Imaging of Painful Conditions of the Hallucal Sesamoid Complex and Plantar Capsular Structures of the First Metatarsophalangeal Joint

Timothy G. Sanders, MD\textsuperscript{a,b,*}, Sharik Kabir Rathur, MD\textsuperscript{c}

KEYWORDS
- Ankle
- Foot
- Sesamoid ossicles
- Turf toe
- Magnetic resonance
- Computed tomography

ANATOMY OF THE FIRST METATARSOPHALANGEAL JOINT

The first metatarsophalangeal (MTP) joint is a condyloid articulation with the proximal articular surface of the proximal phalanx demonstrating a shallow elliptical cavity that articulates with the rounded articular surface of the first metatarsal head. Normal motion is highly variable but typically ranges between 30 degrees of flexion and 50 degrees of extension with very little medial–lateral motion and no axial rotation.\textsuperscript{1,2} The joint capsule is lax along the plantar aspect of the joint with a strong distal attachment to the base of the proximal phalanx and a weaker proximal attachment along the plantar aspect of the first metatarsal neck. The joint is stabilized both medially and laterally by collateral ligaments and along the dorsal aspect of the joint by an expansion of the extensor tendon mechanism.\textsuperscript{3,4} The soft tissue anatomy along the plantar aspect of the joint is complex. Discussion is divided into two separate sections entitled the “hallucal sesamoid complex” and “plantar plate” anatomy.

Hallucal Sesamoid Complex Anatomy

A sesamoid bone is defined as a bone that is embedded within a tendon and typically occurs in a location where a tendon passes over a joint.\textsuperscript{1} Sesamoid bones are so named because they are similar in shape and appearance to a sesame seed. The patella is the largest and best-known sesamoid bone in the body, but sesamoids also occur in several other locations including numerous sites within the hands and feet. The patella acts as a nice anatomic model for other sesamoid bones in the body, which all have a very similar anatomic configuration. Although sesamoids are embedded within a tendon, one side of the bone is typically covered with hyaline cartilage and...
articulates with the underlying joint.\textsuperscript{1,5} This anatomic configuration places the tendon at a slightly increased distance from the joint, thus decreasing the force applied to the tendon during motion of the joint and improving the mechanical advantage of the tendon. The presence of a sesamoid bone also helps to prevent flattening and fraying of the tendon as tension increases on the tendon during motion of the joint.

The hallucal sesamoid complex is composed of two separate sesamoids, the medial (tibial) and lateral (fibular) sesamoids (Fig. 1). Their ossification is complete between 9 and 14 years-of-age.\textsuperscript{6} The tibial sesamoid is the larger and longer of the two and it is embedded within the medial head of the flexor hallucis brevis tendon. The lateral sesamoid is the smaller and rounder and it lies embedded within the lateral head of the flexor hallucis brevis tendon.\textsuperscript{3,4} The dorsal surface of the hallucal sesamoids are covered with hyaline cartilage that articulate with the plantar aspect of the first metatarsal head. Unique to the hallucal sesamoids is the fact that in addition to protecting the surrounding tendons, they also serve a vital function in weight bearing. The hallucal sesamoid complex normally transmits up to 50\% of the body weight and during the push-off stage of gait and may transmit as much as 300\% of the body weight.\textsuperscript{3} The hallucal sesamoids disperse the body weight at the level of the first metatarsophalangeal joint and thus act to protect the tendons that are located along the plantar aspect of the joint as well as to provide a cushioning effect for the first metatarsal head.

