Chapter 2
Turf Toe Injuries

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In 1976, Bowers and Martin coined the term "turf toe" in the literature in response to the increasing injuries to the great toe joint being seen by athletes playing on new artificial surfaces and playing in lighter and more flexible shoes.[1,2] The term classically describes a first metatarsophalangeal joint (MTPJ) ligament sprain, commonly seen in field-related sports.[1-8] This malady can be an undertreated and oversimplified athletic injury of the great toe joint. Unfortunately, many times, any injury to the great toe joint that occurs during a sporting event is erroneously termed turf toe. Often a complete and systematic evaluation of all the structures of the great toe joint is not performed. A differential exam may be performed and injuries other than to the ligamentous supports may be appreciated but all are still coined turf toe. Some authors recommend reserving the term only when injuries to other structures (i.e., muscle, tendon, metatarsal, cartilage, sesamoids, etc.) are not involved and the injury to the great toe joint is purely ligamentous.[1]

In 1978, Coker et al. correlated the increased incidence with a debilitating effect on return to play among college football players.[3] This injury continues to be seen despite advances in artificial turf and shoe interface.[9,10] Long-term sequelae has been noted to many different anatomical structures of the first MPTJ, including the cartilage and sesamoids. We feel involvement to these additional anatomical structures each have a spectrum of injury to themselves or in combination that, if not

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appreciated and treated appropriately, will increase the misunderstanding and morbidity of this injury. Proper diagnosis of the structures involved in turf toe injuries should lead to better treatment outcomes.

2.1 Pathophysiology

The severity of the injury will be a summation of the amount of energy imparted to the great toe joint and the extent and direction of abnormal or excessive range of motion at the time of force. This is known as the mechanism of injury. The mechanism of injury will predictably place various anatomical structures at risk. Among the various mechanisms described for turf toe injuries, hyperextension force to the first MTPJ is the most commonly accepted and reported (Fig. 2.1). In a study by Rodeo et al., 80 professional football players were surveyed, 45% experienced a turf toe injury.[4] In this study, 83% of these players reported their initial turf toe injury occurring on artificial turf and 85% of injuries occurring secondary to a hyperextension injury. The hyper-dorsiflexion force to the MTPJ will occur when the forefoot is in a flexed position to the ground and a concurrent axial load is applied to the heel. This will result in a change of the joint kinematics. As the great toe joint continues to dorsiflex or hyperextend, a compression force is applied between the base of the proximal phalanx and the dorsal central articular surface of the first metatarsal head and base of the phalanx which could result in articular injury (Fig. 2.1). Simultaneously, a distraction force occurs to the plantar plate, the sesamoid apparatus, and/or short flexors to the point of possible rupture or fracture. This hyperextension motion will commonly involve varus or valgus moments around the joint that will also place the collateral ligaments at risk. Conversely, a hyper-plantarflexion injury can cause injury to the dorsal ligaments of the great toe joint as well to extensor tendons joint producing pain and inflammation. This injury is more commonly seen in sand sports such as volleyball and this injury has been coined "sand toe." This injury is usually self-limiting and, unlike turf toe, is not plagued with long-term morbidity.[7,11]

2.2 Etiology

A flexible shoe in combination with a hard artificial surface was considered the source of the turf toe injury in the 1970s.[3,9,10] Even with the return to natural grass from artificial surfaces and third-generation artificial surfaces, this injury is still present. Risk factors for turf toe that have been investigated include: increased shoe sole to surface friction with a fixed forefoot, increased shoe flexibility, reduction in artificial turf's ability to absorb force with wear.[4,9] Valgus and varus stress mechanisms have also been theorized as causative factors of turf toe injuries.[5] One possible risk factor that has not been investigated is chronic, repetitive, low-grade stress across the first MTPJ with physical activity of pushing, pulling, and jumping.

