Common Clinical Conditions of the Foot and Ankle

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Contents

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Goals and Objectives

- *Goal*:
  – Familiarize the reader with relevant orthopedic clinical anatomy of the foot and ankle
  – Provide a framework for understanding common ailments of the foot and ankle
  – Introduce the reader to the basic physical examination of the foot and ankle
- *Objectives*:
  On completion of this unit, the learner should be able to:
  1. Perform a physical exam of the foot and ankle in the ambulatory setting
  2. Understand and order appropriate imaging in the workup of foot and ankle pathology
  3. Be familiar with common nonsurgical modalities for common ailments
  4. Understand and describe common degenerative, neuropathic, and soft tissue problems in the foot and ankle

30.1 Physical Examination of the Foot and Ankle

30.1.1 Overview

Learning the physical exam of the foot and ankle requires consistency and practice. The foot and ankle play critical roles in locomotion; assessment of gait and standing alignment is paramount. Inspection can also reveal systemic pathologies. This section will discuss physical examination based on anatomic regions of the foot and ankle.

30.1.2 Inspection

As a general rule, the patient does not need to change into a gown or shorts unless the proximal lower extremity alignment is of particular concern. While the patient stands in front of the examiner, the alignment of the foot and ankle can be assessed from both anteriorly and posteriorly.

30.1.3 Standing Examination

In stance, the clinician can appreciate alignment and symmetry. Overall leg alignment should be examined by estimating pelvic tilt with fingers placed on the anterior superior iliac spine, as well as assessing varus or valgus alignment at the ankle, hindfoot, and the knee. Varus and valgus alignment of the heel can be appreciated from posteriorly, as well as a “too many toes sign” in planovalgus alignment, when the lesser toes are visible lateral to the heel from posteriorly [1] (Fig. 30.1). The rotational axis of the ankle may be estimated by placing fingers on either malleolus and exam-

Fig. 30.1 Posterior view of both ankles showing bilateral planovalgus alignment. This finding demonstrates visibility of most of the lesser toes—this finding is referred to as the “too many toes” sign

ining in relation to the tibial tubercle. Asking the patient to rise up on to the toes can help assess the strength of the posterior tibialis (PT, the heel should normally invert into varus as the patient plantar flexes). This ability is also dependent on normal function of the subtalar joint.

Viewed from laterally, the longitudinal foot arch may be examined relative to the contralateral side. Calcaneal position may be neutral, valgus, or varus aligned relative to the tibia (e.g., in heel varus, the medial border of the calcaneus will be visible from the front). In disorders of the longitudinal arch, it is important to note how the foot "tripod," demarcated by the 1st metatarsophalangeal (MTP) joint, the 5th MTP joint, and the plantar posterior heel, is affected by the combination of forefoot adduction and abduction and heel alignment.

The Coleman block test is an in-office examination method for testing the cause of cavovarus foot alignment. As described, it is performed by placing a 1-inch block under the heel and lateral border of the foot and then increasing or decreasing the height of the block in increments until the medial foot rests on the floor [2]. A flexible hindfoot will correct with this method; a rigid hindfoot will not.

30.1.4 Gait Examination

Gait should be examined through many strides with the arms swinging freely. The examiner should look at the whole body, noting that the shoulders should rotate 180° out of phase with the pelvis in the absence of pelvic, spinal, or shoulder pathology. Each phase of gait, stance and swing, should be examined. For the foot and ankle, note the degree of in-toeing, pronosupination, and heel inversion. In normal swing phase, the foot internally rotates roughly 15° and achieves external rotation by the time of toe-off. The foot typically pronates with weight bearing during the first half of stance phase and remains pronated as the heel rises. The heel should invert during liftoff.

30.1.5 Palpation

30.1.5.1 Lateral Ankle

The fibula is readily palpable and is a reference point for the lateral structures. Just posterior to the fibula are the peroneal tendons, peroneus longus, and brevis. The peroneus brevis is deep to the longus (remember the mnemonic "*brevis to bone*"). Their course is palpable down the lateral calcaneal wall. Peroneus brevis runs dorsal to peroneus longus, which remains plantar as the tendons course distal to the lateral malleolus. Peroneus brevis inserts at the base of the 5th metatarsal and is primarily responsible for foot eversion, which is counteracted by the inversion of the PT. Peroneus longus inserts at the base of the 1st metatarsal and is primarily responsible for 1st metatarsal plantar flexion and is counteracted by the dorsiflexion of the tibialis anterior.

The intermediate branch of the superficial peroneal nerve, in patients without significant swelling, is visible anterolaterally at the ankle and on the dorsal midfoot when the ankle is plantar flexed and inverted. It is the only peripheral nerve in the human body that is visible on normal surface anatomy [3].

