phalanx of the fifth toe is the most common toe fracture.[36] Most toe fractures are evident by clinical pain, swelling and ecchymosis and easily diagnosed on plain films. Fractures of the second through fifth toes can be managed with "buddy taping" to an adjacent toe. Gauze is placed between the splinted toes and secured with adhesive tape. Most phalangeal fractures are painful for two to three weeks, but if there is significant pain after splinting, immobilization in a short-leg walking cast for one to two weeks may provide some relief until callus formation stabilizes the fracture. Significantly displaced or angulated fractures require reduction in the ED after digital block. Great toe fractures more often benefit from a walking cast for 2-3 weeks for pain relief. Any displaced great toe fracture that cannot be reduced requires orthopedic consultation for possible ORIF.

Phalangeal dislocations of the MTP joints are relatively rare. While easily seen on most plain foot films, the dislocation may not be as easily seen clinically. First MTP dislocations are the exception but also may be more difficult to reduce. Irreducible dislocations, intra-articular fractures or unstable first MTP joint injuries should have orthopedic consultation in the ED. Otherwise, dislocations of the second through fifth toes should be reduced in the ED and heal well without consultation. IP joint dislocations are much more uncommon and more difficult to appreciate clinically. Longitudinal traction after digital block usually reduces most injuries, but again the great toe may be an exception.

References

1. Pinney S, Sangeorzan B. Fractures of the tarsal bones. *Orthop Clin North Am* 2001;32:21-33.
2. Spitz DJ, Newberg AH. Imaging of stress fractures in the athlete. *Radiol Clin North Am* 2002;40:313-331.
3. Courtney TK, Matz S, Webster BS. Disabling occupational injury in the US construction industry. *J Occup Environ Med* 2002;44: 1161-1168.
4. Sanders R, Swiontkowski MF, Nunley JA 2nd. The management of fractures with soft-tissue disruptions. *J Bone Joint Surg* 1993;75: 778-789.
5. Juliano P, Nguyen HV. Fractures of the calcaneus. *Orthop Clin North Am* 2001;32:35-51.
6. Cotton FJ, Wilson LT. Fractures of the os calcis. *Boston Med Surg J* 1908;159:559-565.
7. Janzen DL, Connell DG, Munk PL, et al. Intraarticular fractures of the calcaneus: Value of CT findings in determining prognosis. *AJR Am J Roentgenol* 1992;158:1271-1274.
8. Barei DP, Bellabarba C, Sangeorzan BJ, et al. Fractures of the calcaneus. *Orthop Clin North Am* 2002;33:263-285.
9. Myerson MS. Calcaneal fractures. In: Myerson MS, Helal B, Rowley DI, et al, eds. *Surgery of Disorders of the Foot and Ankle*. Philadelphia: Lippincott-Raven; 1996.
10. Wedmore IS, Charette J. Orthopedic emergencies: Emergency department evaluation and treatment of ankle and foot injuries. *Emerg Med Clin North Am* 2000;18:86-113.
11. Rodriguez-Merchan EC, Galindo E. Intra-articular displaced fractures of the calcaneus. Operative vs non-operative treatment. *Int Orthop* 1999;23:63-65.
12. Csizy M, Buckley R, Tough S, et al. Displaced intra-articular calcaneal fractures: Variables predicting late subtalar fusion. *J Orthop*

Trauma 2003;17:106-112.