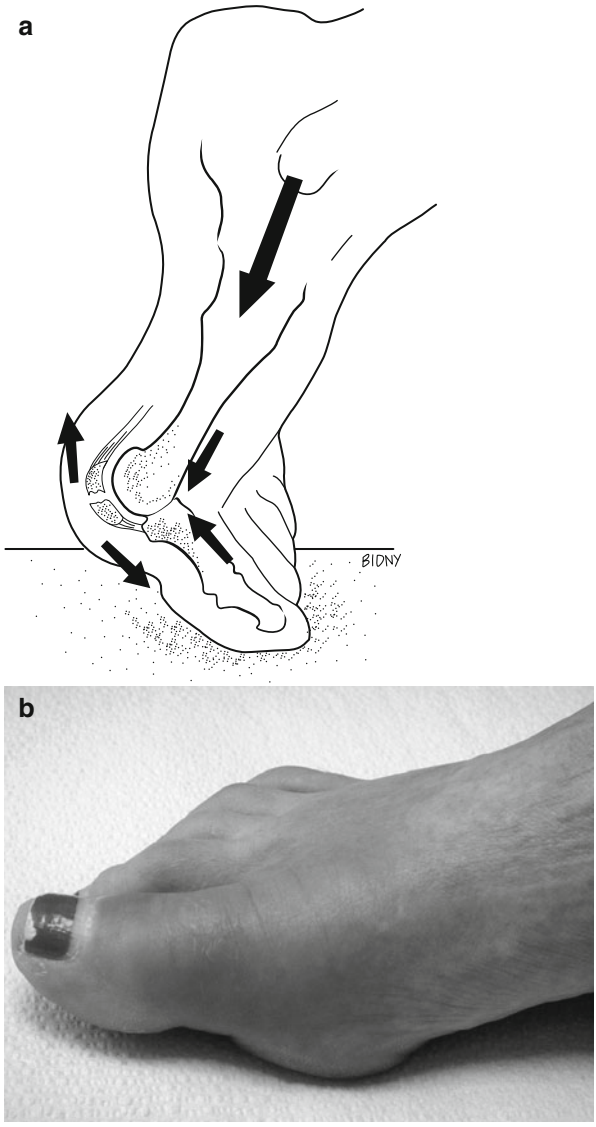

Fig. 2.1 (**a**) Hyperextension injury; (**b**) clinical presentation of acute turf toe

These ballistic movements may contribute to inflammation of the first MTPJ causing a low-grade sprain on surfaces of varying rigidity. With repeated practices and games throughout a season including off-season workouts, overuse and breakdown of the joint tissue may occur. If 90% of the body's weight is translated through the forefoot and 40–60% of the weight being placed across the great toe joint, overuse due to repetitive stretching or excessive tension on the plantar capsule ligaments could cause breakdown and disruption. An additional factor would include the increased physical ability of the modern athlete, being faster and stronger, intensifying the speed and velocity of ballistic movements.

2.3 Clinical Evaluation

Evaluation of the acute or subacute injured great toe joint needs to occur in a systematic, concise, and accurate manner. Initial exam may be thwarted by pain and splinting and thus, serial examination as acute symptoms resolve is mandatory. Each anatomical structure of the joint should be considered injured until proven otherwise. Identifying all structures that are potentially involved and determining the severity or lack thereof will allow the specialist to accurately grade the initial injury(s), outline an appropriate treatment program, determine a return to sports timeline, and to predict long-term morbidity. These goals are the cornerstone to the treatment of athletes.

