7 The Foot and Ankle

7.1 Introduction to Ankle Fractures

Ankle fractures occur at all ages and in a variety of situations from simple tripping to high-speed motor vehicle accidents. Occasionally patients can tell exactly how the injury occurred, but most cannot other than that they fell and the ankle hurts. After inquiring if there are other injuries, a careful physical exam can tell the examiner if radiographs of the foot are necessary in addition to those of the ankle.

Unfortunately, the standard protocol for most hospital ERs is AP, lateral, and oblique views of the ankle, when AP, lateral, and mortise views are more helpful. The mortise view is especially important as this gives some idea as to the necessity of closed vs open treatment. On the mortise view, there should be even spacing between the talus and medial malleolus, talus and distal tibia, and talus and lateral malleolus. In addition, there is a shallow concavity in the dome of the talus that should line up with the shallow convexity in the distal tibia (Fig. 7.1).

Radiographically, there are two major systems to classify ankle fractures in addition to the AO system. The Weber system is easiest (A, B, C).

The Weber (full name is Danis-Weber) system primarily describes where the lateral malleolar fracture is in relation to the tibiotalar joint. The Weber classification is supplemented by describing any medial or posterior malleolus fractures and displacement of said fractures. Weber A fractures have the lateral malleolus fracture line below the level of the mortise (tibiotalar joint line), Weber B at the joint line, and Weber C above (Fig. 7.2). The original articles describing this classification method are not in English [1, 2].

The other system is generally too complicated to remember, but it is useful for reduction methods and research. The Lauge-Hansen system is based on the position of the foot (pronation/supination), the direction of the deforming force (e.g., varus/valgus), and the number of structures injured [3–5].

When operative management of any foot or ankle fracture or injury is being considered, the AP needs to remember that swelling from the injury may make skin closure difficult. Generally, surgery is done in the first 8–10 hours before the

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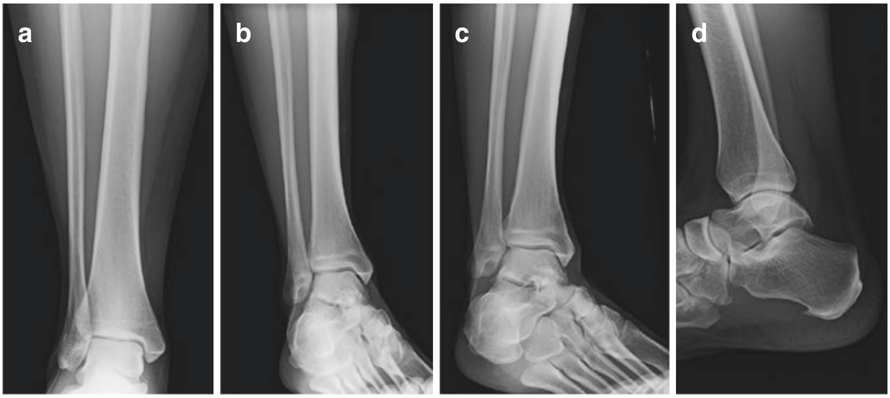

Fig. 7.1 (**a**) AP radiograph with no rotation of right ankle in flexed position. (**b**) Mortise view of right ankle, rotated medially 15–20° showing the even spacing around the talus. (**c**) Oblique view of right ankle, rotated laterally to 45°. (**d**) Right ankle lateral view

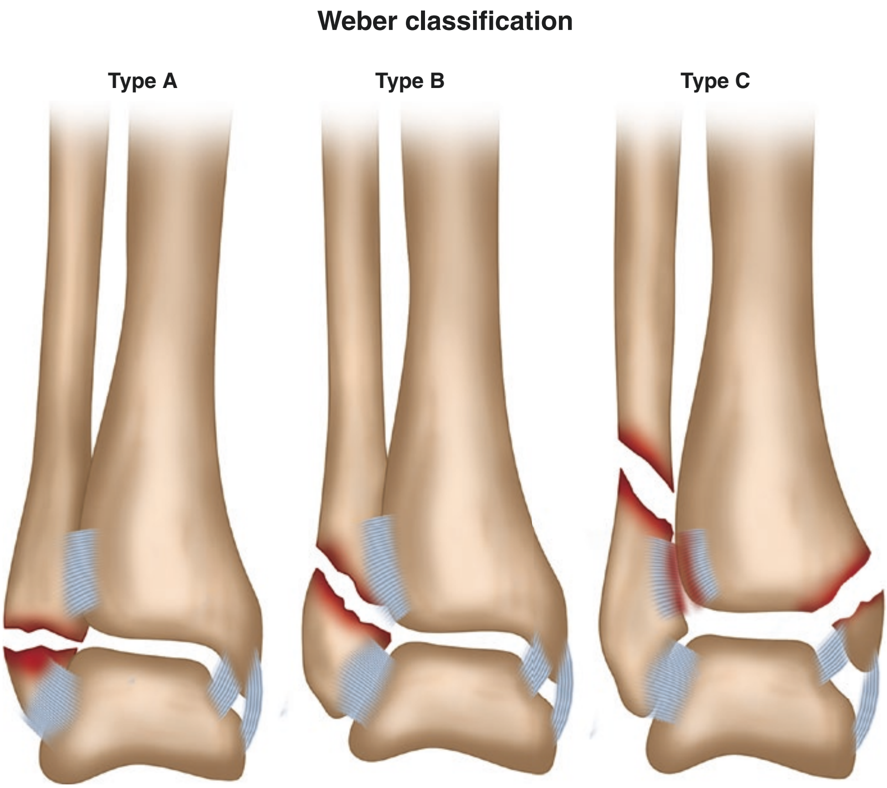

Fig. 7.2 Weber classification

Fig. 7.3 A posterior splint, as seen in the middle, is easier to apply but typically breaks at the heel rendering it nonfunctional for the purposes of immobilization. The posterior and horseshoe (or stirrup) splint, as seen on the left and right, provides much better stability, but care must be taken to leave a gap anteriorly to allow for swelling. Also be careful not to pinch the toes when applying the posterior portion of the splint

swelling has become severe or after 3–5 days when the swelling has subsided. For the latter time frame, splinting in a reasonably reduced position as well as ice and elevation will promote swelling reduction. In the operating room, a bump is placed under the ipsilateral hip allowing access to the lateral malleolus while intraoperative fluoroscopy ensures fracture reduction, metal placement, and stability of the syndesmosis. Patients with a posterior malleolar fracture may need to be treated in the prone position.

Many ankle and foot fractures will initially be treated with a splint before operative treatment or casting. It is important to splint using both a posterior and “horseshoe” splint. Using a posterior splint only is weak and ineffective at immobilization because it will break at the heel rendering the splint useless (Fig. 7.3).

7.2 Traumatic

7.2.1 Specific Foot and Ankle Fractures

7.2.1.1 Triplane and juvenile Tillaux

Triplane ankle fractures are most common in 12–14-year-old males and are the most common Salter-Harris type IV fracture. The fracture typically occurs just as the growth plates slightly widen before closure. Diagnosis is made with plain radiographs that show a fracture extending up the posterior tibial metaphysis in the coronal plane, across the physeal plate in the transverse plane and through the epiphysis into the joint in the sagittal plane. The mechanism of injury is an external rotation force.

Because the amount of displacement is not always easy to determine, CT scans are frequently necessary. If the articular surface is displaced greater than 2 mm or there is a step off, then closed (possible open) reduction is appropriate, followed by two percutaneous screws placed under fluoroscopic control. One screw is placed medial to lateral through the epiphysis across the sagittal fracture. A second screw is placed from anterior to posterior through the metaphysis. Some fractures may require two screws in the aforementioned locations. Many orthopedic surgeons use a cannulated screw to ensure the most accurate placement and minimize damage to the physis and the articular surface [6, 7].