Although the two sesamoids lie primarily within the medial and lateral heads of the flexor hallucis tendon, the adjacent soft tissue anatomy is quite complex. The tibial sesamoid also serves as the distal attachment site of the abductor hallucis tendon. The fibular sesamoid serves as the distal attachment site of the adductor hallucis tendon and receives fibers from the transverse intermetatarsal ligament. The sesamoids are also embedded within a thickened portion of the plantar aspect of the joint capsule referred to as the plantar plate. The central portion of the plantar plate located between the two sesamoids is also referred to as the intersesamoid ligament. There is a small gap between the fibular and tibial sesamoids that allows passage of flexor hallucis longus tendon beneath the first metatarsophalangeal joint (Fig. 2A). This configuration also provides protection to the flexor hallucis tendon as it courses along the plantar aspect of the joint. Portions of the capsule also attach to the sesamoids. Along the medial aspect of the joint, the tibial sesamoid attaches to the phalanx via a thickening of the capsule sometimes referred to as the medial sesamoid phalangeal ligament, and to the metatarsal via a capsular thickening referred to as the medial metatarsosesamoid ligament (Fig. 2B). The fibular or lateral sesamoid attaches via the lateral sesamoid phalangeal and the lateral metatarsosesamoid ligaments (Fig. 2C).\textsuperscript{7}

Faulty ossification may lead to a bipartite or rarely a multipartite configuration of the hallucal sesamoids (Fig. 3). The tibial sesamoid may demonstrate a bipartite configuration in up to 30\% of individuals while a bipartite configuration of the fibular sesamoid is rather uncommon.\textsuperscript{3,5,8}

The hallucal sesamoid complex receives the

![Fig. 1. Normal sesamoids.](image-url) Normal sesamoids. AP radiograph (A) of the forefoot shows the tibial (medial) sesamoid (long arrow) and the fibular (lateral) sesamoid (short arrow). Note that on an AP view of the forefoot, the sesamoids overlap the first metatarsal head. Lateral oblique radiograph (B) of the forefoot allows better visualization of the fibular sesamoid (short arrow), which is now projected off of the first metatarsal head. Tibial sesamoid (long arrow) overlaps the metatarsal head on this projection.
The plantar plate, in conjunction with the hallucal sesamoid complex and the adjacent tendinous attachments, plays a vital role in providing support and stability to the first metatarsophalangeal joint.

**THE PAINFUL HALLUCAL SESAMOID COMPLEX**

The sesamoids provide a significant cushioning effect for the first metatarsophalangeal joint and they are also important with regard to weight-bearing with up to three times the body weight transferred across the sesamoids during the push-off phase of normal gait. Sesamoid pathology can be varied and is often difficult to differentiate clinically from other forms of pathology at level of the first MTP joint. When abnormalities are isolated to the sesamoids, the patient usually presents with limited and painful dorsiflexion of the joint. Physical examination may reveal swelling and synovitis along the plantar aspect of the joint. Pain is usually elicited with direct palpation or when the examiner pushes the affected sesamoid distally.¹,³,⁴

**Sesamoiditis**

The definition of sesamoiditis varies throughout the literature, but sesamoiditis is most often used...
as a nonspecific descriptive term referring to any painful inflammatory condition of the sesamoid bones. As previously described, the sesamoid bones of the first metatarsophalangeal joint are embedded within the medial and lateral heads of the flexor hallucis brevis tendon and as such, sesamoiditis can be considered equivalent to a focal tendinosis; indeed, it is sometimes associated with inflammatory changes of the surrounding tendon and adjacent soft tissue structures.\(^1\),\(^4\),\(^15\)

Sesamoiditis often occurs in the young athlete in the setting of repetitive trauma to the plantar aspect of the forefoot and it may be associated with stress related marrow edema, stress fracture or even an acute fracture of one or both of the sesamoids. Alternatively, sesamoiditis may occur in the context of osteoarthritis, inflammatory arthropathy, avascular necrosis, or infection.