30.1.5.2 Medial Ankle

The medial malleolus is the reference for all medial structures. As the medial malleolus is traced laterally and superiorly, the medial soft spot is felt, representing the medial gutter and Notch of Henry. By dorsiflexing the great toe and foot, respectively, the extensor hallucis longus and tibialis anterior tendons can be felt which is useful when performing a medial-sided ankle injection in this soft spot. The saphenous nerve courses just medial to the ankle joint at this level, and care should be taken to avoid the nerve with procedures such as injections.

Posterior to the tip of the medial malleolus is the PT. It can be felt along its entire course from proximally adjacent to the tibia to distally along its insertion on the navicular. Approximately one fingerbreadth posterior and superior to the medial malleolus, one can palpate the posterior tibial artery as it courses through the tarsal tunnel.

Deep and less palpable are the flexor digitorum longus (FDL) and the flexor hallucis longus (FHL). "*T*om, *D*ick, *a*nd *v*ery *n*ervous *H*arry" is a common mnemonic denoting the order from anterior to posterior of the P*T*, F*D*L, *a*rtery, *v*ein, *n*erve, and F*H*L.

30.1.5.3 Posterior Ankle

The major structure is the Achilles tendon which inserts broadly upon the calcaneus. The tendon receives contributions from the medial and lateral gastrocnemius and soleus. Plantaris, which does not contribute significantly to function, inserts on the medial calcaneus on its long course from its origin on the posterolateral proximal tibia.

30.1.5.4 Anterior Ankle

The reference point for the anterior ankle is the tibialis anterior (TA). It can be felt with passive foot dorsiflexion. From medial to lateral, the tendons of the extensor hallucis longus (EHL), extensor digitorum longus (EDL), and occasionally the peroneus tertius may be felt by isolating their actions. The dorsalis pedis artery and deep peroneal nerve course between the EHL and EDL tendons.

30.1.6 Seated Examination

The examiner should take special note of the hair (especially loss, indicating decreased microvascular blood flow), temperature, and any scarring or calluses. The capillary refill of the toes should be tested (normal <2 seconds) and pulses of the dorsalis pedis and posterior tibial arteries felt.

Individual peripheral nerves may be evaluated for proper function. The tibial nerve may be assessed as it passes behind the medial malleolus with gentle percussion, with distal paresthesias indicating a Tinel sign (a common term for such an exam in other areas of the body).

Range of motion and stability should be noted in all joints of the foot and ankle. The ankle normally medially deviates during plantar flexion (PF) and laterally deviates during dorsiflexion (DF). Normal DF is 10–15° and normal PF is 45–50°. Isolation of tibiotalar motion is accomplished by inverting the heel to lock the transverse tarsal joints. The anterior talofibular ligament (ATFL) may be assessed via the anterior drawer test in plantar flexion and the calcaneofibular ligament (CFL) via the anterior drawer test in dorsiflexion inversion stress test. Subtalar motion is measured by inversion and eversion of the heel and denoted either in degrees or a percentage of normal. The ankle and subtalar joints have linked motion, as the subtalar joint has one degree of eversion for each degree of ankle dorsiflexion and one degree of inversion for each degree of ankle plantar flexion. When assessing the transverse tarsal joints (talonavicular and calcaneocuboid), the adduction-abduction ratio should be 2:1. Midfoot range of motion is more limited on examination, with the medial tarsometatarsal (TMT) joints having less range of motion than the 4th and 5th TMT joints.

30.2 Appropriate Radiographic Evaluation of Foot and Ankle Problems

Advanced imaging options offer detailed anatomic and biologic views. Cost-effective use of imaging must either confirm a clinical suspicion or change clinical management.

30.2.1 Radiographs

Most imaging workup will begin with plain radiographs. Whenever possible, these radiographs should be weight bearing. They include an AP, lateral, and mortise (Figs. 30.2, 30.3, and 30.4). For the foot, an AP, oblique, and lateral view are standard.

Several other views exist and may be useful in the diagnosis of different pathologies. These include the ankle impingement views in the extremes of plantar and dorsiflexion and stress views of the syndesmosis. Many common foot and ankle pathologies, such as strains or sprains, may resolve without incident. Thus, the Ottawa Ankle rules serve as useful guidelines for obtaining advanced imaging. Essentially, if the patient

Fig. 30.2 Anteroposterior (AP) view of the right ankle

Fig. 30.3 Internal rotation (mortise) radiograph of the right ankle. Note that this radiograph more clearly demonstrates the joint space

has bony tenderness or inability to bear weight for at least four steps, an X-ray series should be obtained [4].