The initial assessment includes ascertaining the mechanism and timing of the injury. Observe for any generalized deformity of the toe, the extent of joint effusion, the soft tissues around the distal first ray, and the possible presence and location of ecchymosis and swelling. Neurovascular compromise is not common except for extreme examples as seen with nonreduced dislocations. The author believes that ecchymosis is a hallmark clinical indicator of either a fracture or rupture of ligamentous or tendon structures. Ecchymosis plantarly increases the suspicion for sesamoid fracture and disruption of the plantar capsule-ligamentous structures or tear of the flexor hallucis brevis (FHB) muscle belly. Observation of ecchymosis dorsally may indicate dorsal tearing of the joint capsule, dorsal articular injury, or dorsal cortical fracture of the metatarsal. Palpation of the dorsal metatarsal head and neck along with the dorsal aspect of the base of the proximal phalanx provide suspicion for periarticular fracture. Further, palpation of the sesamoids and the long and short flexor and extensor tendons will provide information in regard to possible injury or fracture. Following palpation of the joint structures, manual manipulation of the joint should be performed. Specifically the medial and lateral collateral ligaments along with the phalangeal sesamoid ligaments provide controlled range of motion, proprioception and structural stability of the joint. Each ligament can and should be evaluated for the presence of pain and varying degrees of instability. A universal grading system should be applied to each ligament as increasing degree of injury will prolong return to sport and increase morbidity. A circumferential examination of the MTPJ should be performed beginning dorsal, medial then lateral and finally, plantar. The dorsal ligaments are assessed with plantar flexion of the joint, while the collaterals are evaluated with varus and valgus force with the hallux in a rectus position. Valgus stress can result in a ruptured medial joint capsule including the medial collateral ligament, abductor hallucis insertion and sesamoid apparatus (Fig. 2.2). The plantar ligaments are assessed by performing a Lachman-type maneuver. Again, while each ligament is evaluated (stressed), the presence or absence of pain as well as the amount of instability should be noted. Comparing stress evaluation of the noninjured side will at times be helpful. Tendonous injuries to the great toe will primarily involve the three main tendons of the great toe joint, the extensor hallusis longus (EHL), flexor hallusis longus (FHL), and FHB. Each tendon should be assessed for integrity and strength. In the authors' experience,

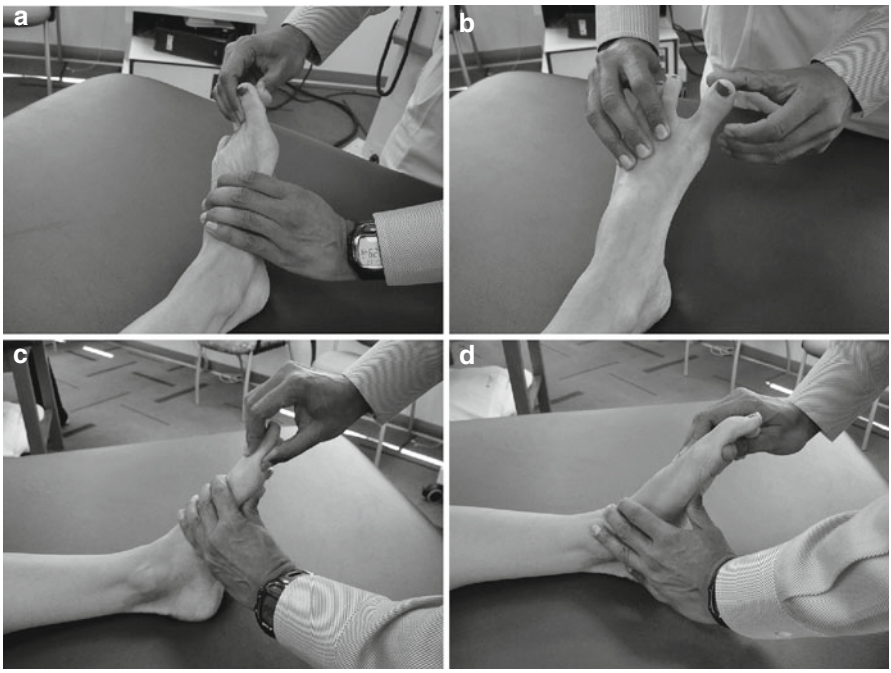

Fig. 2.2 (**a**) Abduction stress test to assess medial collateral ligament/medial capsule/abductor hallucis; (**b**) Adduction stress test to assess lateral collateral ligament/lateral capsule/adductor hallucis; (**c**) "Lachman" of first MPJ to assess plantar plate; (**d**) FHB strength/integrity assessment

injury to tendons other than the FHB has not been encountered. As the exam is carried out, a clinical scorecard of the noninjured and injured structures and severity should be kept. The clinical exam will be prognostic for further imaging modalities.