13. Kundel K, Funk E, Brutscher, M, et al. Calcaneal fractures: Operative versus nonoperative treatment. *J Trauma* 1996;41:839-845.
14. Ho K, Abu-Laban RB. Ankle and foot. In: Rosen P, Barkin R, eds. *Emergency Medicine: Concepts and Clinical Practice*, 4th ed. Mosby:1998:821-860.
15. Heckman JD. Fractures and dislocations of the foot. In: Rockwood CA, Green DP, Bucholz RW, eds. *Rockwood and Green's Fractures in Adults*. 3rd ed. Philadelphia: JB Lippincott; 1991.
16. Mulfinger GL, Trueta J. The blood supply to the talus. *J Bone Joint Surg* 1970;52:160-167.
17. Daniels TR, Smith JW. Talar neck fractures. *Foot Ankle* 1990;14: 395-421.
18. Mayer D. Isolated talus fractures: Description of a new clinical sign. *Am J Emerg Med* 1997;15:412-414.
19. Simon RR, Koenigsknecht SJ, eds. *Emergency orthopedics: The*

extremities. 2nd ed. Norwalk, Conn.: Appleton & Lange;1987.
20. Navid DO, Myerson MS. Approach alternatives for treatment of osteochondral lesions of the talus. *Foot Ankle Clin* 2002;7:635-649.
21. Archdeacon M, Wilber R. Fractures of the talar neck. *Orthop Clin North Am* 2002;33:247-262.
22. Hawkins LG. Fractures of the neck and the talus. *J Bone Joint Surg Am* 1970;52:991-1002.
23. Metzger MJ, Levin JS, Clancy JT. Talar neck fractures and rates of avascular necrosis. *J Foot Ankle Surg* 1999;38:154-162.
24. Thordarson DB. Talar body fractures. *Orthop Clin North Am* 2001;32:65-77.
25. Bohay DR, Manoli A. Subtalar joint dislocations. *Foot Ankle Int* 1995;16:803-808.
26. Bibbo C. Missed and associated injuries after subtalar dislocation: The role of CT. *Foot Ankle Int* 2001;22:324-328.
27. Torg JS, Pavolv H, Cooley LH, et al. Stress fractures of the tarsal navicular. A retrospective review of twenty-one cases. *J Bone Joint Surg Am* 1982;64:700-712.
28. Perron AD, Brady WJ, Keats TE. Orthopedic pitfalls in the ED: Lisfranc fracture-dislocation. *Am J Emerg Med* 2001;19:71-75.
29. Burroughs KE, Reimer CD, Fields KB. Lisfranc injury of the foot: A commonly missed diagnosis. *Am Fam Phys* 1999;58:118-124.
30. Vuori J, Aro HT. Lisfranc joint injuries: Trauma mechanisms and associated injuries. *J Trauma* 1993;35:40-45.
31. Stein RE. Radiological aspects of the tarsometatarsal joints. *Foot Ankle* 1983;3:286-289.
32. Kuo RS, Tejwani NC, Digiovanni CW, et al. Outcome after open reduction and internal fixation of Lisfranc joint injuries. *J Bone Joint Surg Am* 2000;82:1609-1618.
33. Richter M, Wippermann B, Krettek C, et al. Fractures and fracture dislocations of the midfoot: Occurrence, causes and long-term results. *Foot Ankle Int* 2001;22:392-398.
34. Amagan OE, Shereff MJ. Injuries to the toes and metatarsals. *Orthop Clin North Am* 2001;32:1-10.
35. Jones R. Fracture of the base of the 5th metatarsal bone by indirect violence. *Ann Surg* 1902;35:697-709.
36. Shereff MJ. Fractures of the forefoot. *Instr Course Lect* 1990;39:133-140.

Physician CME Questions

201. Which of the following is true regarding evaluation of the foot?
    A. The entire foot should be palpated for crepitus in injury and

Emergency Medicine Reports CME Objectives

To help physicians:

- quickly recognize or increase index of suspicion for specific conditions;
- understand the epidemiology, etiology, pathophysiology, and clinical features of the entity discussed;
- apply state-of-the-art diagnostic and therapeutic techniques (including the implications of pharmaceutical therapy discussed) to patients with the particular medical problems discussed;
- understand the differential diagnosis of the entity discussed;
- understand both likely and rare complications that may occur.

cases of infection.