30.2.2 Ultrasound

Ultrasound can be a useful adjunct in diagnosis of foot and ankle pathologies. Advantages include its ability to provide dynamic imaging in a low-cost, radiation-free manner. It is, however, limited by the ability to penetrate materials such as bone, hardware, and gas. Clinically, ultrasound is used to assess ganglion cysts and superficial structures. When the probe is passed over a painful structure, sonopalpation provides visual confirmation to diagnosis.

Fig. 30.4 Lateral radiograph of the ankle

30.2.3 Computed Tomography

Computed tomography (CT) is useful in delineating bony anatomy in the three anatomic planes: coronal, sagittal, and axial. This is of particular value in surgical planning for complex fractures of the foot and ankle, especially midfoot fractures and dislocations, Tillaux fractures, and pilon fractures. It is also a useful imaging modality to assess for bony union in fusion procedures.

30.2.4 Magnetic Resonance Imaging

Commonly used sequences are T1, T2, and fat-suppressed images. Briefly, T1 images delineate anatomy in high resolution, T2-weighted are fluid bright and detect inflammation and edema, and fat-suppressed images are a useful adjunct for further characterizing lesions.

Ligaments appear dark and often lie oblique to the axis of imaging. Strains appear as signal hyperintensity within the ligament with thickening or possibly edema versus a discontinuity in fibers with tears (Figs. 30.5 and 30.6). MRI is not routinely used for sprains except in determining extent of midfoot ligamentous injury (as found in Lisfranc injuries) and helping the clinician determine whether to proceed with exam under anesthesia. It should be noted that CT is also a very sensitive and less costly modality for imaging the midfoot for these injuries [5].

Fig. 30.5 A T1-weighted sagittal MRI image of the ankle in a patient with an Achilles tendon rupture

Fig. 30.6 A T2-weighted MRI image in the same patient. Note that this fluid-sensitive sequence visualizes the significant amount of edema surrounding the injured tendon

MRI is also commonly used to characterize articular cartilage topography and assess for bone marrow edema found in osteochondral defects. Some special sequences such as T1rho and DGEMRIC sequences exist to quantify cartilage health, but their discussion is beyond the scope of this text.

Finally, MRI may be used to assess tendinous structures. Tendinosis may be visualized as an increase in signal intensity on T1 GRE sequences or peritendon inflammation on T2-weighted sequences.

30.3 Orthotics: Principles of Nonoperative and Operative Management

30.3.1 Alignment

Lower extremity alignment is fundamentally important in pain-free, normal gait and stance mechanics. The mechanical axis is defined in the frontal plane by a line drawn from the center of the femoral head to the center of the talus. It should intersect approximately 1 cm medial to the tibial plateau. Deviations from this normative value predispose to osteoarthritis in various joints of the lower extremity.

Below the knee, the anatomic and mechanical axes are parallel. The anatomic axis of any bone is defined by the line subtending two midpoints of the bone diaphysis. When viewed from behind, the calcaneus lies in slight valgus relative to the tibia. Sagittally, the axis of the tibia should intersect the center of the talar dome. Generally speaking, it is important for the foot to be plantigrade (as discussed earlier with the tripod of the foot). As a result, most deformities about the foot and ankle develop a secondary deformity (e.g., in pes planovalgus, the forefoot may be in varus). Understanding this concept allows the clinician to make modifications to shoewear and via orthotics to improve alignment.

30.3.2 Shoewear

In the adult foot and ankle, most deformities are acquired and may be the result of ill-fitting shoes. As a result, patient education and prescription of proper shoewear, devices, and orthoses may be a cost-effective means of treating various problems. These include hallux valgus (bunions), hammer toes, hard corns, interdigital neuromas, and plantar keratoses.

When buying footwear, patients are advised to consider the recommendations of a joint panel from the National Shoe Retailers Association, Pedorthic Footwear Association, and the American Orthopedic Foot and Ankle Society. Main points include trying shoes on at the end of the day, leaving one fingerbreadth of space between the end of the shoe and the longest toe, and measuring the shoe in a weight-bearing position.

30.3.3 Orthoses

Orthoses attempt to correct the position of the foot and ankle by applying a controlled force to various anatomic structures. These can range from simple shoe inserts to ankle-foot orthoses (AFOs). Ultimately, the goal of these devices is to cushion areas that experience too much pressure, controlling the shape of flexible deformities, and to accommodate fixed deformities to more evenly distribute body weight in a more anatomic way. While these devices may be useful in alleviating pain, there is no evidence that they can prevent structural deformities.

