Bowers and Martin\textsuperscript{1} coined the term \textit{turf toe} in 1976 for an injury to the first metatarsophalangeal joint. The term has been used ever since by athletes, coaches, trainers, and physicians for a myriad of more specific diagnoses, such as first metatarsophalangeal joint sprain or strain, osteochondral fracture, sesamoiditis, sesamoid fracture, first metatarsal head contusion, first metatarsophalangeal joint dislocation, capsulitis, and hallux limitus.

Originally, Bowers and Martin\textsuperscript{1} described the injury as a “sprain of the plantar capsuloligamentous complex of the metatarsophalangeal joint of the great toe.” Common factors in turf-toe injuries include axial jamming of the joint, rapid stops of the foot on the playing surface, a varus or valgus stress, faster playing surfaces, lighter shoes, and direct jamming against a fixed object (rare). With shoes becoming lighter owing to design characteristics, and playing surfaces being designed to increase speed, the resulting injury is due to decreased foot support and increased stress on the foot. These injuries can vary from mild to severe, causing an athlete to miss practices and games, and some turf-toe injuries can end an athlete’s career. As a result, prompt, proper diagnosis and treatment must be rendered by a well-informed podiatric physician to allow the athlete to return to participation in sports as soon as possible and to prevent long-term functional disability and deformity. Long-term disability greatly reduces the athlete’s ability to perform and limits the future physical activities and possibly employment opportunities of the athlete. Long-term sequelae of turf toe include an inability to return to pre-injury performance owing to lack of push-off strength, hallux rigidus, hallux valgus, arthrofibrosis, loose bodies, and hallux cock-up deformity.\textsuperscript{2} Clanton et al\textsuperscript{3} noted a 50% incidence of persistent symptoms at more than 5 years of follow-up in 20 athletes diagnosed as having a turf-toe injury. Some athletes with turf-toe injuries experience difficulty with toe-off or push-off power with or without hallux limitus or rigidus deformities.

This injury was originally thought to be due to the combination of athletic playing surfaces and flexible shoes, and it is commonly associated with American football players playing on artificial surfaces. Athletes playing other sports, such as basketball, tennis, soccer, gymnastics, and wrestling, can also experience turf-toe injuries.

Over time, artificial surfaces become firmer and lose the ability to absorb shock.\textsuperscript{4} However, Clanton et al\textsuperscript{3} reported that during a 3-year period at Rice University, an equal number of turf-toe injuries occurred before and after installation of new artificial playing surfaces, thus giving less credence to the theory that hard surfaces contribute to first metatarsophalangeal joint injuries. Artificial athletic surfaces were developed in 1966, and since that time there has been an increase in the number of reported injuries to the metatarsophalangeal joint; however, with a return to more natural surfaces and improved surfaces becoming available, a decrease in this type of injury could be expected. However, the technical athletic shoe,
another contributory factor, is becoming lighter and more flexible. During the 25 years before 1986, the trainers and physicians at Rice University could not recall a single instance of a severe first metatarsophalangeal joint sprain occurring in a football player wearing traditional grass shoes. Fewer forefoot injuries occur on grass surfaces, as cleated shoes used on grass surfaces usually have a stiffer plate in the sole that reduces flexion forces across the forefoot. Turf-style shoes can be made stiffer by the addition of a steel or carbon fiber or graphite insert. Stiffening the sole of the shoe can decrease the range of motion of this joint to 25° to 30° without significantly altering an athlete’s gait pattern. Springlite (Salt Lake City, Utah) offers a 100% carbon fiber plate that is the thinnest and lightest available. The Springlite foot plate comes in a flat, arch, or Morton’s extension style (ideal for use by athletes with injuries to the first metatarsophalangeal joint). This plate is extremely durable and will not crack or deform over time.