2.4 Imaging of Turf Toe Injuries

When imaging turf toe injuries, a protocol is necessary for accurate diagnosis. These radiographs should be evaluated for overt or small avulsion fractures of the distal first ray as well as mal-alignment, chondral injury, and sesamoid position. Radiographs of the contralateral foot should be performed for comparison. Initial imaging of the injured foot begins with plain radiographs taken in a standard anteroposterior (AP) projection, lateral oblique projection, and lateral views of the foot in weight bearing. Sesamoid position on an AP radiograph can provide information regarding the presence of sesamoid injury such as dislocation, retraction of the sesamoids (Fig. 2.3), disruption of the inter-sesamoid ligament, or fracture of the sesamoids. An additional image is the axial sesamoid view, with the foot weight bearing,

Fig. 2.3 X-ray of dislocation with sesamoid retraction

the heel raised with the toe dorsiflexed and the radiographic beam being introduced from posterior 90° to the foot.

Additional radiographs can be taken performing provocative maneuvers to the first MTPJ, stressing the plantar joint capsule and surrounding ligamentous attachments. A Lachman's type maneuver or dorsiflexion stress maneuver can be performed at the joint to accentuate instability. Performing dorsiflexion stress maneuvers can reveal retraction of the sesamoids or disruption of the plantar plate on the metatarsal showing evidence of metatarsal sesamoid ligament disruption. In addition, fluoroscopic imaging can be used to evaluate range of motion of the first MTPJ and demonstrate instability.

There is very little information defining the indications of magnetic resonance imaging (MRI) for turf toe injuries. But clearly, this advanced imaging modality will allow the clinician to appreciate the full spectrum of the injury and serve as an adjunct to the clinical exam. MRI will allow for each potentially injured structure to be evaluated for the presence or absence of injury and severity (Fig. 2.4). MRI imaging of the MTPJ complex using a non-fat-suppressed T1-weighted or proton density–weighted sequence in three standard planes is recommended.[6] In addition, according to Crain et al.,[6] a proton density–weighted fat-suppressed or short tau inversion recovery

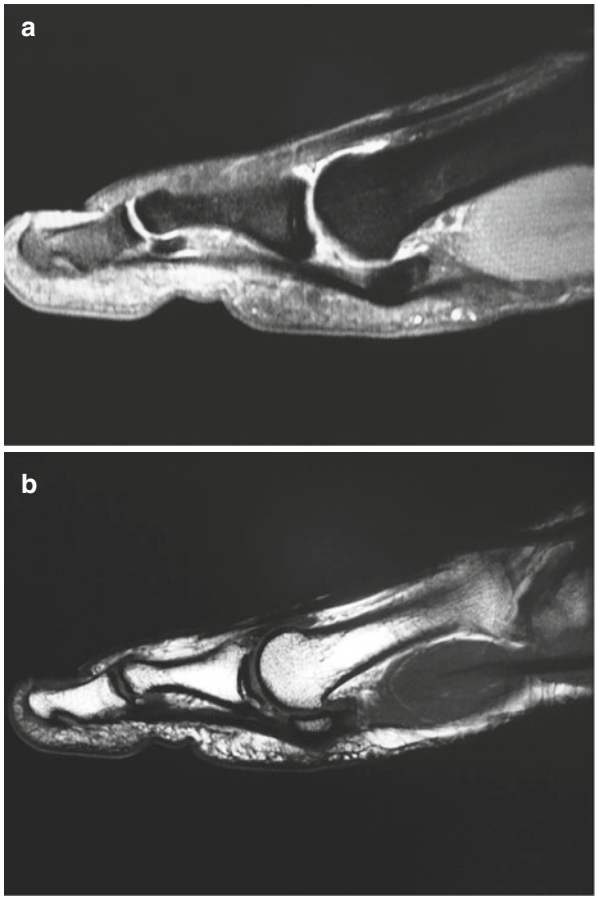

Fig. 2.4 (**a**) MRI showing plantar first MTPJ plate rupture without sesamoid fracture; (**b**) Repaired plantar plate