Custom orthoses may be made of soft, semirigid, or rigid materials and may require adjustment of the depth of footwear for the patient to accommodate the orthosis. Soft materials are used for cushioning which is of particular importance in people with diminished sensation, such as in diabetic feet or neuropathy from other causes. Semirigid inserts offer structural support and impact absorption. As such, they can be used for flexible deformities by offering structure and modifying weight transfer. Finally, rigid orthoses control motion in rigid deformities that may accompany arthritis of the midfoot and forefoot. These are most commonly used to control over-pronation of the foot but may be uncomfortable in patients with fat pad atrophy or bony plantar prominences and should not be used in insensate patients.

Ankle-foot orthoses (AFOs) span from the mid-tibia down to the foot and may be made from double upright bars or polypropylene molded to the shape of the patient. The ankle portion of the device may be either fixed or hinged. They may be modified through reliefs over bony prominences or to provide comfort. By modifying the position of the trim lines in molded models, the orthotist may control the various joints of the foot and ankle.

30.4 Common Degenerative Problems of the Foot and Ankle and Their Management

End-stage ankle arthritis has been shown to be as disabling as hip arthritis on patient-reported outcome measures [6]. Because it is most commonly posttraumatic in etiology, ankle arthritis often has onset at an earlier age than either hip or knee arthritis and therefore affects an individual for a longer period of their life. Management of ankle arthritis in early stages consists of symptomatic management, either with bracing with a gauntlet or solid ankle-foot orthosis, potentially with a rocker bottom shoe, or limited use of corticosteroid intraarticular injection for symptomatic relief. When nonsurgical options fail, patient-centered discussions should be centered on ankle fusion (picture) or total ankle replacement (picture). While both ankle replacement and ankle fusion offer similar pain relief, ankle replacement offers improved gait pattern, stride length, and cadence [7]. On the other hand, ankle fusion offers a durable option with less likelihood of revision due to implant loosening or failure. Conventional wisdom suggests that younger more active patients are indicated for ankle fusion, while older patients with fewer demands on the components are better candidates for total ankle replacement. Age is not an absolute contraindication to either procedure; therefore a discussion of both options is relevant in most situations.

30.4.1 Common Neuropathic Problems of the Foot and Ankle and Their Complications

Diabetes is a devastating and growing problem in the United States [8] causing a host of problems from peripheral neuropathy to retinopathy to end-stage renal failure. Unfortunately, up to 68% of diabetic patients present with some form of foot or ankle pathology [9]. Impaired glucose management is known to result in damage to the vasa nervorum and is thought to do so by both accumulation of sorbitol and intraneural accretion of glycosylated byproducts [10]. This is currently an irreversible process that results in neuropathy and loss of protective sensation. Ultimately, the loss of proprioception both from neuropathy and retinopathy leads to postural increases in pressure which the insensate patient cannot feel. When combined with the presence of dysautonomia which accompanies microvascular changes, this can result in cracked skin that progresses to an ulcer or other repetitive microtraumas that can result in Charcot arthropathy [11].

30.4.2 Total Contact Casting

Total contact casting (TCC) remains a clinically cost-effective treatment strategy for grade 1 ulcerations. TCC is presumed to work by reduction of forefoot pressures by transfer of weight-bearing load to the cast wall. Studies are equivocal about the utility for TCC in heel ulceration with some studies revealing decreased heel pressures and some showing increased heel pressures [12, 13].

A few important principles in casting are to (1) not over pad as this can lead to shifting in the cast, (2) limit toe motion to diminish metatarsal head pressure, (3) to pad bony prominences experiencing increased pressure, (4) position the foot in a plantigrade position in the cast, and (5) change the cast in 5–10 days.

30.4.3 Tarsal Tunnel Syndrome

Tarsal tunnel syndrome is a compressive neuropathy of the posterior tibial nerve or its terminal branches within or as they exit the tarsal canal. The tunnel itself is behind the medial malleolus and is bordered by the tibia anteriorly, the posterior process of the talus laterally, and the flexor retinaculum medially. The posterior tibial nerve gives off three branches (medial and lateral plantar nerves and the medial calcaneal nerve) as it courses through the tunnel.

Patients with tarsal tunnel syndrome typically complain of burning, shooting, or electric-type pain most prominent at the medial ankle and plantar foot. As with any compressive neuropathy, it can be caused by a space-occupying lesion or may result insidiously after a trauma or be idiopathic in nature.

The diagnosis may be suggested by exam findings of a positive Tinel's sign over the course of the posterior tibial nerve and confirmed with electrodiagnostic (EMG) studies. While some debate exists, the sensory nerve conduction velocity is thought to be about 90% sensitive for confirming the diagnosis when testing the abductor hallucis and abductor digiti quinti muscles [14].