Foot injuries occur frequently in the athletic population. In a study by Clanton and Ford, injuries of the foot were the third most common time-loss injury for university athletes, behind ankle and knee injuries. Clanton and Ford reported that a large portion of the foot injuries were to the toe and, more specifically, to the first metatarsophalangeal joint. Turf-toe injuries have been poorly reported in the literature compared with other injuries. Ankle sprains are four times more common, but turf-toe injuries result in twice the number of missed practices. Clanton et al found that during a 14-year span at Rice University, 63 first metatarsophalangeal joint injuries occurred in 53 athletes and 84% of the initial injuries to the first metatarsophalangeal joint occurred on artificial turf. Coker et al noted that six first metatarsophalangeal joint injuries per season occurred during a 3-year period. In a study of the West Virginia University football team, 27 first metatarsophalangeal joint sprains occurred in 5 years (an average of 5.4 injuries per season in a population of 500 players). Rodeo et al showed that 45% of professional football players had sustained a turf-toe injury: 60% of offensive players surveyed had experienced turf toe, compared with 32% of defensive players. However, the difference between these values was not statistically significant. Direct trauma, such as being tackled or fallen on, caused most of these injuries.

Preexisting reduced range of motion in the first metatarsophalangeal joint has been refuted by recent studies as a factor in injuries to the joint. Eggert found no relationship between decreased range of motion in the first metatarsophalangeal joint and turf toe. However, Rodeo et al found that athletes with turf-toe injuries had mean ankle dorsiflexion of 13.3° versus 7.9° for uninjured players, a statistically significant difference (P < .05). Several researchers have suggested that increased ankle range of motion places the first metatarsophalangeal joint at risk for hyperextension injuries.

Hyperextension of the first metatarsophalangeal joint is the usual cause of a turf-toe injury and results in tearing of the joint capsule at the plantar aspect of the metatarsal head and neck. This mechanism is commonly seen when the toes are flush against the playing surface and the athlete experiences a force or push to the posterior aspect of the heel, thus causing the hyperextension-type injury. The most severe cases also demonstrate a dorsal compression fracture of the proximal phalangeal base as it jams into the first metatarsal head. Rodeo et al found that 85% of turf-toe injuries occurred with dorsiflexion and that 12% occurred with plantarflexion.

Occasionally, a hyperflexion-type injury is encountered, usually in dancers and gymnasts. A leap or dismount can result in the hallux catching the playing surface and then the body traveling over the plantarflexed hallux. A possible avulsion fracture of the distal phalanx from the extensor hallucis longus muscle can result from hyperflexion-type injuries to the first metatarsophalangeal joint. Generally, hyperflexion-type injuries are not as debilitating as hyperextension injuries. Frey et al coined the term sand toe to differentiate flexion injuries from classic turf toe, as they found sand-toe injuries in beach volleyball players.

A rare valgus or varus stress can also result in injury to the first metatarsophalangeal joint. A valgus component to the hyperextension of the first metatarsophalangeal joint results in injury to the plantar medial ligamentous structures and occasionally to the tibial sesamoid bone and in the eventual development of a traumatic bunion with contracture of the lateral structures.

Anatomy of the First Metatarsophalangeal Joint

The first metatarsophalangeal joint is the articulation of the first metatarsal head and the base of the hallux proximal phalanx, which consists of one anatomical joint. Inherently unstable, the soft-tissue construct provides joint reinforcement that allows the hallux to support 40% to 60% of body weight during walking and significantly greater forces during running and jumping. Within this complex joint is a myriad of anatomical components, including the fibrous capsule (metatarsophalangeal joint capsular ligament), the collateral metatarsophalangeal joint ligament, the
plantar metatarsophalangeal joint ligament, the suspensory ligament, the plantar plate, sesamoid bones (tibial and fibular), and sesamoidal ligaments (the medial and lateral metatarsal sesamoidal, medial and lateral phalangeal sesamoidal, and intersesamoidal ligaments). The articular surface of the sesamoid bones is covered with hyaline cartilage. The first metatarsophalangeal joint sesamoid bones give the flexor hallucis brevis muscle a mechanical advantage in the push-off portion of the gait cycle. The function of the sesamoid bones is to increase the moment arm of the flexor hallucis brevis muscle, reduce friction, and help distribute the pressure of weightbearing. Sesamoid bones vary in size, with the tibia usually being somewhat larger than the others. Approximately 10% of the population has bipartite or tripartite sesamoid bones, and this finding is usually bilateral. Approximately two to three times the patient’s body weight passes through the sesamoid bones during normal gait.