Radiography can play an important role in the initial evaluation of the painful sesamoidal complex. Depending upon the precise etiology of pain, radiographs may be normal or may demonstrate sclerosis or fragmentation of the involved sesamoid. Radiographs can also provide a more specific diagnosis including fracture or osteoarthritis as the source pain. Radiographic evaluation should include AP and lateral radiographs. The medial oblique view can be helpful in assessment of the tibial sesamoid, while the lateral oblique view may be of help in assessing the fibular sesamoid.\(^16\) When an isolated sesamoid abnormality is suspected clinically, a special sesamoid view can be obtained as an oblique coronal radiograph in which the beam is directed tangential to the metatarso-sesamoid articulation, allowing direct visualization of the joint without osseous overlap.\(^15\) Nuclear medicine bone scan will demonstrate increased uptake within the affected sesamoid bone, while MR imaging will show diffuse marrow edema (decreased T1 and increased T2-weighted signal) replacing the normal fat signal within the affected sesamoid (Fig. 4). Historically, nuclear medicine bone scan has been used to detect abnormalities of the sesamoids. Bone scan is sensitive, demonstrating radiotracer uptake in the context of abnormality, but does not clarify

---

**Fig. 3.** Bipartite tibial sesamoid. Note that there are two separate fragments of the tibial sesamoid: the distal fragment (long arrows) and the proximal fragment (short arrows). The fragments are rounded with sclerotic margins completely surrounding both ossification centers.

---

**Fig. 4.** Sesamoiditis. Proton density (A) and STIR (B) short axis images through the first metatarsophalangeal joint reveals diffuse marrow edema with the tibial sesamoid in this patient who has metatarsalgia indicating sesamoiditis.
the nature of the pathology and as such, plays little role in evaluation of sesamoiditis. MR imaging typically permits more specific diagnosis of fracture, stress fracture, avascular necrosis or underlying pathology, and as such is considered as the imaging modality of choice for assessment of sesamoiditis.

**Sesamoid Trauma**

Traumatic injuries of the sesamoids may occur as a result of high or low impact injury including direct trauma, forced dorsiflexion of the great toe, or repetitive stress. Various traumatic injuries of the hallucal sesamoids have been described and include acute fracture, avulsion fracture, subluxation or dislocation, stress fracture, or diastasis of a bipartite/multipartite sesamoid.16–20

Most acute sesamoidal fractures involve the tibial sesamoid, as this sesamoid sits more directly under the first metatarsal head and is more directly involved in weight-bearing, placing this sesamoid at increased risk for injury. Furthermore, the position of the fibular sesamoid allows it to slip into the first metatarsal interspace between the first and second metatarsal heads, thus providing some protection from direct trauma. Clinically suspected sesamoid fractures should be initially evaluated with conventional radiographs. Radiographic signs that have been described in association with a sesamoid fracture include irregular margins with unequal separation of sesamoidal fragments, absence of similar radiographic findings on the contralateral side, or evidence of attempted healing (periosteal new bone). Visualization of a fracture or diastasis of sesamoidal fragments that represents a change from pre-injury radiographs is a definitive sign of fracture, but pre-injury radiographs are rarely available.20 It is often difficult to differentiate a bipartite or multipartite sesamoid from an acute fracture on the basis of radiographs alone and more advanced imaging is often required.

Nuclear medicine bone scan is nonspecific but will demonstrate focal increased uptake within the fractured sesamoid.19 CT and MRI are both very helpful in evaluating for acute fracture of a hallucal sesamoid. The sagittal and coronal (long axis) imaging planes using CT are most useful in detecting fractures and separation of fracture fragments.17 On MR imaging, the fracture will be seen as a low signal intensity line on T1-, and as a high or low signal intensity line on T2-weighted imaging (Fig. 5). MRI has the added benefit of demonstrating diffuse marrow edema (bright signal on STIR or T2-weighted imaging with fat saturation and diffuse low T1 signal abnormality). When evaluating the sesamoids with either CT or MR imaging, differentiation of a bipartite sesamoid from an acute fracture often requires evaluation of the morphology of the sesamoid, including the margins and shape of the fragments. A bipartite sesamoid is usually larger than a nonpartite sesamoid and usually demonstrates rounded fragments with smooth sclerotic margins, while a fracture fragment will often reveal irregular nonsclerotic margin often with some degree of separation of the fragments.21

Athletes exposed to excessive running, jumping, or forced dorsiflexion of the first MTP joint are at increased risk for stress fractures of the hallucal sesamoids, and although either sesamoid may suffer from stress fracture, the medial sesamoid is more commonly affected.17,18 Individuals present clinically with tenderness to palpation over the affected sesamoid with worsening of pain during participation in the offending activity.