A second special type of ankle fracture is the juvenile Tillaux which occurs slightly later in the growth spurt of the adolescent. The mechanism of injury is the same as the triplane, but because the medial portion of the distal physis is closed, this is a Salter-Harris type III with the anterolateral portion of the distal tibial epiphysis being fractured. Treatment is closed reduction followed by percutaneous screw fixation. Because the growth plate is nearly closed, avoidance of injury to the physis with any metal placement is not nearly as critical as it is in the triplane fracture, but anatomic reduction of the articular surface is still critical. Obtaining a CT scan to assess articular surface gap and step off is not unusual.

Although in an ideal world the patient would be non-weight bearing for 3–6 weeks postoperatively, to allow the growth plate time to recover, these are teenagers who will probably start weight bearing as soon as tolerated pain wise. Six to eight weeks of cast time is normal. Metal removal is rarely necessary. The long-term consequence of both the triplane and the juvenile Tillaux fractures, even with an anatomic reduction, is possible ankle arthritis due to the cartilage damage suffered at the time of injury or inadequate reduction.

7.2.1.2 Calcaneus Fractures

The most common cause of calcaneal fractures is a fall from height. The patient cannot bear any weight on the affected heel, and there is marked swelling and ecchymosis. Associated compartment syndrome is rare, but associated fractures of the knee, hip, and pelvis as well as compression fractures of the thoracolumbar spine are not uncommon. Careful physical exam and radiographs, where indicated, are crucial to avoid missing additional injuries.

There are a wide variety of radiographs that can be taken to assess the severity of calcaneal fracture and disruption of the subtalar joint. On a plain lateral film of the foot, two angles are important: Böhler's angle which measures from the superior aspect of the posterior calcaneus to the "peak" and then to the superior distal end of the calcaneus. Normal is 25–40° (Fig. 7.4); the second angle is the critical angle of Gissane: an angular measurement made directly inferior to the lateral process of the talus. It is formed by the downward and upward slopes of the calcaneal superior surface. Its normal value is usually between 120° and 145° (Fig. 7.4).

Böhler's angle helps to measure the proper height of the calcaneus, while the angle of Gissane angle helps determine the proper relationship of the three facets of the superior aspect of the calcaneus to the talus.

If operative intervention is being considered, a CT scan is very helpful in delineating fracture lines as well as determining operative approach.

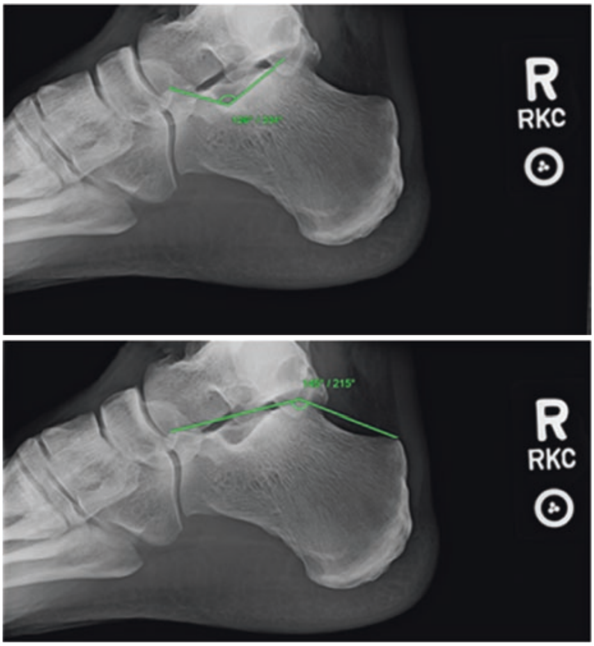

Fig. 7.4 Normal calcaneus. The upper picture shows the angle of Gissane (normal is 120–145°), while the lower picture shows how to measure Böhler's angle which is subtracted from 180 to arrive at a normal of 20–40°

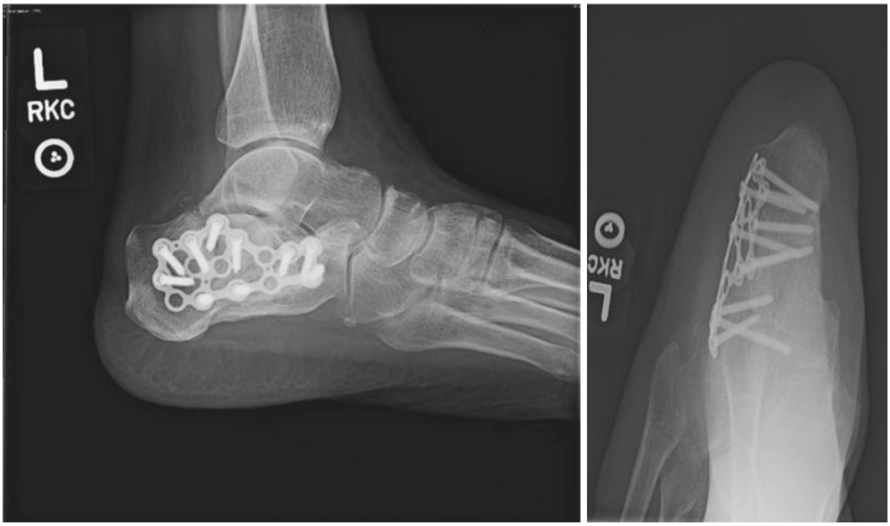

Fig. 7.5 Lateral and axial view after ORIF of calcaneus. The axial view can show if there is over-penetration of the screws that may interfere with the posterior tibial tendon, nerve, and vessels. In addition the heel can be widened as a result of the calcaneus fracture, so the axial view ensures the heel width has been restored

Treatment is based on physiologic age, activity level, severity of injury, associated medical conditions, and skill of the surgeon. Some studies clearly show better outcomes for surgically treated calcaneal fractures (Fig. 7.5), while other studies show equivocal outcomes. Whether treated operatively or not, the typical non-weight bearing time is 8 weeks with up to 2 years being necessary before improvement plateaus. In either case, the patient should be warned that there will be a partial permanent loss of hindfoot inversion/eversion [8].

From a practical standpoint, there are two important questions. Is the fracture significantly displaced (i.e., does it need reduction; if so, how urgently)? If it is reduced, is it stable? Treatment by casting or open reduction and internal fixation is determined by answers to the two above questions. For cases where the best method to use is uncertain, a past medical history of severe diabetes or peripheral vascular disease may tilt the treatment toward casting.

7.2.1.3 Tibial Pilon

Tibial pilon or plafond fractures are in a category all by themselves. They are most commonly the result of a fall from a height or direct high-energy blunt force trauma. Rather than shattering the calcaneus, the distal articular surface of the tibia is shattered. After ensuring there are no other injuries, careful evaluation of the neurovascular status including serial monitoring for compartment syndrome is appropriate. CT scan is almost always necessary to get a better idea of the fracture lines and extent of injury.

Surgical treatment is almost always necessary with a wide variety of options including external fixators which may be only temporary until definitive internal fixation is applied or may be left in place until the fracture is healed (completely or partially). The external fixator may be a simple uniplanar construct or may be a ring/circular fixator. Internal fixation may be multiple screws or a plate and screws (Fig. 7.6). If there is an associated fibular fracture, it is usually fixed first to identify and restore appropriate length. The healing process is long (3–12 months) and often complicated by infection or tissue breakdown because of the lack of muscular coverage and/or tenuous wound closure. The patient should be reminded that a second or third trip to the OR is not unusual.

The most common long-term complication is post-traumatic arthritis which can be treated with an offloading brace, arthrodesis, or arthroplasty depending on patient age, activity level, and the state of the bone and soft tissues [9, 10].

7.2.1.4 Syndesmosis Injury

Syndesmosis injuries usually indicate a more severe injury and are the result of a significant external rotation force with disruption of ligaments connecting the distal fibula to the distal tibia. The more severe injuries are easy to diagnose, but the less severe may only be detected with stress films (external rotation) under general anesthesia.

In the past treatment had been closed reduction and placing a screw across the four cortices of the fibula and tibia with persistent controversy as to how long to ask the patient to limit weight bearing and timing on screw removal (if at all). The latter is important because motion of the fibula relative to the tibia will eventually cause screw breakage.