Treatment consists of both nonsurgical and surgical options with the choice of treatment dictated by the cause of neural compression. Space-occupying lesions may simply be excised whereas tarsal tunnel syndrome of other causes may be adequately treated with NSAIDs, multimodal pain regimens, or steroid injections adjacent to the posterior tibial nerve. When all nonoperative modalities have failed or if a structural problem exists, surgery is warranted. Any space-occupying lesion should be removed with care to not damage the nerve. Correction of deformities may provide indirect compression without need for nerve release. Surgical release of the posterior tibial nerve involves release of the flexor retinaculum with care to identify the nerve throughout its course and protect it.

30.4.4 Neuroma

Interdigital neuromas are a common source of pain in the foot. They are not always associated with a mass or inflammation but rather compression of the interdigital nerves which branch from the medial plantar nerve (MPN). The exact etiology of interdigital neuromas is not clear but may be a combination of anatomic, traumatic, or other extrinsic factors. Anatomically, the third webspace experiences greater mobility due to the relatively fixed position of the medial three rays and the relatively mobile nature of the lateral two rays. This may predispose the nerve, which lies below the transverse metatarsal ligament, to greater daily microtraumas. Other trauma such as falls, crush injuries, or transection may cause interdigital neuroma. Finally, processes that cause pressure against the nerve may result in interdigital neuralgia. Thickening of the transverse metatarsal ligament can cause pressure on the nerve as can fracture of the metatarsal.

Regardless of the cause, patients commonly report pain in the plantar aspect of the foot with radiation to the toes in several patients. This is aggravated by tight-fitting shoes or by prolonged dorsiflexion of the toes as in walking.

MRI may not be a cost-effective diagnostic modality in diagnosing this condition with some studies demonstrating lack of correlation between MRI findings and symptoms in one-third of the patients and others demonstrating favorable surgical results with transverse measurement of nerve greater than 5 mm. MRI may be useful in providing anatomic detail to rule out other causes of pain in the area such as degenerative joint capsule [15, 16]. Local anesthetic injection may be useful in relieving pain although interpretation of this should be done with caution as it may relieve pain as a result of other anatomic structures in the area (fat pad, plantar plate) [17]. Additionally, the use of cortisone may cause atrophy of the collateral ligaments or other collagenous structures and the plantar fat pad [18].

Morton's neuromas, which affect the interdigital nerves, may be treated with a wider shoe and a metatarsal pad. If a patient has failed all nonoperative management options, a dorsal approach is typically selected to prevent painful scar on the weight-bearing surface of the foot. The transverse metatarsal ligament is transected, and the nerve is freed proximally to the metatarsal head and excised. Rungprai et al. reported good results from burial of the nerve intramuscularly.

30.5 Common Soft Tissue Injuries of the Foot and Ankle and Their Management

30.5.1 Lateral Ankle Instability

Lateral ankle instability is a very common condition, with ankle sprains occurring an estimated 23,000 times a day in the United States [19, 20]. Activity in sports, cavovarus alignment, and ligamentous laxity are all risk factors for sustaining recurrent ankle sprains and developing chronic lateral ankle instability.

Nonoperative treatment consists of physical therapy with proprioceptive training and peroneal strengthening. Any cavus alignment merits considering a lateral forefoot posted foot orthotic to realign the deformity. A lace-up ankle brace can also serve as an adjunct in the healing process. Functional, active rehabilitation is key for rapid and effective healing.

If nonoperative treatment fails, surgical options are considered. Lateral ankle ligament reconstruction, such as the modified Brostrom-Gould procedure where the inferior extensor retinaculum is imbricated over the repaired anterior talofibular and calcaneofibular ligaments, is a common option for primary surgical treatment. If severe cavovarus malalignment exists, surgical correction through realigning osteotomies is a consideration.

30.5.2 Achilles Tendon Injuries

The Achilles tendon sees the highest load of any tendon in the human body, up to ten times body weight [21]. As a result, the Achilles tendon is subject both to acute rupture and chronic degenerative conditions.

Achilles tendinopathy occurs either at the insertion of the Achilles tendon at the calcaneus or in the non-insertional region of the tendon between 2 and 5 centimeters proximal to the insertion, where the tendon both has a watershed area of decreased vascular supply [22] and a torsional twist that allows it to store energy [23]. With aging, Type I collagen in the tendon decreases, and tendon fibril diameter decreases, leading to decreased flexibility of the tendon [24]. The mainstay of Achilles tendinopathy is stretching exercise by the patient of the gastrocsoleus complex. A heel lift in the shoe decreases stress on the tendon during daily activity. Nitroglycerin patches, cut to the size of the symptomatic area and applied directly to the skin on a daily basis, also have been shown to increase blood flow to the tendon and promote long-term healing [25]. After failure of nonoperative options, often after at least 6 months' trial, surgical options include gastrocnemius recession and debridement of severely diseased tendon, either through open or endoscopic techniques.