Radiographs of the foot are often normal in individuals with hallucal sesamoidal stress fracture. Possible findings however include a complete or incomplete fracture, sclerosis, or a bipartite or multipartite configuration. Nuclear medicine bone

---

**Fig. 5.** Acute fracture of the fibular sesamoid. Sagittal STIR (A) and long axis T1 (B) images through the first metatarsophalangeal joint demonstrate an acute vertical fracture (long arrows) through the fibular sesamoid. Note that there is bright T2 signal within the fracture on the STIR image with low T1 signal on the coronal image. There is slight distraction of the proximal fragment (arrow heads) and the distal fragment (short arrows).
scan, as previously mentioned, is nonspecific but will reveal increased uptake in the affected sesamoid. CT imaging maybe normal but usually reveals a complete or incomplete fracture, with or without separation of fragments. In the early stages of stress response, MR imaging is nonspecific demonstrating diffuse marrow edema within the sesamoid. With persistent activity, a fracture develops and MR imaging will demonstrate a vertical low signal intensity line best seen on sagittal or long axis images through the involved sesamoid (Fig. 6). If the offending activity persists, the fracture can go on to completion and in the later stages, flattening and fragmentation of the sesamoid may occur.²²

Traumatic dislocation or subluxation of the sesamoids usually occur as a result of significant trauma to the great toe and are most often seen in conjunction with plantar capsular injury or disruption. These injuries have also been reported in ballet dancers and soccer players. Radiographs are usually sufficient to establish the diagnosis, but MR imaging can be useful in fully delineating the associated soft tissue injuries.

Delayed union and nonunion are common complications of sesamoid fracture, in part due to the tenuous blood supply of the sesamoids and possibly also related to the tremendous force applied across the sesamoids during normal weight-bearing.⁴ Over time, nonunion fracture fragments will develop sclerotic margins, which are nicely depicted on CT or MR imaging. Marrow edema may persist within the fracture fragments of a symptomatic nonunion (Fig. 7).

Initial treatment of sesamoidal fractures is usually conservative with rest, partial weight-bearing, avoidance of aggravating activity, and possible short leg casting. High level athletes or those who fail conservative treatment may undergo surgical resection of the proximal fragment. However, due to the crucial role of the sesamoids in distribution of force during weight-bearing, complete sesamoidal resection is ill advised as it may lead to serious complications including hallux valgus or cock-up deformity of the hallux.¹⁶

**Avascular Necrosis**

Avascular necrosis of the hallucal sesamoids represents an uncommon cause of metatarsalgia. Patients typically present with insidious onset of pain overlying the affected sesamoid. Although numerous etiologies have been suggested, it is repetitive trauma that is most often cited as the probable etiology in the majority of cases.⁹–¹¹,²³,²⁴ The tibial and fibular sesamoids appear to be involved with near equal frequency and females are affected slightly more often than men.⁶,²³ The condition is most often reported in adolescents or young adults who participate in athletic activity.

Radiographs are usually normal during the first 6 months following onset of symptoms, but eventually radiographic abnormalities develop, which include fragmentation, a stippled appearance, and increased density.⁶,⁹ Fragmentation into several fragments is classic and usually excludes other etiologies such as acute fracture or stress fracture. Nuclear medicine bone scan is nonspecific but will demonstrate increased uptake within the affected sesamoid. CT imaging will show findings similar to radiographs but typically demonstrates the abnormalities of fragmentation and increased density earlier and with increased precision (Fig. 8). MR imaging will show abnormality of the involved sesamoid very early with marrow edema present at the time of initial symptoms. This is manifest as

![Fig. 6. Stress fracture of the tibial sesamoid. This long distance runner developed insidious onset pain of at the level of her first metatarsophalangeal joint, exacerbated by running. Short axis (A) and long axis (B) T2-weighted images reveal diffuse marrow edema within the tibial sesamoid (long arrow) and an incomplete stress fracture (short arrow) noted on the long axis image.](image-url)
low T1 and bright T2-signal throughout the marrow space of the involved sesamoid (Fig. 8). This is also a nonspecific finding and is similar to the appearance of a nonspecific sesamoiditis and early stress related changes. Late MR findings include fragmentation and areas of mixed T1 and T2 signal representing areas of sclerosis intermixed with marrow edema (Figs. 9 and 10). The presence of extensive fragmentation is nearly diagnostic of avascular necrosis and usually excludes acute or stress related fractures.