Fig. 7.6 Pre- and post-op pictures of a tibial plafond or pilon fracture. If the fibula is fractured, it is normally fixed first to restore length

The trend over the last few years has been to a more dynamic fixation system (Arthrex) in which the dislocation is reduced, and two metal buttons placed: one on the lateral aspect of the fibula and one on the medial aspect of the tibia. Stout

Fig. 7.7 Radiograph of the Arthrex TightRope used to fix a syndesmosis injury. The single screw from anterior to posterior was used to fix an associated posterior malleolar fracture

nonabsorbable sutures connecting the two buttons are tightened, thus finalizing and holding the reduction while the syndesmosis injury heals (Fig. 7.7) [11, 12].

7.2.1.5 Phalangeal Fractures and Dislocations

Most lesser toe fractures and dislocations come from kicking something on purpose or by accident. Many are self-reduced. Once reduced and in reasonable alignment, treatment is buddy taping to an adjacent toe and wearing a stiff open toed shoe or cast shoe. Return to activity and regular shoes is up to the patient with regard to activity type and pain tolerance. If seen acutely, there may be a subungual hematoma (i.e., blood under the nail bed), and the patient should be offered the option of drainage (trephination with an 18 gauge needle) if the hematoma is too painful (Fig. 7.8).

Open fractures of the lesser toes are uncommon except during the mowing season. Because of the high energy and dirty nature of the wound, these injuries should be taken to the operating room for thorough irrigation and debridement, followed by several days of antibiotics to cover both gram-positive and gram-negative bacteria. Verification of tetanus coverage should be obtained. Because of the usual severe contamination, the patient should be warned of the possible need for a second trip to the operating room and the possibility of the loss of a portion of the foot.

Great toe fractures are treated similarly to lesser toe fractures with the exception of intra-articular fractures where consideration should be given to closed reduction and percutaneous pinning or even open reduction with internal fixation using a mini-fragment screw set.

Loss of one or two of the lesser toes does not usually alter gait, but loss of the great toe will cause a mild limp.

Fig. 7.8 Typical appearance of subungual hematoma. This happens to be in a distance runner, is chronic and non-painful. A change in shoe size may alleviate the problem

7.2.1.6 Metatarsal Fractures

Metatarsal fractures require more energy than phalangeal fractures and often are the result of a fall from a height, dropping a weight, heavy contact sports like American football, or motor vehicle accidents. With higher-energy injuries, it is important to be aware of the possibility of compartment syndrome as missing this diagnosis can result in long-term foot pain and dysfunction [13]. Three special types of metatarsal fractures will be discussed below.

The important thing to remember about metatarsal fractures is that a significant amount of angulation can be accepted in the medial-lateral direction (coronal plane), especially of the middle three metatarsals. What is not tolerated well is significant deviation in the dorsal or plantar direction. If there is excessive dorsiflexion of one metatarsal, then the other metatarsals will have to bear more weight than designed resulting in painful plantar callosities. If there is excessive plantar flexion, then the head of the fractured metatarsal may develop a painful plantar callosity. If not corrected acutely (with either closed reduction and percutaneous pinning or open reduction and internal fixation), treatment options are a custom orthotic with a channel cut out under the offending metatarsal head(s) or a corrective osteotomy. How much displacement is acceptable is unknown.

7.2.1.7 Avulsion Fractures

Fractures at the base of the fifth metatarsal are most often the result of a "near-fall" or misstep with acute pain at the point of injury. Diagnosis is straightforward based on history, physical exam, and plain films of the foot. Because of its location, it is important to examine the ankle to rule out an ankle fracture or sprain. Whether or not to get ankle radiographs in addition to the foot is dependent on the results of both the history and physical examination. One should avoid getting routine radiographs of both the foot and ankle just because one or the other is injured (Fig. 7.9).

Treatment is symptomatic allowing the patient to weight bear as tolerated. Some patients may only require stiff soled shoes, while others may need more aggressive immobilization such as a fracture boot or even a short-leg walking cast depending on pain tolerance and activity level [14].

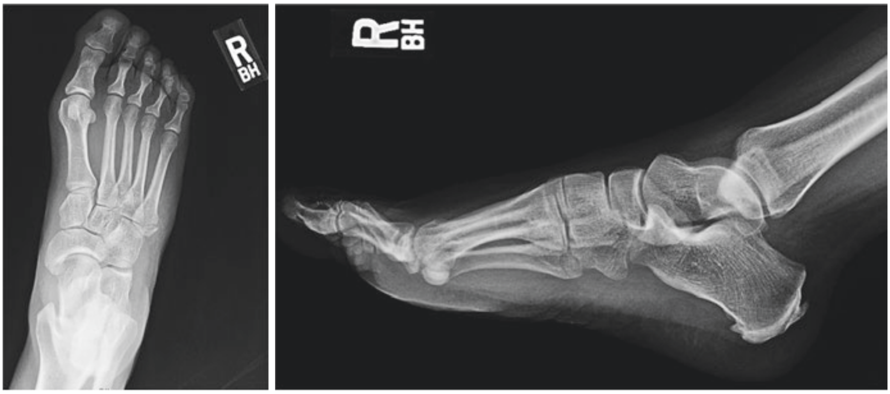

Fig. 7.9 Avulsion fracture at the base of the fifth metatarsal. Symptomatic treatment is usually all that is necessary. It should be differentiated from the much less common Jones fracture which occurs at the proximal meta-diaphyseal junction

7.2.1.8 "Jones" Fractures

Although anatomically close to the avulsion fracture at the base of the fifth metatarsal, the Jones fracture is a very different injury. The patient presents either with very limited weight bearing or completely non-weight bearing after a higher-energy injury than normally associated with an avulsion fracture of the fifth metatarsal. Physical exam shows tenderness along the lateral border of the foot, especially the fifth metatarsal, while radiographs show a transverse fracture at the proximal meta-diaphyseal junction of the fifth metatarsal shaft.

This can be a difficult fracture to treat because the blood supply to this area of the fifth metatarsal is poor and nonunion is common.

Careful history may reveal some aching in the foot in the several weeks or months prior to injury, and close examination of the radiographs may even reveal early callus in what is supposed to be an acute injury. Either one of these findings indicates the injury is the end stage of a stress reaction and has a higher chance to result in a nonunion. If this is the case, serious consideration should be given to early operative intervention, especially in athletes to minimize downtime. For truly acute injuries, a short-leg cast with 6–8 weeks non-weight bearing will result in healing. For fractures that are the consequence of a stress reaction or nonunion of an acute fracture, surgery consists of an intramedullary screw inserted from proximal to distal with or without autogenous iliac crest bone grafting or bone marrow aspirate [15].

7.2.1.9 Tarsometatarsal Dislocations and Midfoot Fractures

The final category of special metatarsal fractures is the *Lisfranc fracture/dislocation*. The sine qua non of this injury is a fracture at the base of the second metatarsal with associated dislocation/subluxation or fractures of some or all of the remaining tarsometatarsal joints. Like many other fractures, there is a bimodal demographic with high-energy injuries in the younger population and low-energy injuries in the elderly. Typical injury patterns in the younger population are hyperdorsiflexion injuries to the midfoot in American football or simultaneously hitting the brake when the vehicle hits an immovable object. In the elderly, low-energy injury can result from a hyperdorsiflexion injury to the midfoot when excessive force is used such as when stepping on a curb with the forefoot.

Physical exam shows more swelling than expected with a forefoot or midfoot sprain. Before assigning the diagnosis of a mid- or forefoot sprain, it is incumbent on the AP to rule out a Lisfranc injury. Pronation/supination of the forefoot while stabilizing the hindfoot is unusually painful in those patients with a Lisfranc injury.

If non-displaced, the fracture and associated dislocation/subluxation may be difficult to see on initial plain films especially if the initial films are non-weight bearing (Fig. 7.10). Consequently weight-bearing films (when and if the patient can tolerate) or a CT scan may be necessary to identify a Lisfranc injury. On plain films, any fleck of bone around the base of the second metatarsal, especially plantar, should raise suspicion of a Lisfranc injury. Because of the location, the dorsalis pedis artery may be injured; ultrasound may be necessary to ensure its integrity.