Achilles rupture is most commonly an injury of the middle-aged athlete performing jumping or similar activity, although it can affect all ages, both athletes and nonathletes. Similar to the region of non-insertional tendinopathy, Achilles rupture most commonly occurs in the watershed area between 2 and 5 centimeters proximal to the insertion (Figs. 30.5 and 30.6). Nonoperative treatment is often successful in healing Achilles rupture for individuals of all functional levels, with randomized controlled trials supporting good outcomes compared to operative management [26]. Other studies have also shown benefits of operative treatment for long-term strength of plantar flexion by up to 18% [27]. Operative treatment can be performed with suture methods through open, mini-open, or percutaneous methods. The rehabilitation for operatively and nonoperatively treated Achilles tendon ruptures is typically the same, using a functional rehabilitation protocol, with early weight-bearing and range of motion, avoiding dorsiflexion past neutral ankle position for the first 6 weeks.

30.5.3 Plantar Fasciitis

Plantar fasciitis is a relatively common cause of medial heel pain and tenderness. Patients characteristically complain of pain with their first steps in the morning and lessening with activity. Patients typically localize the pain about the medial tubercle of the calcaneus. Through a mechanism known as the windlass mechanism, dorsiflexion of the toes will increase tensile forces on the calcaneal aspect of the plantar fascia and therefore pain. Treatment is almost always nonoperative with improvement or elimination in pain noted with maximizing length of the gastrocnemius/soleus complex [28, 29]. Corticosteroid injection may provide temporary relief of pain [30] but typically does not provide sustained relief and is also accompanied by complications such as plantar fascia rupture and fat pad atrophy [31]. The literature has not proven the effectiveness of extracorporeal shock wave therapy. Finally, gastrocnemius recession may be used after extensive nonoperative treatment has failed to provide adequate relief [32].

30.5.4 Posterior Tibial Tendinitis

Tendinitis of the PT can lead to adult flat foot deformity and is staged according to the severity of symptoms and deformity. It was first classically described by Johnson and Strom as having three stages [33]. It is ultimately a degenerative process that begins with tendinitis/tendinosis of the PT tendon and progresses to dysfunction of the tendon and inability to perform single heel rise, followed by eventual collapse of the spring ligament and resultant collapse of the arch and stiff flat foot. The stages and their respective treatments are cited in the table below as modified from the JAAOS article by Deland from 2008 [34] (Table 30.1).

Table 30.1 The stages and their respective treatments are cited in the table below as modified from the JAAOS article by Deland from 2008 [34]

Stage	Deformity	Physical exam findings	Radiographic findings	Treatment
I	Tenosynovitis, may have preexisting pes planus but without deformity	Able to perform single heel rise (SHR)	Essentially normal	Rest, NSAIDs, PT strengthening, CAM boot
IIA	Mild/moderate flexible deformity (can be passively corrected)	Inability to perform SHR	<30% talonavicular (TN) uncoverage, collapse of Meary's angle and longitudinal arch	Consider medial forefoot posted custom AFO, gastrocnemius stretching, PT strengthening
IIB	Severe flexible deformity	"Too many toes" sign (forefoot abduction) Inability to perform SHR Mild sinus tarsi pain	>30% TN uncoverage, arch collapse as in IIA	"All-American" procedure (calcaneal slide osteotomy to correct hindfoot valgus, lateral column lengthening to correct forefoot abduction, cotton osteotomy to correct forefoot varus)
III	Fixed deformity	Inability to perform SHR Severe sinus tarsi pain	Arch collapse with subtalar arthritis	Arizona bracing, double arthrodesis (subtalar/TN) vs triple osteotomy (subtalar, TN, calcaneocuboid) [35]

30.5.4.1 Fractures

Fractures of the foot and ankle are common and a potential source of significant morbidity. Given the wide array of possible osseous injuries in this anatomic location, detailed discussion of these conditions is outside the scope of this text. As a general principle, clinicians should consider obtaining plain radiographs of the foot and/or ankle in patient with significant bony tenderness (e.g., over the malleoli), ecchymosis, possible mechanism of injury, or inability to bear weight (Figs. 30.7 and 30.8).