(STIR) sequence in all three planes is recommended for optimal evaluation of the turf toe pathology. A STIR sequence should be used to evaluate acute pathology. Proton density–weighted fat-suppressed images provide better resolution than STIR with shorter imaging time and also provide more detail of the anatomy than heavily fat-suppressed T2-weighted images and STIR sequences. To optimize the resolution with lower field MRI scanners, that field of view should range from 13 to 15 cm with a slice thickness of no less than 3.5 mm of STIR images.[6] Higher field MRI scanners such as 3.0 T magnet provide better definition and detail. Injury of the metatarsal sesamoid ligament and phalangeal sesamoid ligament is best visualized on sagittal slices. The inner sesamoid ligamentous anatomy is best visualized on axial images. The most common injured soft tissue structures along the plantar first MTPJ capsule are the phalangeal sesamoid ligamentous attachments. In MRI, evaluation of the injured plantar phalangeal sesamoid ligamentous structures will reveal incontinuity or edema. Once the clinical exam is correlated with radiographic and possible advanced imaging, the clinician can now truly understand the full spectrum of the injury.

2.5 Classification of Turf Toe

Turf toe injuries are classified on the basis of severity. To date, there is no grading system that is truly comprehensive and takes into consideration injuries to structures other than the ligaments. As can be appreciated, if there is injury to osseous, articular, or tendonous structures, each will have its own spectrum of injury, treatment protocol, and morbidity. A general assumption can be made that with increasing degrees and involvement of ligamentous structures, there is a greater chance of associated injuries to occur. It is often the lack of appreciation of these associated injuries that will lead to an inaccurate initial diagnosis and prognosis. In treating athletes, the specialist is tasked with working with a small margin of error. This margin will decrease as the level of the athlete increases. Establishing the grade of turf toe injury from clinical evaluation and imaging protocol will provide the most accurate initial diagnosis and treatment, shorten the convalescent period, reduce the time to return to play, and predict possible morbidity that may affect long-term performance.

Grade 1 injuries are the least severe. These injuries typically are a minor stretch or strain without compromise to the soft tissue restraints. Clinically, patients with Grade 1 injuries present with localized plantar or medial tenderness, mild edema, and no visible ecchymosis. The patient is able to bear weight and there is little change in the range of motion or strength. Radiographs are normal, and MRI demonstrates intact capsular integrity with mild soft tissue edema.

Grade 2 injuries are moderate in severity. They represent partial tears of the capsuloligamentous structures, most often the sesamoid phalangeal and metatarsal phalangeal ligaments. But, the medial collateral ligament is commonly involved (Fig. 2.5). Clinically, patients present with more diffuse and intense tenderness, mild to moderate edema with ecchymosis on the plantar and medial surface of the first MTPJ. These injuries typically have varying levels of disability. The MTPJ has a restricted range of motion with severe pain and antalgic gait with weight bearing. Symptoms are typically progressive. Radiographs may appear normal with the sesamoid bones lying in the normal position. MRI demonstrates moderate soft tissue edema extending through the plantar plate indicating a partial thickness disruption. This can be seen plantarly at the level of the sesamoid phalangeal or metatarsal phalangeal ligaments.