Truly non-displaced Lisfranc injuries are rare and may be treated with casting and strict non-weight bearing. Displaced fracture/dislocations will require anatomic reduction, closed or open, with fixation, either percutaneous pins, screws, plates, or a combination thereof (Fig. 7.11). Prolonged casting and non-weight bearing is required in the postoperative period. The patient should be warned that like calcaneal fractures, recovery may not plateau for 2 years. The earliest complication is compartment syndrome; the late complication is midfoot arthrosis [16, 17].

Fractures of the cuboid and cuneiform bones are uncommon and can usually be treated with immobilization and limited weight bearing, unless significantly displaced usually in compression. If significantly displaced, open reduction and internal fixation, perhaps with autogenous or artificial bone graft, will be necessary especially in younger or more active patients [18].

7.2.2 Stress Fractures

Most stress fractures occur in athletes or people starting an aggressive exercise program, so history is important. Questions to ask include recent changes (6–12 weeks) in activity level at home, work, or play; change in running surfaces or shoes; recent weight gain or loss; and when does the pain bother them and how much. Is the pain only present after the activity, is the pain present during but not interfering with activity, or is the pain interfering with the activity? Physical exams will often show point tenderness, and the base of a vibratory tuning fork placed on the affected bone will elicit pain. Range of motion is normal, and depending on severity there may or may not be an associated limp. For some the limp is only detected while running.

Radiographs are often normal or only show changes late in the process: typically a periosteal reaction showing new bone formation or the fracture edges may have resorbed showing a clear fracture line. Bone scans are not used much for stress

Fig. 7.10 Preoperative films of Lisfranc fracture/dislocation. Note the fractures at the bases of both the third and fourth metatarsals in addition to the sine non qua of the fracture at the base of the second metatarsal. The first tarsometatarsal joint is stable

Fig. 7.11 Post-op radiographs of a Lisfranc fracture/dislocation. Once the second metatarsal fracture was stabilized, a second screw was placed through the fifth metatarsal into the cuboid which stabilized the rest of the TMT joint. Healing was uneventful

fracture diagnosis as MRI has become the imaging modality of choice if the plain films are nondiagnostic.

Like muscle, bone when subjected to stress gets stronger. The process by which this occurs is when stress is applied, the old bone is partially taken down (osteoclast activity) followed by new thicker, stronger bone being laid down (osteoblastic activity). Stress fractures arise when the external stress continues to be applied during the temporary weak phase, i.e., when the bone is being rebuilt.

Although it can occur in any bone, the most common locations for stress fractures are fifth metatarsal (aka March fracture – the name taken from the frequent occurrence in military recruits), medial tibial plateau, femoral neck, and distal tibial metaphysis.

Treatment varies. Convincing most athletes to stop is an exercise in frustration for both the patient and the AP. In addition complete rest (except extreme cases) prevents any stimulation necessary to continue the healing response. Treatment consists of three parts. First, any underlying muscle weakness or imbalance needs to be addressed, ideally by a physical therapist who specializes in athletes. Second, technique, equipment, and training issues need to be addressed by a qualified coach. Third, the athlete needs to cut back but not stop training. This can include either volume or intensity or both with the amount of decrease dependent on the severity of the stress fracture or stress reaction [19].

Differential diagnoses include a variety of bursitides and tendinitis depending on the body part involved.

A special case that needs to be briefly discussed is the female athlete triad of anorexia, amenorrhea, and stress fractures. As part of the history, routine questioning of female athletes should include recent weight change and regularity of menstrual periods. Many female athletes, especially dancers and distance runners, put themselves at risk for long-term health issues by eating less than what is required to maintain a positive energy balance. In addition to amenorrhea, they can also develop osteoporosis even as a teenager. Although not seen often, an energy deficit causing osteoporosis and stress fractures can occur in male athletes such as distance runners or wrestlers trying to make weight. As most healthcare providers now know, treatment of eating disorders such as anorexia and bulimia is not a simple "just eat more" but are symptoms of underlying psychological distress that needs to be addressed by mental health practitioners [20].

7.2.3 Ankle Sprains

Ankle sprains are endemic in almost all sports that require movement on the feet from running to basketball to gymnastics to ice hockey. They occur at all ages but are most common from 15 to 40 years of age. The history is of an inversion injury, either the result of a misstep, uneven ground, or landing on another player's foot. With minor sprains the patient may be able to continue playing, albeit at a reduced level, but most are unable to do so. Many ankle sprains are never seen by a medical professional as the patient "walks it off" or modifies his activities until the symptoms go away. Some patients may not see a medical practitioner until they have a sprain from which they are unable to recover despite having self-treated previous sprains.

On a physical exam, there is tenderness over the lateral collateral ligaments of the ankle with variable amounts of swelling and ecchymosis. Weight-bearing ability varies depending on the degree of injury. Many patients will walk with the lower limb externally rotated to decrease the stress on the lateral ligaments. Careful palpation will reveal if there is any additional injury. The following should be palpated: the peroneal tendons, the base of the fifth metatarsal, the Achilles tendon, the posterior tibial tendon, and the anterior aspect of the distal tibiofibular joint. The degree of instability resulting from an ankle sprain is determined by talar tilt and anterior drawer. Because of the wide variation in ligamentous laxity in each patient, it is important to examine the normal, uninjured side first. Due to swelling in the acute injury, it may be difficult to determine if there is significant laxity with the talar tilt and anterior drawer tests. Talar tilt is performed by grasping the posterior ankle with the left hand for a right ankle and grasping the midfoot with the right hand with the thumb over the anterolateral aspect of the talus and placing the hindfoot in inversion and feeling for the amount of gapping of the lateral tibiotalar joint. The anterior drawer test is done by placing the right hand on the anterior left distal tibia, grasping the posterior calcaneus with the left hand, and pulling forward and observing the amount of subluxation of the talus. If the patient has a syndesmotic injury, the so-called "high" ankle sprain, recovery may be longer than average.

Two additional tests may help to diagnose a syndesmotic injury; the external rotation test is performed with the knee flexed, and applying an external rotation force to the forefoot looking for an increase in pain. The second is the squeeze test where again while the knee is flexed, firm pressure is applied at the midportion of the leg squeezing the tibia and fibula together. An increase in pain is a positive test.

Radiographs are helpful to rule out associated fractures and periodically a small fleck of bone associated with either the anterior talofibular or calcaneofibular ligament can be seen. Additional imaging is rarely needed for most ankle sprains. In children and adolescents with open growth plates, non-displaced Salter I fractures of the distal fibula are much more common than true ankle sprains. Careful palpation in these patients shows tenderness over the growth plate rather than the collateral ligaments of the ankle.

The Ottawa ankle rules were developed by Dr. Ian Stiell [21] in an effort to decrease the number of radiographs for ankle sprains. According to the Ottawa rules, radiographs are needed only if:

- There is tenderness of the tip or posterior half, distal 6 cm, of the fibula.
- If there is tenderness of the tip or posterior half of the medial malleolus.
- Bony tenderness at the base of the fifth metatarsal.
- Bony tenderness over the tarsal navicular.
- Inability to bear weight for four steps after injury and inability to bear weight for four steps in the emergency room.

Several exclusions apply, including intoxication, severe swelling, and other injuries. In addition, one cannot neglect the "therapeutic" value of the patient knowing it is "just a sprain" and nothing is "broken." Ultimately history, physical, and clinical judgment should prevail in ordering any diagnostic test including ankle radiographs for ankle injuries.

The underlying pathology of course is a tear, stretch, or avulsion of one, two, or all three lateral ankle ligaments (anterior talofibular (ATF), calcaneofibular (CF), and posterior talofibular (PTF)) with the most common and important being the anterior talofibular ligament. Grading of ankle sprain can be done by determining the number of ligaments injured, the degree of injury to the ligament (sprain, stretched, or torn), or the amount of clinical laxity. Again, comparison to the uninjured side is helpful.