**First Metatarsophalangeal Joint Capsular Ligament**

The first metatarsophalangeal joint capsular ligament surrounds the entire joint. This ligament may be somewhat thin dorsally and “loose” or redundant plantarly to allow flexion and extension of the digits with gait.

**Collateral Metatarsophalangeal Joint Ligament**

Proximally, this ligament is attached to the dorsal medial and lateral tubercles of the metatarsal head; distally, it blends with the joint capsule and attaches to the plantar phalangeal base; and laterally, it tends to be thicker, providing greater support and stability.

**Plantar Metatarsophalangeal Joint Ligament**

The plantar metatarsophalangeal joint ligament attaches proximally from the metatarsal head to the phalanx base, and it extends from the medial tubercle to the lateral tubercle along the plantar joint surface.

**Suspensory Ligament**

A section of the suspensory ligament (a triangular-shaped ligament) extends from the tubercles to the plantar plate. This ligament has fibers that run in a vertical-oblique direction. There is localized thickening within the plantar metatarsophalangeal joint ligament.

**Plantar Plate**

The plantar plate is a thickening of the plantar metatarsophalangeal joint ligament, which is attached to the fibrous flexor sheath. The deep transverse ligament attaches to the plantar plate. Weight is distributed across the metatarsal heads *via* the plantar plate.

**Flexor Hallucis Brevis Muscle**

The flexor hallucis brevis muscle plantarflexes the proximal phalangeal head. Distally, this muscle forms medial and lateral heads, which become tendons. These tendons contain a sesamoid bone at the level of the first metatarsal head. The abductor hallucis and adductor hallucis tendons blend with the medial and lateral heads, respectively, of the flexor hallucis brevis tendons.

Other structures that cross the first metatarsophalangeal joint include the extensor hallucis brevis muscle, first proper digital nerves (the superficial peroneal, deep peroneal, and medial plantar nerves), and the first proper digital artery.

**Physical Examination of the First Metatarsophalangeal Joint**

Having a thorough knowledge of the patient’s sport greatly assists the podiatric physician in diagnosing the injury and in determining the return-to-play demands and expectations of the athlete and the coach. When examining an athletic injury to the first metatarsophalangeal joint, the following items should be considered: the history of the injury, range of motion (before and after injury, if possible), area of maximum tenderness, medial and lateral collateral ligaments, sesamoid apparatus, stability of the joint, and radiographic examination (initially and sequentially). Patients usually report a sudden onset of pain. An antalgic gait, either externally rotating the lower extremity to avoid dorsiflexion of the first metatarsophalangeal joint during push-off or walking on the outside of the foot (supinated position)\(^{11}\) to minimize pressure on the first metatarsophalangeal joint, may be identified in athletes with turf-toe injuries. Swelling and ecchymosis may occur and will vary depending on the severity of the injury. Generally, 60° to 65° of dorsiflexion\(^{10}\) and 25° of plantarflexion is considered normal for the first metatarsophalangeal joint. However, the range of motion of this joint has been studied extensively and is noted to be quite variable. In the resting position, the first metatarsophalangeal joint is in a mean position of 16° of dorsiflexion.\(^{2}\) The passive arc of motion was noted to be 3° to 43° of plantarflexion and 40° to 100° of dorsiflexion.\(^{2, 12}\) The mean passive first metatarsophalangeal joint dorsiflexion in normal gait during push-off was 84°.\(^{2}\) Bojesen-Moller and Lamoreux\(^{13}\) found that at least 60° of dorsi-
flexion is considered normal during barefoot walking on a level surface. Athletes may accommodate up to a 50% reduction in first metatarsophalangeal joint motion by various gait adjustments, such as foot and leg external rotation, shortened stride, and increased ankle, knee, or hip rotation. Radiographs obtained during weightbearing can include anteroposterior, lateral, oblique, and forefoot axial and sesamoid axial views. Most injuries occur in the soft tissue, but one should inspect for small avulsion fragments around the joint, possible sesamoid fractures, and possible degenerative arthritis. Rodeo et al suggested that a forced dorsiflexion lateral view may delineate joint subluxation, sesamoid migration, or separation of a bipartite sesamoid bone. Other imaging modalities, such as magnetic resonance imaging, computed tomography, and bone scanning, may be required for accurate diagnosis and treatment. In a chronic injury, a thorough history of the original injury and attempted treatments is important, as is determining whether there is crepitus (a possible osteochondral lesion) or synovitis and the level of motor strength. All examination findings should be compared with the contralateral side, when in question.