B. The physician also should examine the ankle because there may be combined foot and ankle injuries.

C. Neurovascular exams should include dorsalis pedis and posterior tibial pulses, evaluation of gross sensation, and motor function.

D. The physician should observe the patient for obvious deformity, swelling, ecchymosis, and evidence of vascular compromise.

E. All of the above

202. Which of the following is true regarding calcaneal fractures?

A. Fractures vary little from patient to patient and are easily classified.

B. The prognosis for recovery is good in most cases.

C. Compartment syndrome occurs in 10% of displaced fractures.

D. Surgical treatment of displaced fractures is not controversial.

203. Which of the following is *false* concerning talar fractures?

A. Talar neck fractures comprise 50% of talar fractures.

B. Minor talar fractures are difficult to see on plain films.

C. There is little risk of AVN with displaced talar neck fractures.

D. The Hawkins classification scheme was employed in the past and still is useful today.

204. Concerning navicular fractures, which of the following is true?

A. Navicular fractures are the most common fractures of the midfoot.

B. Navicular stress fractures are rare in the athlete.

C. Navicular fractures are easily seen on plain films.

D. AVN is not seen with navicular fractures.

205. Which of the following is *false* regarding Lisfranc injuries?

A. ED physicians must maintain a high suspicion for this injury with midfoot pain/injury.

B. Fractures of the base of the second metatarsal rarely cause of Lisfranc injury.

C. Up to 20% of Lisfranc injuries are not diagnosed on the patient's first evaluation.

CME Instructions

Physicians participate in this continuing medical education program by reading the article, using the provided references for further research, and studying the questions at the end of the article. Participants should select what they believe to be the correct answers, then refer to the list of correct answers to evaluate their knowledge. To clarify confusion surrounding any questions answered incorrectly, please consult the source material. *After completing this activity, you must complete the evaluation form that will be provided at the end of the semester and return it in the reply envelope provided to receive a certificate of completion.* When your evaluation is received, a certificate will be mailed to you.

D. Most Lisfranc injuries are surgically treated.

206. True Jones fractures are:
   A. fractures at the base of the fifth MT resulting from peroneus brevis tendon avulsion.
   B. fractures occurring 1.5 cm distal to the fifth MT base.
   C. not important for ED physicians to differentiate.
   D. Both A and B

207. The most common mechanism of cuboid fracture is direct trauma from a crush injury.
   A. True
   B. False

208. Which of the following plain foot films is best for identifying injuries to the forefoot and midfoot?
   A. AP view
   B. Lateral view
   C. 45° oblique
   D. Calcaneal view

209. The calcaneus has the most fractures of the hindfoot.
   A. True
   B. False

210. Which of the following is true regarding MT stress fractures?
   A. They are the most common type of stress fracture.
   B. Diseases such as rheumatoid arthritis, osteoporosis, and renal disease can predispose patients to MT stress fractures.
   C. Bone scans are the imaging modality of choice for MT stress fractures.
   D. Treatment includes avoiding any activity that causes pain and immobilizing for comfort.
   E. All of the above.

In Future Issues:

Acute Bacterial Exacerbations of Chronic Bronchitis

Answer Key

201. E	206. B
202. C	207. A
203. C	208. A
204. A	209. A
205. B	210. E

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Emergency Medicine Reports

The Practical Journal for Emergency Physicians

Part II: Foot Fractures

Bones and Joints of the Foot

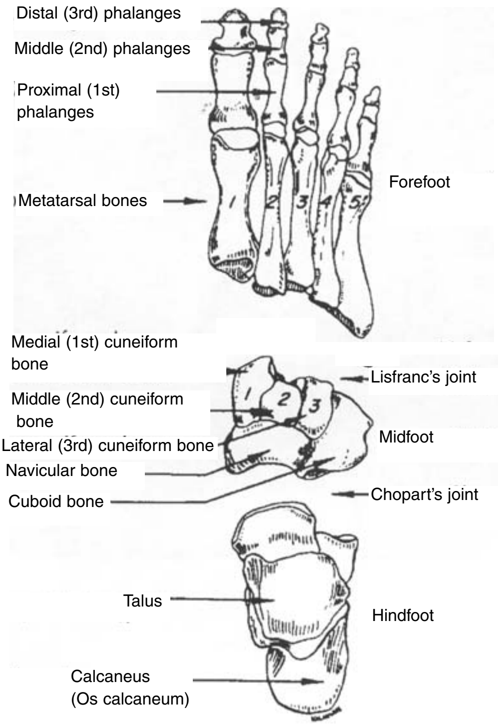

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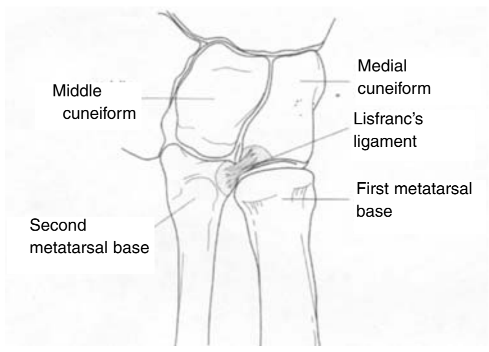
Diagram of Lisfranc's Ligament



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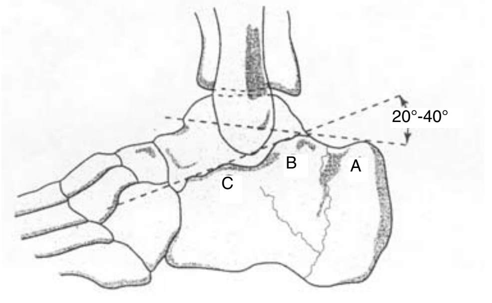
Bohler's Angle



Calculate by drawing two lines, one from the posterior facet (B) and the posterior tuberosity (C), and the other from the posterior facet (B) and the anterior process (A). Normal angles are between 20-40°. An angle lower than the opposite normal side by more than 5° is also considered abnormal.

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Ottawa Ankle Rules

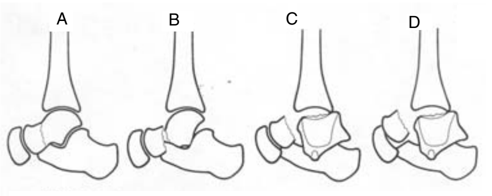
THE RULES

Ankle x-rays are ordered when there is:
- Bony tenderness along the posterior edge or distal 6 cm of either malleolus.
- Inability to bear weight for at least two steps with each foot immediately after the injury and at the time of evaluation.

Foot x-rays are ordered when there is:
- Bony tenderness over the navicular or at the base of the fifth metatarsal.

THE EXCEPTIONS/LIMITATIONS
- Rules were developed only for patients age 18-55 years.
- Does not apply to pediatric patients
- Mechanism of injury only applies to acute blunt trauma.
- Does not apply to subacute or chronic injuries
- Does not apply to injuries of hindfoot, forefoot

Hawkins Classification of Talar Neck Fractures



Type 1 are the only fractures routinely treated without surgery and the only ones with low incidence of AVN (< 10%).

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Supplement to *Emergency Medicine Reports*, October 6, 2003: "Management of Acute Foot and Ankle Disorders in the Emergency Department: Part II—Fractures of the Foot." *Authors:* **Gary D. Hals, MD, PhD**, Attending Physician, Department of Emergency Medicine, Palmetto Richland Memorial Hospital, Columbia, SC; **Matt Logan, MD**, Resident Physician, Department of Emergency Medicine, Palmetto Richland Memorial Hospital, Columbia, SC; and **John Cory, MD**, Resident Physician, Department of Orthopedics, Palmetto Richland Memorial Hospital, Columbia, SC.