Treatment for most ankle sprains is nonoperative. For severe sprains an upright fixed walking brace is appropriate. Other patients may only need some type of ankle-stabilizing orthosis.

The initial treatment for ankle sprains, like other strains and sprains, is RICE: rest, ice, compression, and elevation. Tylenol or OTC NSAIDs should suffice for pain control in all but the most severe injuries. The ice is primarily for pain control and should be limited to no more than 15–20 minutes at time (to avoid frostbite) and should not be used after the first 48 hours. This is followed by a course of either physical therapy or a home exercise program depending on the severity of injury and level of activity to which the patient wishes to return. Recovery can be anywhere from 2 to 12 weeks, again depending on the severity of the injury and desired activity level.

A few ankle sprains do not respond to treatment and will need operative intervention. There are two types of repair. One involves taking all or part of a peroneal tendon and weaving it through the fibula and talus, occasionally the calcaneus, in various patterns to restore stability with the Chrisman-Snook, Watson-Jones, and Evans being the most common. The second is direct repair of the ligaments sometimes reinforced by the inferior retinaculum (Broström repair). A recent addition to the direct repair is an internal brace made of synthetic material to protect the repair as it matures. Both types of procedures are followed by a period of immobilization and therapy which vary depending on the repair type and stability as well as the surgeon's preference [22].

Differential diagnoses include fracture, bone bruising, and peroneal tendon tears [23] or subluxation.

7.2.4 Achilles Tendon Ruptures

Achilles tendon ruptures are the result of abrupt excessive load, either while starting a sprint (e.g., running for first base) or an unexpected excessive eccentric contraction (e.g., landing after going for a rebound in basketball). The injury occurs in the 40–60-year-old age range and is much more common in males than females. Some patients describe it as feeling like they have been hit or shot in the calf; others simply describe a pop and inability to walk or run.

Physical exam, especially early, is remarkable for loss of continuity of the Achilles tendon. There is an inability to stand on one foot (affected side). If examined after the hematoma forms, the hematoma may conceal the defect making diagnosis more difficult. Weakness of plantar flexion can be hidden by the long toe flexor, the posterior tibial, and peroneal tendons. The Thompson test is especially helpful and should be done in any suspected cases of Achilles tendon rupture. The test is performed by having the patient lie in the prone position with a knee flexed to 90°. Squeezing the upper calf muscle normally results in plantar motion of the foot and ankle. If there is little or no motion, the test is considered positive with the presumptive diagnosis of Achilles tendon rupture. Radiographs are useful to rule out concomitant injuries such as avulsion of the calcaneal tuberosity as well as looking for signs of chronic Achilles tendinopathy, such as calcification and posterior calcaneal spurring. If the diagnosis is in doubt, MRI or ultrasound can be used but are rarely necessary.

The underlying pathology is rupture of the Achilles tendon, typically one to two centimeters proximal to the calcaneus. As stated above it is normally the result of greater than expected eccentric loading and occurs in a portion of the tendon that has less than an optimal blood supply.

Treatment varies according to the patient and surgeons' preferences. The first surgical option is open surgical treatment with repair of the torn ends, which frequently look like mop ends, followed by casting in plantar flexion, gradually bringing the foot into the neutral position over a period of 6–8 weeks. The second surgical option is the repair of the tendon percutaneously followed by a similar period of casting (Fig. 7.12). The disadvantage of the first method is that there can be difficulty getting the skin closed with open surgery; however, the second percutaneous method is technically more difficult.

The third option is to treat the tendon rupture solely by casting the ankle in plantar flexion. The primary advantage is the avoidance of surgical complications such as infection and wound dehiscence. The primary disadvantages are a longer time in cast and a slightly higher re-rupture rate [24, 25].

7.2.5 Puncture Wounds

Most puncture wounds are benign. After making sure the patient's tetanus vaccine is up to date, no further treatment is usually necessary. Radiographs can ascertain if any radiopaque foreign body is retained with follow-up in 2–5 days or if the patient develops symptoms such as worsening pain, fever, and cellulitis. In that case additional imaging such as CT or MRI looking for an abscess is appropriate. Whether or not antibiotics are necessary is controversial. The patient's health and the type of puncture wound should be considered. For instance, an otherwise healthy 20-year-old stepping on a thumb tack in the living room is a very different situation than a 60-year-old with poorly controlled diabetes stepping on a rusty nail in the barnyard. If the puncture wound is intra-articular, surgical debridement may be necessary. Common organisms, if an infection develops, are *Staphylococcus*, *Streptococcus*, and surprisingly *Pseudomonas* [26].

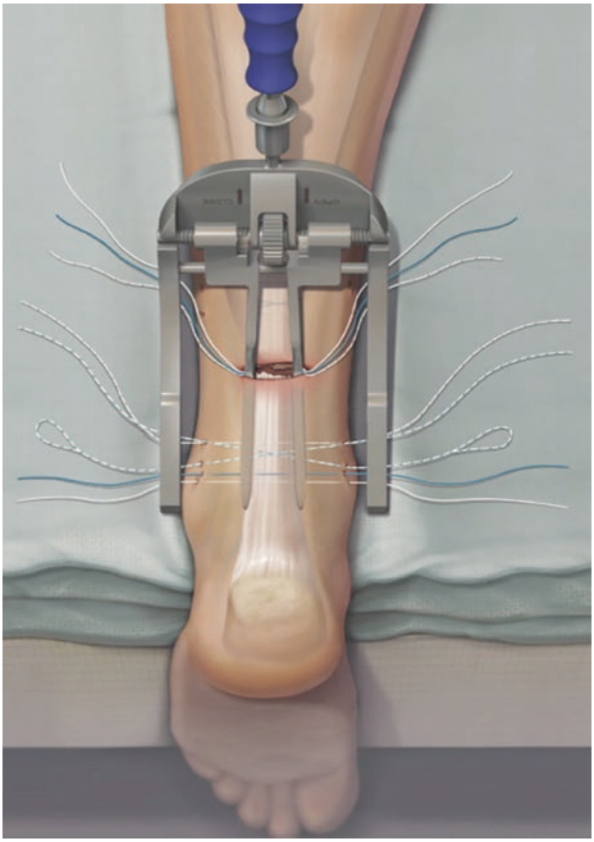

Fig. 7.12 Picture of percutaneous Achilles tendon repair. https://link.springer.com/chapter/10.1007/978-3-662-58704-1_34

7.3 Non-traumatic Foot and Ankle Conditions

7.3.1 Ankle Arthritis

Ankle arthritis (specifically of the tibiotalar joint) may present in both ankles or be unilateral. The most common causes are osteoarthritis, rheumatoid disease, and post-traumatic arthritis; gout and pseudogout must also be considered. Most patients present with a gradual onset of ankle pain and stiffness that is worse with prolonged weight bearing. Examination shows tenderness over the anterior talotibial joint as well as decreased flexion-extension. Physical examination should include vascular status and examination of the posterior tibial tendon function.

Imaging is normally limited to weight-bearing radiographs of the foot and ankle. Other diagnostic testing may include labs (to rule out infection or autoimmune disease), bone scans, or MRI to rule out chronic infection (especially after ORIF of a previous fracture).

Initial treatments are bracing and physical therapy. The length of time to try bracing and physical therapy varies according to the patient and surgeon, but a minimum of 6–12 weeks is the norm. NSAIDs are of limited benefit; intra-articular corticosteroid injections give relief, but do not last. There is some evidence that the steroid or accompanying anesthetic (e.g., bupivacaine) may cause additional cartilage deterioration, thus accelerating the arthritis. Surgical treatment has traditionally been arthrodesis of the tibiotalar joint which can be done open or arthroscopically. Ankle arthroplasty has become more common over the last few years with early to mid-term results show equivalent outcomes compared to arthrodesis [27–29].