Weight Distribution of the First Metatarsophalangeal Joint

In normal stance, body weight should be equally balanced between the heel and the metatarsophalangeal joints. The first metatarsal carries twice the weight of the other metatarsals, which is one-third the weight of the forefoot or one-sixth of the body weight. In weight-loaded stance, the first metatarsal may carry as much as the other metatarsals combined. During athletic activity, the peak forces may approach three times the body weight, and the forces may increase to eight times body weight when a running jump is performed. Muscular contraction is required for balance, and relatively small changes in muscle balance and tone result in significant changes in foot load distribution.

Differential Diagnosis of First Metatarsophalangeal Joint Injuries

Differential diagnoses for an injury to the first metatarsophalangeal joint include sprain or strain of the first metatarsophalangeal joint, osteochondral lesion, sesamoiditis, sesamoid fracture, dislocation (with spontaneous reduction, with and without fracture), capsulitis, contusion, and hallux limitus.

Sesamoiditis

Injury to the sesamoid bones results from repetitive or direct trauma and from first-ray mechanics, such as plantarflexion and eversion of the foot. Sesamoiditis is pain and swelling of the sesamoid bones or complex. Etiologies include a cavus foot, rigid feet, equinus, and a plantarflexed first metatarsal, all of which expose the sesamoid bones. Signs and symptoms include pain with range of motion, with direct palpation, and with passive dorsiflexion of the hallux (stressing the sesamoid apparatus and ligamentous structures). Fractured sesamoid bones must be differentiated from sesamoiditis, owing to different treatment protocols and potential sequelae. Treatment for sesamoiditis includes decreasing contact pressure with padding and off-loading, shoe alteration (rocker-bottom sole), eliminating the use of high-heeled shoes, using custom-made foot orthoses with sesamoid pads proximally, physical therapy, nonsteroidal anti-inflammatory drugs, and rest.

Osteochondral Fracture

An osteochondral fracture of the first metatarsophalangeal joint should always be considered, with or without radiographic evidence. These types of fractures are frequently a late diagnosis. The athlete may experience persistent edema, synovitis, crepitation, and pain. Radiographs may reveal a lucent triangular defect or sclerotic margins. Treatment includes arthrotomy, fracture fragment excision, and subchondral bone fenestration.

Capsulitis

Capsulitis can be defined as inflammation of a joint capsule due to excessive activity (usually dorsiflexion) of the first metatarsophalangeal joint. Ankle joint equinus and a plantarflexed first metatarsal may also have a role in the etiology of capsulitis. Signs and symptoms include pain on passive range of motion at end points and with propulsion and toe-off. Treatment may depend on the biomechanical mechanism and includes padding, a rocker-bottom sole, nonsteroidal anti-inflammatory drugs, physical therapy, and rest.