Grade 3 injuries are the most severe type of turf toe injury. This stage describes severe acute injuries with plantar capsuloligamentous disruption or the lasting chronic effects of a capsuloligamentous injury. Clinically, patients present with severe and diffuse tenderness. There is often marked swelling accompanied with moderate to severe ecchymosis to the MTPJ with an acute injury. Pain is often so severe that patients are unable to bear weight. Radiographs may demonstrate proximal migration of sesamoids, compression fractures, asymmetric lateral, medial or dorsal subluxation, or capsular avulsion fragments or capsular avulsion. Joint subluxation or deviation may also be apparent on radiographs or stress views. MRI typically demonstrates complete disruption of the plantar plate as well as any other associated injuries to the capsuloligamentous structures.[2,5]

Fig. 2.5 (**a**) Valgus stress injury resulting in medial collateral first MPTJ rupture ("traumatic bunion") Patient felt a "pop" while running 10 days post-injection for 1st MP synovitis and notice acute lateral deviation of his hallux; (**b**) Post-op X-ray of repair of medial collateral ligament with a soft tissue anchor

MRI can also delineate osteochondral injury (Fig. 2.6). Imaging is helpful to stage these lesions and determine if surgery is needed for displaced fragments or significant bony defects. Ascertaining the entire spectrum of injury and potential need for treatment via MRI is helpful and strongly recommended for athletic patients.

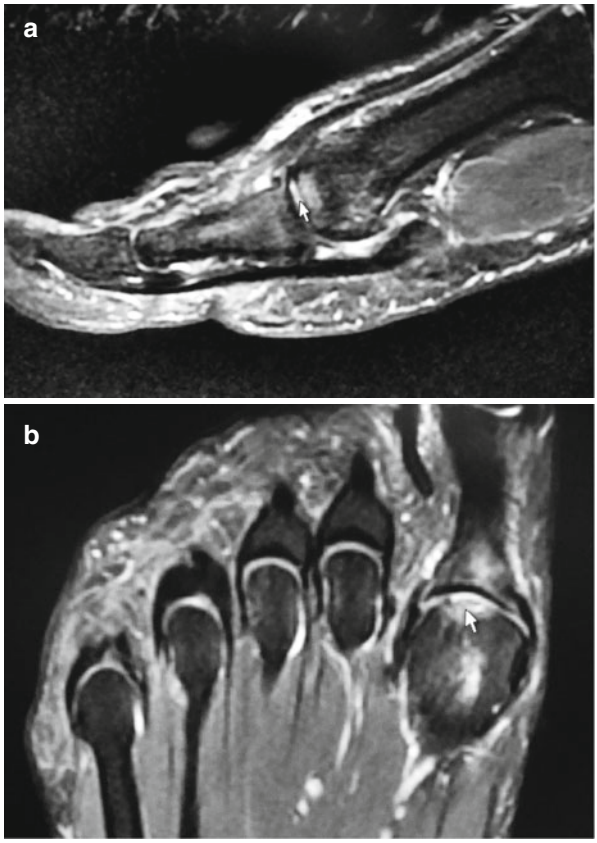

Fig. 2.6 (**a**, **b**) MRIs showing osteochondral injuries of the first metatarsal head after hyperextension injuries

2.6 Treatment of Turf Toe Injuries

Grade 1 injuries require immobilization, nonsteroidal anti-inflammatories (NSAIDs), and cryotherapy. Functional immobilization with taping of the joint provides adequate stability for the athlete to return to play with minimal discomfort. Functional immobilization with a short leg weight-bearing cast with toe spica for 3–5 days can be helpful in patients that do not tolerate taping. A postoperative shoe or short leg walking boot can be used when not playing or practicing to allow the soft tissues of the plantar aspect of the MTPJ to rest by reducing dorsiflexion stress across the joint. The athlete may return to activity with spica taping (Fig. 2.7) or even a turf toe plate (Fig. 2.8) temporarily in the shoe. This plate can be removed later as the athlete gains more confidence and function in the great toe joint.