7.3.2 Plantar Fasciitis

Plantar fasciitis is the most common diagnosis made when a patient comes in complaining of plantar heel pain, but other diagnoses are possible (see below). Patients with plantar fasciitis present with medial plantar heel pain that is worse when getting up in the morning or after sitting for a period of time. After walking for 5–15 minutes, the pain subsides but returns as an ache toward the end of the day.

The majority of the time there is no known precipitating cause, but many patients will have a history of recent weight gain or of beginning an aggressive exercise program.

Physical exam is remarkable for tenderness on the medial plantar aspect of the heel. Inspection, sensory, motor, and stability exams are normal, although some patients may have decreased ankle dorsiflexion.

Imaging consists of lateral and axial radiographs of the heel and is usually normal. Some patients will have an inferior calcaneal spur, but the significance is unclear as many patients without plantar fasciitis have an inferior calcaneal spur as well (Fig. 7.13).

Fig. 7.13 Lateral of a foot and ankle showing both a posterior and inferior calcaneal spur. The former frequently accompanies Achilles tendinitis but a significant portion of the population has one or the other with no accompanying symptoms

Advanced imaging is not necessary unless the pain is persistent or exam atypical; then, an MRI may rule out other pathologies.

Etiology is still debated but may be related to tight heel cords or microtears of the plantar fascia where it attaches to the inferior calcaneus.

Treatment for most patients is nonoperative. This consists of some combination of heel-cord stretching, plantar fascial massage, night splints (to keep the ankle dorsiflexed), and NSAIDs. Other patients may respond to off-the-shelf or custom orthotics. More invasive treatment includes extracorporeal shockwave therapy (similar to lithotripsy), a localized steroid injection, PRP injection, or rarely surgical intervention. Importantly, before trying the more invasive or expensive treatments, a wide variety of alternate diagnoses should be considered including peroneal or posterior tibial tendonitis, tarsal tunnel syndrome, Achilles tendinitis, retrocalcaneal bursitis, and stress fractures [30, 31].

7.3.3 Deformities of the Midfoot

There are three "varieties" of a flatfoot: physiologic (flexible) flatfoot, tarsal coalition, and acquired flatfoot from posterior tibial tendon dysfunction.

7.3.3.1 Flexible Flatfoot

Patients with physiologic flatfeet usually present, if at all, with "sore" feet after prolonged walking or running. They are otherwise asymptomatic. The easiest way to assess whether or not the flat feet are physiologic is to look for symmetry, and a normal arch appears when non-weight bearing.

The underlying problem is mild ligamentous laxity, usually isolated to the midfoot, and there is often an association with obesity.

Treatment is symptomatic with weight loss for obese patients, activity modification, and arch supports [32].

7.3.3.2 Tarsal Coalition

Tarsal coalition presents in adolescents as a unilateral flatfoot which can be fairly rigid. The pain varies from mild discomfort to pain that interferes with athletic pursuits. Physical exam may show tenderness over the coalition (calcaneo-navicular, talonavicular, or talocalcaneal) with painful lack of motion on pronation/supination of the forefoot in those with talonavicular coalition. There will be a lack of inversion/eversion in those with talocalcaneal coalition. Those with calcaneo-navicular coalition tend to lack subtalar motion and have some hindfoot valgus.

More than the usual AP, lateral, and oblique radiographs (Fig. 7.14) may be necessary to identify the coalition which can be fibrous, cartilaginous, or bony. In fact, CT or MRI (Fig. 7.15) may be necessary to fully delineate the nature and extent of the coalition.

Etiology is unclear, but there seems to be a strong genetic component.

Treatment varies per coalition type. Many patients of all types respond to temporary activity reduction or intermittent casting (which of course reduces their activity

Fig. 7.14 Three views of the foot with a tarsal coalition. Note the subtle peaking between the calcaneus and navicular. The MRI is in Fig. 7.15

Fig. 7.15 MRI scan of a tarsal coalition between the navicular and calcaneus. Courtesy Medical College of Georgia, Department of Orthopedics

level). If this fails, surgical resection accompanied by some type of soft tissue interposition (e.g., autologous fat or extensor digiti minimi muscle belly) is the normal treatment. Postoperatively there will be a period of casting and limited weight bearing followed by range of motion exercises. Surgery in adults with tarsal coalition is not as successful as when the surgery is performed in adolescence. For adults, subtalar or triple arthrodesis (subtalar, talonavicular, calcaneocuboid joints) may be a better option. For both adults and adolescents using the resection option, the AP needs to make sure the patient and family understand that motion will be improved but not normal [33].

7.3.3.3 Acquired Flatfoot

Posterior tibial dysfunction appears in middle-aged or older adults and has several presentations. Stage I is vague medial ankle pain with worsening on prolonged walking or standing. On physical exam there is tenderness along the course of the posterior tibial tendon with either a painful single-heel raise or inability to do so in addition to painful, weak resisted inversion from an everted position. The AP should remember that testing inversion strength from the inverted position can be deceptive as the anterior tibial tendon can maintain inversion strength from that position.

Stage II symptoms are generally worse. The patient will have a flatfoot while weight bearing and difficulty or inability to perform a single-limb heel raise. When viewed from behind, there will be a “too many toes” sign (Fig. 7.16). Foot flexibility remains normal.

Stage III exhibits the same as stage II except flexibility is decreased, and the patient is always unable to do a single-heel raise.

Because of loss of medial support, patients in stage II, III, or IV of posterior tibial dysfunction may have lateral ankle pain from impingement of the lateral malleolus.

Stage IV is a rigid collapse of the hindfoot into valgus with subtalar arthritis.

Fig. 7.16 Patient with posterior tibial dysfunction stage II or III on the right. Although it appears the photo was taken from the side, it is actually from almost directly behind this patient who has a positive "too many toes" sign

Imaging studies include weight-bearing radiographs to assess various angles (e.g., talo-first metatarsal angle varies from 0 to 10° in normal feet; greater than 10° shows loss of the normal arch) and to assess for any associated arthritis. MRIs can be helpful in determining the nature and severity of the posterior tendon pathology which in turn helps with surgical planning and managing patient expectations.

For stages I and II, some type of arch support and physical therapy is the first line of treatment. If still symptomatic, then surgery for stages I and II consists of tendon debridement, repair, or transfer. For stages III and IV, any orthotic will have to cross the ankle joint in order to take sufficient tension off the posterior tibial tendon for relief of symptoms. For any orthosis, a period of time to adjust to the orthosis may be necessary, not to mention the need to change shoe sizes (1/2–1 size larger) as well as several trips to the orthotist to make adjustments for the best fit.

Patients with stage III or IV disease unresponsive or unwilling to undergo non-operative treatment require more extensive surgery, including subtalar or triple arthrodesis with a possible calcaneal osteotomy as well. In severe cases the tibiotalar joint will need fusion [34, 35].

7.3.3.4 Cavovarus Foot (High Arch)

The causes and subsequent presentation of a patient with a cavovarus foot vary and range from central nervous system disorders (cerebral palsy, stroke, and muscular dystrophy) to the residua of untreated compartment syndrome. Treatment depends on the underlying cause as well as the patient's age, health, and activity level.

One of the more common causes is Charcot-Marie-Tooth (CMT) disease or one of the other hereditary sensorimotor neuropathies (HSMNs). Complaints include pain under the metatarsal heads, difficulty finding shoe wear, and balance difficulties. Many patients with a cavovarus foot have a positive family history as HSMNs which can be either autosomal dominant or recessive.

Physical examination in patients with HSMN may show atrophy of the hand and foot intrinsic muscles with thin legs in addition to a high arch.

Other than showing the bony degree of arch and ruling out the other causes, radiographs are not diagnostic, whereas EMG/NCS can be very helpful in diagnosing the cause of the cavovarus foot.

Treatment of the cavovarus foot depends on the underlying etiology as well as age and activity level of the patient. Details are beyond the scope of this book but consists of a variety of tendon transfers, midfoot osteotomies, and plantar fascial releases [36, 37].