Dislocation of the First Metatarsophalangeal Joint

First metatarsophalangeal joint dislocations are rare. Jahss reported treating two dislocations in approximately 25,000 patients with foot problems. Giannikas et al indicated treating only four cases in more than
10,000 orthopedic patients. A hyperextension force of the phalanx–sesamoid apparatus on the metatarsal is generally accepted as the mechanism of injury. A secondary force of direct pressure to the plantar joint may be present to complicate the hyperextension force. Jahss described a classification scheme for first metatarsophalangeal joint dislocation. The scheme is based on the sesamoid bone position and whether a fracture is present. Type I dislocations represent dorsal subluxation of the phalanx–sesamoid complex on the metatarsal head. The intersesamoidal ligament remains intact. These dislocations are poorly reducible by closed means. Type I injuries generally require open reduction. Type II dislocations involve some degree of intersesamoidal apparatus disruption. Type IIA dislocations involve disruption of the intersesamoidal ligament. Radiographically, the sesamoid bones appear well separated medially and laterally but still dorsal to the metatarsal head. Type IIB dislocations are avulsion fractures of the fibular sesamoid bone dorsal to the metatarsal. The fracture fragment is still attached to the base of the distal phalanx. This classification scheme does not recognize any medial or lateral dislocation possibilities or dorsal migration of the proximal phalanx with the plantar attitude of the sesamoid bones. First metatarsophalangeal joint dislocations, when reduced early, generally do not result in degenerative joint disease or prolonged disability. This seems to be the prognosis regardless of the degree or type of injury. When prompt reduction is not possible, secondary adhesions and fibrosis occur, preventing relocation.

**Treatment of Turf-Toe Injuries**

Once a definitive diagnosis has been made and the extent of injury has been determined, a proper treatment plan can be instituted. Initial treatment for turf-toe injuries should consist of protection, rest, ice, compression, elevation, and support (referred to as “PRICES”). Nonsteroidal anti-inflammatory drugs, turf-toe taping, and stiff-soled shoes or a CAM Walker (Zinco Industries, Inc, Pasadena, California) can be used during the weightbearing day to assist with mild injuries. Use of a stiff-soled shoe can reduce first metatarsophalangeal joint dorsiflexion to 25° to 30° without significantly affecting gait. A walking cast with a toe spica extension in slight plantarflexion can also be used. Nocturnal bracing of the first metatarsophalangeal joint capsule in the neutral and slightly varus positions is recommended during the acute phase. If the injury is minor, athletes may progress with gentle range-of-motion exercise and activities, as tolerated. Taping is performed by bringing successive loops of a 1-cm-wide piece of athletic tape (reinforced with moleskin) from the dorsal surface of the great toe to the plantar surface to prevent dorsiflexion beyond 30°. However, for more serious injuries, immobilization is required until the injury is stabilized. Soft-tissue injuries should respond well to 3 to 6 weeks of immobilization. Mann suggests that vigorous exercise not be attempted for several months to allow complete healing. If conservative measures fail, then surgical repair of the plantar capsule or removal of the loose body fragment is indicated. A gradual return to play is allowable if motion is pain-free and there is no postexercise edema. Athletes must be able to perform the motions, directions, actions, and techniques of each individual sport and must have complete resolution of symptoms before they can be allowed to return to competition.