Grade 2 injuries require immediate immobilization, NSAIDs, and cryotherapy. The athlete should be placed in a short leg cast boot with strict non-weight bearing on crutches for approximately 2 weeks. After healing of the partial plantar

Fig. 2.7 Toe spica taping

capsule-ligamentous structures, the athlete must complete a rehabilitation program in order to safely return to play. A custom orthotic with Morton's extension (Fig. 2.9) can be placed in a shoe; changing to a shoe with a stiffer forefoot construction may help reduce re-injury rate. A turf toe plate is the alternative to an orthotic with Morton's extension and can provide the necessary rigidity in the forefoot to allow comfortable play. An orthotic with Morton's extension can also be used until the patient transitions to pre-injury performance level.

Grade 3 injuries are the most severe and usually involve dislocation or subluxation of the first MTPJ due to disruption of the plantar capsular ligamentous structures of the first MTPJ. Grade 3 injuries can require immediate closed reduction if dislocation is present followed by immobilization, cryotherapy, NSAIDs, and short leg cast with toe plate or toe spica to the hallux non-weight bearing for 4–6 weeks. Physical therapy and rehabilitation will be required for an additional 4–6 weeks. The athlete should have rehabilitation to restore function to the first MTPJ and restoration of strength to the EHL and FHL muscles also strengthen to the FHL and EHL muscles for safe return to play at pre-injury strength, mobility, and pain-free function. Generalized de-conditioning of the musculature may require 8–16 weeks of additional rehabilitation for the athlete to return to ballistic maneuvers of running, jumping, and cutting. The athlete will have to be able to tolerate a significant amount of dorsiflexion at the first MTPJ when considering stance positions in football where the dorsiflexed position is needed for propulsion and push-off. The athlete needs to be able to perform this activity with a minimal amount of pain and discomfort in order to return to the game at full speed. Steroid injections should not be performed in the area of the injury and can be detrimental to healing of the soft tissues. Steroid injections can mask pain which would be an important indicator whether an athlete is ready to return to pre-injury performance. If there is no improvement with conservative management, surgical repair of the plantar capsular ligamentous structures may be required. Table 2.1 highlights these recommendations.

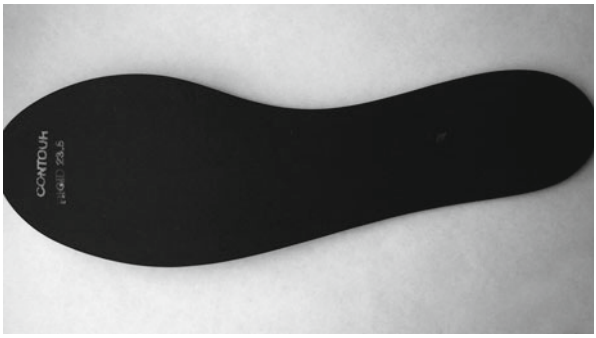

Fig. 2.8 Turf toe plate/insole

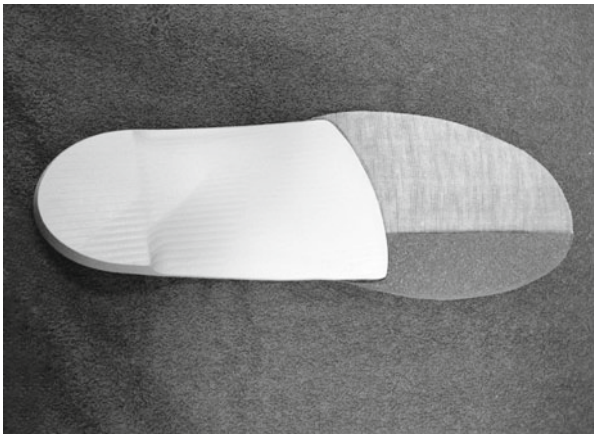

Fig. 2.9 Morton's extension insole with more rigid material, in this case cork, under 1st MPTJ