30.5.4.2 Arthritis

As with fractures, the management of ankle arthritis is outside the scope of this text. Although less common than in other areas such as the hip and knee, degenerative changes at the ankle are a significant source of morbidity. Patients with ankle arthritis have activity-related pain, loss of motion, and functional deficits as seen in other anatomic locations. Radiographs demonstrate a loss of articular cartilage, associated subchondral sclerosis, and osteophyte (bone spur) formation (Fig. 30.9). Some patients' mild or moderate symptoms can be treated nonsurgically with injections, bracing, and footwear modifications. Patients who do not respond to less invasive modalities may benefit from ankle replacement (Fig. 30.10) or ankle fusion (Fig. 30.11). Ankle replacement (arthroplasty) is increasing in popularity but can be complicated by infection and loosening as in other joint replacement surgeries. Ankle fusion is a durable reconstruction that provides lasting pain relief for many patients. The loss of motion at the tibiotalar joint, though, can make patients more likely to develop degenerative changes elsewhere in the foot.

Figs. 30.7 and 30.8 AP and lateral radiographs of a fracture dislocation of the ankle. Note the significant disruption of the bony structures around the ankle as well as the significant lateral and posterior displacement of the talus

Fig. 30.9 AP radiograph of a patient with osteoarthritis of the ankle. Note the loss of joint articular cartilage (joint space) and bone spur formation

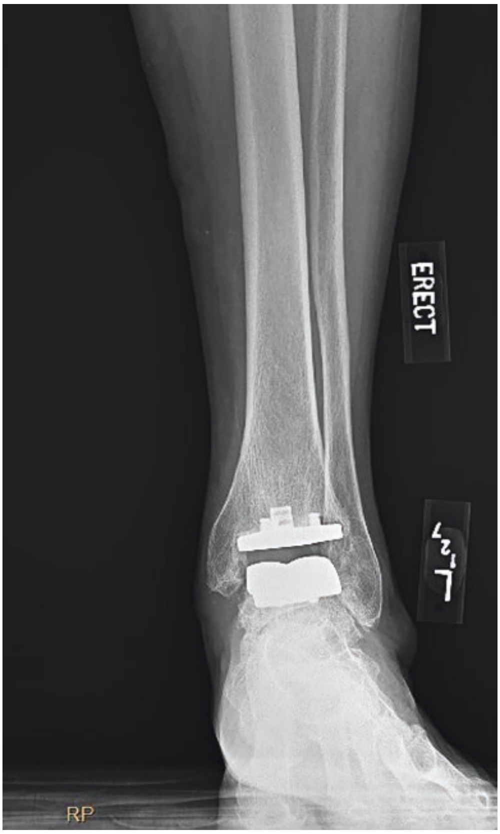

Fig. 30.10 AP radiograph of a patient after total ankle arthroplasty

Fig. 30.11 Lateral radiograph of a patient after tibiotalar (ankle) fusion

References

1. Johnson KA. Tibialis posterior tendon rupture. Clin Orthop Relat Res. 1983;177:140–7.
2. Coleman SS, Chesnut WJ. A simple test for hindfoot flexibility in the cavovarus foot. Clin Orthop Relat Res. 1977;123:60–2.
3. Horwitz M. Normal anatomy and variations of the peripheral nerves of the leg and foot: application in operations for vascular diseases: study of one hundred specimens. Arch Surg. 1938;36(4):626–36.
4. Stiell IG, et al. Implementation of the Ottawa ankle rules. JAMA. 1994;271(11):827–32.
5. Preidler KW, et al. Conventional radiography, CT, and MR imaging in patients with hyperflexion injuries of the foot: diagnostic accuracy in the detection of bony and ligamentous changes. AJR Am J Roentgenol. 1999;173(6):1673–7.
6. Glazebrook M, et al. Comparison of health-related quality of life between patients with end-stage ankle and hip arthrosis. J Bone Joint Surg Am. 2008;90(3):499–505.
7. Flavin R, et al. Comparison of gait after total ankle arthroplasty and ankle arthrodesis. Foot Ankle Int. 2013;134:1340–8.
8. Geiss LS, et al. Prevalence and incidence trends for diagnosed diabetes among adults aged 20 to 79 years, United States, 1980-2012. JAMA. 2014;312(12):1218–26.
9. Holewski JJ, et al. Prevalence of foot pathology and lower extremity complications in a diabetic outpatient clinic. J Rehabil Res Dev. 1989;26(3):35–44.
10. Yagihashi S, Mizukami H, Sugimoto K. Mechanism of diabetic neuropathy: where are we now and where to go? J Diabetes Investig. 2011;2(1):18–32.
11. Brand PW. Tenderizing the foot. Foot Ankle Int. 2003;24(6):457–61.
12. Baumhauer JF, et al. A comparison study of plantar foot pressure in a standardized shoe, total contact cast, and prefabricated pneumatic walking brace. Foot Ankle Int. 1997;18(1):26–33.
13. Birke JA, Sims DS Jr, Buford WL. Walking casts: effect on plantar foot pressures. J Rehabil Res Dev. 1985;22(3):18–22.
14. Oh SJ, et al. Tarsal tunnel syndrome: electrophysiological study. Ann Neurol. 1979;5(4):327–30.
15. Bencardino J, Rosenberg ZS, Delfaut E. MR imaging in sports injuries of the foot and ankle. Magn Reson Imaging Clin N Am. 1999;7(1):131–49, ix.
16. Biasca N, Zanetti M, Zollinger H. Outcomes after partial neurectomy of Morton's neuroma related to preoperative case histories, clinical findings, and findings on magnetic resonance imaging scans. Foot Ankle Int. 1999;20(9):568–75.
17. Markovic M, et al. Effectiveness of ultrasound-guided corticosteroid injection in the treatment of Morton's neuroma. Foot Ankle Int. 2008;29(5):483–7.
18. Greenfield J, Rea J Jr, Ilfeld FW. Morton's interdigital neuroma. Indications for treatment by local