**Case 1**

A 17-year-old male high-school athlete who participated in 400-m state-level track presented at the author’s office with left first metatarsophalangeal joint pain experienced for the first few weeks of preseason track conditioning; weather conditions dictated indoor training (running in the school hallways 3 days per week for approximately 20 to 25 min per session). His medical history was positive only for a fibular stress fracture sustained during the previous football season. Physical examination revealed no edema, no erythema, good active and passive range of motion without crepitus, and good strength (5/5) for the left first metatarsophalangeal joint. Radiographs demonstrated no pathologic findings (Figs. 1 and 2). Differential diagnosis included first metatarsophalangeal joint strain and capsulitis. Treatment included nonsteroidal anti-inflammatory drugs, ice massage, turf-toe taping, reduction of activity, and a cross-training regimen. One week later, no improvement was noted. The patient deferred local anesthetic injection with corticosteroid intra-articular injection, with the associated cessation of running (2 to 3 weeks) to allow healing. He was given a Springlite carbon fiber plate (Morton’s extension), which he wore during all weightbearing activity; other treatments included deep-water pool running, stationary bicycling, maintenance of strength training and flexibility programs, physical therapy, and an Aircast pneumatic walking splint (Aircast, Inc, Summit, New Jersey) worn during all nonexercise weightbearing activity. Three weeks later, mild improvement was noted. First metatarsophalangeal joint soreness was noted more medially and was worse on plantarflex-
ion and toe-off. Magnetic resonance imaging showed a medial plantar focal capsular rupture of the first metatarsophalangeal joint, mild effusion with minimal tenosynovitis of the flexor hallucis longus tendon, and inflammation of the superficial and deep transverse metatarsal ligaments (Fig. 3). Further reduction of training was instituted. Two weeks later, the patient began a gradual running and walking program 3 days per week, with continuation of the present regimen. Three weeks later, the patient had minimal soreness with running and, as a senior in high school, elected to return to full training and racing as tolerated. He completed the season placing runner-up in a state championship.

Case 2

A 17-year-old high-school football fullback and linebacker sustained an in-season severe left turf-toe injury 7 weeks earlier. His medical history was unremarkable. Physical examination revealed 3+/5 strength of the extensor hallucis and brevis tendons. Active range of motion of the first metatarsophalangeal joint was less than 5° dorsiflexion and plantarflexion, with moderate pain noted. Mild edema and erythema were noted after activity. Radiographs revealed a slightly shortened first metatarsal, with mild, uniform joint space narrowing (Fig. 4). Differential diagnosis included a partial extensor hallucis or brevis tendon tear and a partial first metatarsophalangeal joint capsule tear. Magnetic resonance imaging demonstrated...
a partial flexor hallucis brevis tear, severe tenosynovitis of the extensor hallucis and brevis tendons, bony contusion (marrow edema) of the first metatarsal head, and first metatarsophalangeal joint effusion with capsular inflammation (Fig. 5). The patient and his parents insisted that the patient continue participation in practice and state playoff games. The patient and his parents were informed about the potential risks and complications of continuing with the football season versus discontinuing the season; an informed consent form was signed in this regard. Treatment included nonsteroidal anti-inflammatory drugs, ice massage, significant reduction of all weight-bearing activities, physical therapy, cross-training, strength and flexibility maintenance, an Aircast pneumatic walking splint, a Springlite carbon fiber full-length plate, and turf-toe taping for practice and games. This athlete completed the state playoffs without experiencing further damage. Approximately 1 month after the original magnetic resonance image was obtained, a repeated image revealed a partial-to-complete rupture of the abductor hallucis tendon, a sprain or strain of the medial first metatarsophalangeal joint capsule, a plantar first metatarsal head contusion, and a sprain or strain of the flexor hallucis brevis medial head (Fig. 6). Surgical repair was deferred on the basis of clinical examination findings. This athlete was then placed in a nonweight-bearing fiberglass cast for 4 weeks, followed by physical therapy. He healed without long-term sequelae. Serial radiographs did not reveal any osteochondral pathologic findings (Fig. 7).

Conclusion

Many athletic endeavors may result in traumatic injury to the first metatarsophalangeal joint. Understanding the specific sport demands and the subtle nuances of the different mechanisms of injury allows the sports medicine physician to accurately diagnose and treat the potentially career-ending injury to the first metatarsophalangeal joint. Along with the athletic concerns, the potential long-term sequelae and disability must be considered when treating these patients and making decisions concerning resumption of sport activity.

References


Figure 7. Anteroposterior (A) and medial oblique (B) radiographs demonstrate no long-term osteochondral pathologic findings in the first metatarsophalangeal joint.