7.3.4 Charcot Foot

Although the most common underlying cause of Charcot foot in the industrialized world is diabetes, any disease that can cause peripheral sensory loss, e.g., leprosy, must be considered. Patients may present early with a swollen, erythematous foot or may present later in the course of the disease with varying degrees of arthrosis, bony collapse, angular deformation, and subsequent foot ulceration.

Physical exam mirrors the above presenting complaints. Importantly there is loss of sensation and the degree of pain is highly variable. There may be no pain, or there may be as much pain as the AP would expect given the deformity.

Radiographs show varying degrees of collapse and osteoporosis, but osteoporosis may resolve in the later stages with more normal bone (Fig. 7.17).

Although diabetes is the most common cause, other etiologies for peripheral neuropathy such as heavy metal poisoning, alcohol, and leprosy can cause similar clinical and radiographic findings.

While the exact cause is not known, most agree there is a lack of protective feedback because of decreased pain perception. This results in both soft tissue and bony damage, which in itself is minor. But because the body does not protect itself, the cumulative effect is the damage similar to that seen in the radiograph above.

Treatment is twofold. First, the underlying etiology needs to be controlled (e.g., better glucose control, cessation of alcohol). Second, if the disease is caught in the early inflammatory stage, some type of total contact orthotic or walker boot can distribute the stress preventing collapse and some of the more severe deformities. A CROW (Charcot restraint orthotic walker) boot is frequently ordered (Fig. 7.18).

Surgical intervention is more common now than in the past, but still should be approached with caution as 2–3% of patients with Charcot foot will ultimately have an amputation of the affected foot. Surgery may involve excision of bony prominences to prevent ulceration or varying arthrodeses to prevent or correct any collapse [38, 39].

Fig. 7.17 Progression of a Charcot foot. In the initial stage, there is some minor subluxation of the second tarsometatarsal joint. By the time of the final radiographs, the same joint is obviously subluxed and the joint itself eroded. In addition the first tarsometatarsal joint has subluxed as has the calcaneocuboid joint

Fig. 7.18 A CROW boot used to support the Charcot foot until the bone remodels

7.3.5 Neurologic Disorders

7.3.5.1 Tarsal Tunnel Syndrome

Tarsal tunnel syndrome is similar to carpal tunnel syndrome (CTS) of the wrist in that the posterior tibial nerve or one of its branches is compressed beneath the flexor retinaculum, just posterior and/or distal to the medial malleolus. Unlike CTS, diagnosis can be elusive. Patients present with vague pain or paresthesia on the medial and/or plantar aspect of the foot. There may be some specific anatomical abnormality such as a ganglion or a previously displaced calcaneal fracture. The most common misdiagnosis associated with tarsal tunnel is plantar fasciitis. Differentiating the two can be difficult, but patients with plantar fasciitis usually present with plantar heel pain when first arising from a night's sleep or after standing following a prolonged period of sitting. And while plantar fasciitis symptoms subside after walking a few minutes, tarsal tunnel symptoms occur during all activities including rest and sleeping.

After obtaining the history, a physical exam may reveal a positive Tinel's over the posterior plantar nerve. Remember to ask what symptoms the Tinel's caused; not a yes/no "does this reproduce your pain?" Prolonged compression over the nerve (~30 seconds) while holding the ankle in inversion and flexion may recreate the symptoms. EMG/NCS can be of use, but tarsal tunnel has a high incidence (relative to CTS) of being electrodiagnostically negative.

Like many foot and ankle problems, treatment is initially conservative. NSAIDs, wide-heeled shoes with cushion, or possibly some type of night splint may relieve the symptoms.

Surgical treatment is an option, but has a high failure rate, especially if some type of space occupying lesion is not identified. Surgery requires release of the posterior tibial nerve beneath the flexor retinaculum as well as all of its branches including both the medial and lateral plantar nerves. There is frequently a venous plexus inferiorly which may cause persistent oozing, both intraoperatively and postoperatively.

Of note, the deep peroneal nerve can likewise be trapped under the exterior retinaculum causing an anterior tarsal tunnel syndrome [40].

7.3.5.2 Interdigital Neuroma (aka Morton's Neuroma)

Presenting primarily in women, patients with Morton's neuroma present with vague pain between two toes in the associated web space, most commonly between the third and fourth toes. Clinical exams may reveal a "fullness" in the web space or rarely a small nodule. Medial lateral compression of the forefoot may reproduce or exacerbate the pain (Mulder's sign). AP, lateral, and oblique weight-bearing radiographs to rule out arthritis or stress fractures are helpful. MRI, ultrasound, and nerve studies are not generally useful for confirming or ruling out the diagnosis.

The underlying pathology is unclear. It may be an irritation of the common digital nerve against the intermetatarsal ligament. It is most common at the third-fourth interspace because frequently the medial and lateral plantar nerves (which are both branches of the posterior tibial nerve) come back together to form the common digital nerve for that space before dividing into the respective digital nerves for the lateral aspect of the third and medial aspect of the fourth toes, respectively.

As with many common foot problems, the first line of treatment is modified shoe wear with a wider toe box. Other options include a spacer (e.g., cotton ball) between the affected toes or a metatarsal pad, although most patients find these latter options unacceptable. A corticosteroid injection into the affected area may give long-lasting relief and, if the diagnosis is uncertain, can confirm that the clinician has the correct diagnosis. In addition a successful injection can portend a satisfied patient if the symptoms return and surgery is necessary.

Surgical treatment by excising the neuroma (from either a plantar or dorsal approach – patient and surgeon dependent) is normally successful but does leave the patient with a permanent numbness between the affected toes. The patient needs to be warned of this as well as the rare possibility of recurrence. If there are other causes of forefoot pain, the patient will have incomplete relief, so careful patient selection and counseling are necessary [41, 42].

7.3.6 Pediatric Deformities

7.3.6.1 Clubfoot (Equinovarus Foot)

Babies with a clubfoot are normally identified at birth by a unilateral foot and ankle deformity that consists of three parts. First, there is excessive adduction of the forefoot – in other words, all five metatarsals are deviated medially. Second, the hindfoot is in varus; i.e., the bottom of the heel is pointed toward the midline. Third, the ankle is in equinus, that is, pointed downward. All of these deformities are semirigid (Fig. 7.19).

The important thing to remember about a clubfoot is that it is not just a positional deformity. Even if completely corrected, the leg and foot will never be normal; the affected leg will always be smaller and never as flexible nor as strong as normal. Microscopic studies of the calf muscle of the affected limb show both decreased muscle cell size and number.

Although surgical treatment is certainly necessary in severe or late cases, most are now treated with serial short-leg casting known as the Ponzi method using plaster not fiberglass. The deformities are gently stretched and corrected, starting with the forefoot; then the hindfoot is addressed, followed by the equinus. Currently the first two are almost always corrected with casting, and most surgery is some type of

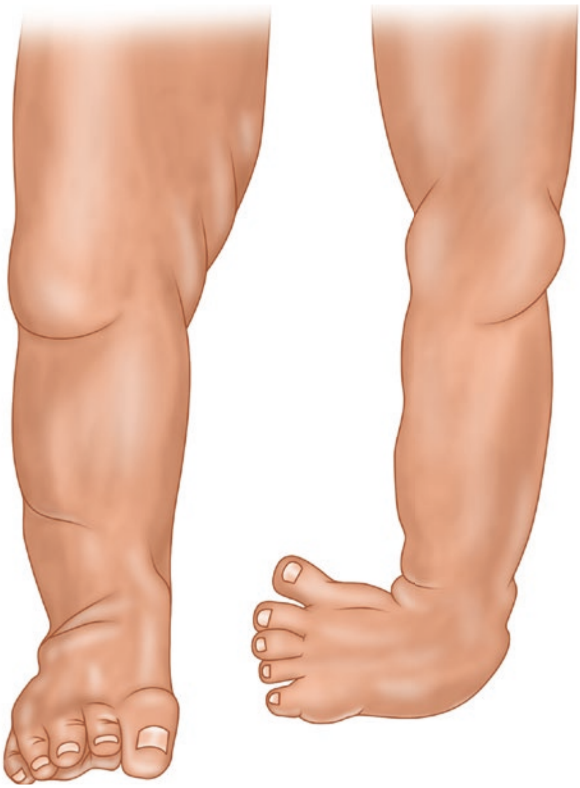

Fig. 7.19 A normal foot and a clubfoot. In addition to the foot and ankle deformity, there is significant atrophy of the calf musculature that is lifelong even if the foot deformity is completely corrected

Achilles lengthening to correct the equinus. Periodic radiographs to assess bony correction are helpful.