2.6.1 Surgical Treatment

Sesamoid avulsion fractures and sesamoid fractures may occur with turf toe injuries. Sesamoid fractures have a low occurrence rate, but a high incidence of nonunion due to avascularity to the surrounding fibro-cartilaginous structures. If the sesamoid fractures are not healed and symptomatic after 3–4 months, surgical excision of the sesamoid is advised. Dislocation and subluxation injuries of the MTPJ often have a dislocation of the FHL tendon present. Immediate reduction is necessary, to prevent loss of plantar flexion function, nonanatomic scar, and fibrosis. Severe turf toe injuries with first MTPJ instability or dislocation as a result of complete disruption of the plantar capsular ligamentous structures, surgical repair is indicated. The approach to this should include a plantar or plantar medial incision to help with direct visualization of the plantar capsular ligamentous structures and repair (Fig. 2.10). Chapter 21 gives good insight to plantar approaches and repair of the anatomical structures.

The postoperative course includes short leg cast immobilization with toe spica for 2–3 weeks followed by physical therapy which would progressively return the

Table 2.1 Treatment recommendations for turf toe injuries

	Grade 1	Grade 2	Grade 3
Description	Attenuation of the plantar joint capsule	Partial tear of the plantar joint capsule	Complete tear of the plantar joint capsule
Clinical findings	Mild swelling no ecchymosis tenderness with palpation	Moderate swelling, ecchymosis, limited motion with pain, moderate pain	Swelling, ecchymosis, limited motion with pain, severe pain, positive Lachman's
Treatment	Taping and continued play	Immobilization in walking boot or cast, NSAIDs, and physical therapy	• Immobilization in cast or surgical repair. • Dislocation with instability after reduction requires surgical repair of plantar plate. • Symptomatic sesamoid fracture nonunion requires surgical excision.

Fig. 2.10 Incisional approach as an option for plantar first MPTJ capsule and plate repair

athlete back to pre-injury performance. Protected weight bearing would begin at 3 weeks after surgery in a walking boot.

The indications for surgical repair are the following[8]:

- Large capsular avulsion with unstable joint
- Diastasis of partite sesamoid
- Diastasis of sesamoid fracture
- Retraction of sesamoids
- Traumatic hallux valgus deformity
- Vertical instability with Lachman's test
- Loose body
- Chondral injury
- Failed nonsurgical treatment

Osteochondral defects sustained from turf toe injuries deserve special mention. Chondral lesions require treatment with microfracture techniques treated with microfracture techniques after débridement of loose cartilage flaps. Some of these isolated lesions may be amenable to arthroscopic treatment. Osteochondral defects sustained during the injury may need to be treated with bone grafting. An osteochondral autograft transfer (OATS) procedure of the first metatarsal head can be performed with autograft from the medial talar head, or in cases with hypertrophic dorsal exostoses, a portion of the resected bone can be harvested and placed into the defect (Fig. 2.11). Postoperative management will be dictated by the performance of additional procedures such as capsular or plantar plate repair. Generally, a period of 3 or more weeks non-weight bearing is required for chondral and osteochondral injuries.

Hallux malleus, hallux varus, hallux valgus, and hallux rigidus deformities may be secondary deformities as a result of turf toe injuries, these late sequelae of turf toe injuries may be addressed with various procedures. If these sequelae are asymptomatic, they should be addressed at the end of the athlete's career to restore normal function. If these deformities are symptomatic while the athlete is still active, the hallux rigidus can be addressed with cheilectomy (dorsal exostectomy) in the off-season. The hallux valgus deformity can be addressed with a bunionectomy. The hallux malleus should be addressed at the end of an athlete's professional career because of tendon transfers required to restore function and anatomic alignment. Transfer of tendons may result in a loss of strength and power in regard to an athlete, but the hallux malleus deformity should be addressed with shoe accommodations, orthotics, and proper foot care.

Fig. 2.11 (**a**–**d**) Pre-operative (**a**), immediate (**b**) and one year post-operative (**c** & **d**) X-rays of autogenous "OATS" repair of 1st metatarsal head (donor graft from medial talar head). Note normal appearing talo-navicular joint

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