injections versus surgery. Clin Orthop Relat Res. 1984;(185):142–4.
19. Kannus P, Renstrom P. Treatment for acute tears of the lateral ligaments of the ankle. Operation, cast, or early controlled mobilization. J Bone Joint Surg Am. 1991;73(2):305–12.
20. Shah S, et al. Incidence and cost of ankle sprains in United States emergency departments. Sports Health. 2016;8(6):547–52.
21. Smart GW, Taunton JE, Clement DB. Achilles tendon disorders in runners--a review. Med Sci Sports Exerc. 1980;12(4):231–43.
22. Chen TM, et al. The arterial anatomy of the Achilles tendon: anatomical study and clinical implications. Clin Anat. 2009;22(3):377–85.
23. Benjamin M, Evans EJ, Copp L. The histology of tendon attachments to bone in man. J Anat. 1986;149:89–100.
24. Pierre-Jerome C, Moncayo V, Terk MR. MRI of the Achilles tendon: a comprehensive review of the anatomy, biomechanics, and imaging of overuse tendinopathies. Acta Radiol. 2010;51(4):438–54.
25. Paoloni JA, et al. Topical glyceryl trinitrate treatment of chronic noninsertional achilles tendinopathy. A randomized, double-blind, placebo-controlled trial. J Bone Joint Surg Am. 2004;86-A(5):916–22.
26. Willits K, et al. Operative versus nonoperative treatment of acute Achilles tendon ruptures: a multicenter randomized trial using accelerated functional rehabilitation. J Bone Joint Surg Am. 2010;92(17):2767–75.
27. Lantto I, et al. A prospective randomized trial comparing surgical and nonsurgical treatments of acute Achilles tendon ruptures. Am J Sports Med. 2016;44(9):2406–14.
28. DiGiovanni BF, et al. Tissue-specific plantar fascia-stretching exercise enhances outcomes in patients with chronic heel pain. A prospective, randomized study. J Bone Joint Surg Am. 2003;85-A(7):1270–7.
29. Digiovanni BF, et al. Plantar fascia-specific stretching exercise improves outcomes in patients with chronic plantar fasciitis. A prospective clinical trial with two-year follow-up. J Bone Joint Surg Am. 2006;88(8):1775–81.
30. Crawford F, et al. Steroid injection for heel pain: evidence of short-term effectiveness. A randomized controlled trial. Rheumatology (Oxford). 1999;38(10):974–7.
31. Acevedo JI, Beskin JL. Complications of plantar fascia rupture associated with corticosteroid injection. Foot Ankle Int. 1998;19(2):91–7.
32. Molund M, et al. Proximal medial gastrocnemius recession and stretching versus stretching as treatment of chronic plantar heel pain. Foot Ankle Int. 2018;39:1071100718794659.
33. Johnson KA, Strom DE. Tibialis posterior tendon dysfunction. Clin Orthop Relat Res. 1989;239:196–206.
34. Deland JT. Adult-acquired flatfoot deformity. J Am Acad Orthop Surg. 2008;16(7):399–406.
35. Moseir-LaClair S, Pomeroy G, Manoli A. Intermediate Follow-Up on the Double Osteotomy and Tendon Transfer Procedure for Stage II Posterior Tibial Tendon Insufficiency. Foot & Ankle International. 2001;22(4):283–91. https://doi.org/10.1177/107110070102200403.