After correction modified, shoe wear and periodic follow-ups (especially during growth spurts) are necessary to prevent recurrence; further treatment may be necessary if the deformity recurs [43–46].

7.3.6.2 Metatarsus Adductus

Metatarsus adductus is just what it sounds like; the forefoot (metatarsals) is adducted (deviated toward the midline) (Fig. 7.20). This is normally picked up at the newborn exam or at the first (6 weeks) well-child visit.

Unlike clubfoot, metatarsus adductus does not usually have the long-term decrease in size, shape, strength, or flexibility of the hindfoot and calf.

Treatment is either parental stretching at every diaper change or serial casting, both of which are followed by a modified shoe to prevent reoccurrence. Length of time wearing the corrective shoes is patient and surgeon dependent [47].

7.3.7 Deformities of the Forefoot

7.3.7.1 Bunions (aka Hallux Valgus)

Although juvenile bunions do exist, most bunions present in middle- or older-aged women who complain of a painful prominence on the medial aspect of the first metatarsal head, associated with some deviation of the great toe laterally. There may or may not be associated arthritis of the great toe metatarsophalangeal joint.

Physical exam shows the deformity as described above. There may be secondary deviation of the lesser toes with callus or bursitis on the medial aspect of the first metatarsophalangeal joint. In more severe cases, there may also be rotational (pronation) deformities of the great toes.

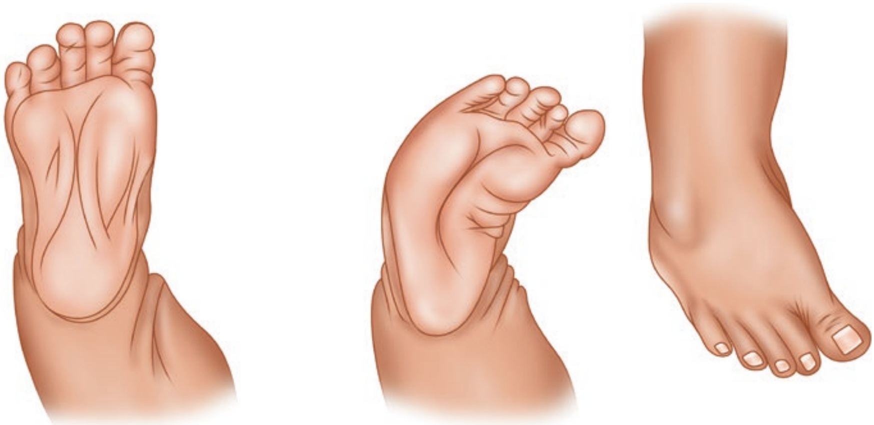

Fig. 7.20 Normal right foot viewed from the plantar aspect and a right foot with metatarsus adductus. Unlike clubfoot there is no accompanying hindfoot varus or equinus

Fig. 7.21 Radiograph and photo of a bunion. Note the subluxation of the first metatarsal phalangeal joint on the left and the rotational deformity of the great toe on the right

Standard radiographs include weight-bearing AP, lateral, and oblique views of the foot (Fig. 7.21). Two particular angles should be measured: the angle between the first and second metatarsal shafts and the angle between the first metatarsal shaft and the proximal phalanx of the great toe. The normal upper limits are 10° and 20°, respectively.

If it is just a cosmetic deformity with no associated pain, surgical intervention is not recommended. If there is pain, the first line of treatment is to change footwear to minimize the heel-forefoot height differential (i.e., no high-heeled shoes) and a wide toe box to accommodate the widened forefoot. Fortunately, in the last 10–20 years, many more stylish women's shoes with a wide toe box and a normal-sized heel have come on the market.

Should accommodative footwear not work or be declined, surgical treatment is available for patients who are good candidates (be leery of operating on patients with diabetes as their complication rate, especially infection, is much higher). Factors to consider in deciding which surgical option is appropriate include any associated arthritis, degree of deformity, age, and any associated conditions, e.g., a crossover toe. Depending on how one counts, there are 110–130 different operations to correct a hallux valgus deformity. Generally speaking, the surgery involves loosening the capsule, ligaments, and tendons of the lateral aspect of the first metatarsophalangeal joint, tightening the medial capsular laxity, removing the bony prominence, and correcting any medial deviation of the first metatarsal with an osteotomy in either the proximal or distal shaft. Recovery period is generally 6–8 weeks with crutch or walker use for 2–3 weeks while wearing a rigid post-op shoe. Many surgeons will have the patient wear a spacer between the first and second toes. The patient should be warned that it may be up to 6–12 months before recovery is finished. Other surgical options include soft tissue arthroplasty and first metatarsophalangeal arthrodesis [48, 49]. The two most common complications are recurrence and hallux varus. The latter is a result of overcorrection wherein the great toe is deviated medially making shoe wear difficult if not impossible.

7.3.7.2 Bunionette (aka Tailor's Bunion)

Similar to a bunion but not nearly so common, a bunionette presents as a painful prominence of the lateral aspect of the fifth metatarsal head. Like bunions, bunionettes can have associated calluses and bursitis (Fig. 7.22). The only diagnostic study normally needed is three weight-bearing views of the foot (AP, lateral, oblique).

Again, the initial treatment is shoes with a wide toe box. If this does not work, then several surgical options exist consisting of some type of resection of the bony prominence with or without a fifth metatarsal osteotomy depending on the degree of deformity and the fourth-fifth metatarsal shaft angle. Recovery is normally uneventful [50].

7.3.7.3 Hammertoes and Claw Toes

The smaller toes (digits 2–5) can have two primary deformities. The first is hammertoes which is a flexion deformity of the PIP joint, either rigid or fixed. There may be an associated extension contracture of the metatarsophalangeal joint (Fig. 7.23). Claw toes are similar but have a flexion deformity of the PIP and DIP joints. Often the hammertoe is isolated to a single toe, but claw toes involve three to four toes. As one would expect, the presenting complaint for both is a combination

Fig. 7.22 Small bilateral bunionettes which are asymptomatic as long as this patient wears shoes with a wide toe box or when wearing sandals

Fig. 7.23 Hammertoes with callus on the dorsum of the second and fifth toes. A shoe with a deeper toe box will frequently alleviate the symptoms

of painful calluses on the dorsum of the PIP joint and the distal end of the involved toe(s). This makes shoe wear difficult.

Hammertoes are thought to be the result of narrow poorly fitted shoes, while claw toes frequently are the result of an underlying neuromuscular disorder such as Charcot-Marie-Tooth disease.

As usual the first line of treatment for adult-onset forefoot deformities is modified shoe wear, in this case a deep toe box. Taping and splinting for hammertoes usually fail, but surgery is successful in most cases. Similarly, for claw toes, ultimately surgery will be necessary for those who are good surgical candidates and fail treatment with modified shoe wear. There are a variety of procedures to correct the deformity ranging from dorsal MTP joint capsulotomies to tendon transfer or tenotomies to partial phalangectomy [51].

7.3.7.4 Corns

Corns present as a painful callus between the toes and are usually "soft." On physical exam, in addition to the corn, the clinician can often palpate the bony prominence in the adjacent toe. Radiographs are useful to assess the underlying bony prominences.

Corns are the result of a bony prominence on one phalanx irritating the soft tissue in the adjacent phalanx, causing a callus. The callus becomes “soft” because of interdigital moisture.

Shoes with a wide toe box or a cotton ball between the toes will relieve the symptoms for many patients. If unsuccessful then surgery consists of excision of the bony prominence which eliminates the pressure on the callus and allows the skin to heal, thus making excision of the corn unnecessary.

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