Avascular necrosis does not usually respond well to conservative treatment and often requires surgical excision of the involved sesamoid, although excision of both sesamoids is not generally recommended. A limited excision of the necrotic portion of the sesamoid may be an acceptable surgical alternative to complete excision of the involved sesamoid.

**Arthritis**

The first metatarsophalangeal joint is a true synovial joint composed of three separate articulations including the metatarsophalangeal and two metatarsosesamoidal articulations. Osteoarthritis, gout, and inflammatory arthropathies commonly involve this joint and can lead to various changes of the sesamoids including chondral loss with joint space narrowing of the metatarsosesamoidal joints, subchondral sclerosis, marrow edema, erosions, and subchondral cysts. Advanced arthritis often leads to progressive hallux valgus deformity and metatarsosesamoidal subluxation or dislocation (Fig. 11).

**Infection**

Osteomyelitis of the sesamoids most often occurs from contiguous spread either from the underlying soft tissue infection or from septic arthritis of the first MTP joint. Sesamoidal osteomyelitis is often seen in the diabetic foot and may be associated with overlying skin ulcers, cellulites, and draining sinus tracks. MR imaging is the most sensitive imaging modality for evaluation of osteomyelitis and usually demonstrates marrow edema throughout the involved sesamoid. There may also be

---

**Fig. 7.** Nonunion of a tibial sesamoid fracture. Short axis T2-weighted image with fat saturation (A) shows marrow edema (arrow) within the tibial sesamoid in a patient with chronic pain in this region. Sagittal T1-weighted image (B) shows a vertical fracture (arrow) with sclerotic margins of both fracture fragments indicating nonunion.

**Fig. 8.** Avascular necrosis of the tibial sesamoid demonstrated on CT imaging. Short axis (A) and sagittal (B) CT images through the tibial sesamoid (long arrows) reveals mixed sclerosis and fragmentation of the tibial sesamoid in this patient with avascular necrosis of the tibial sesamoid. The fibular sesamoid (short arrow) is normal in appearance.
associated cortical destruction. The presence of an overlying skin defect, adjacent soft tissue abscess, or sinus track increases the specificity of MR imaging with regard to the diagnosis of osteomyelitis.

Nerve Impingement

Occasionally, the tibial sesamoid can result in impingement on the medial branch of the plantar digital nerve along the medial aspect of the hallux. Symptoms typically include decreased sensation and radiating pain. No specific imaging findings are associated with impingement of the medial plantar digital nerve and treatment is supportive with resection of the tibial sesamoid reserved for refractory cases of pain.

Absent Sesamoid

As previously described, the sesamoids play a key role in cushioning of the metatarsal head and in appropriate weight distribution across the first MTP joint. An absence of one of the sesamoids is a known cause of metatarsalgia. The most common reason for an absent sesamoid is previous surgical resection (Fig. 12). There are also case reports of congenitally absent tibial sesamoids that result in MTP joint pain. Total resorption of the tibial sesamoid resulting from infection has been reported as a mimic of a congenitally absent sesamoid and may present with MTP joint pain as a result of altered biomechanics of the joint. Radiographs, CT and MR imaging will all demonstrate the absence of the tibial sesamoid. MR imaging may also reveal soft tissue changes such as tendinitis or capsular injury associated with the altered anatomy.

PLANTAR PLATE INJURIES (TURF TOE)

The term “turf toe” has been used loosely to describe various soft tissue injuries about the first MTP joint; however, turf toe is strictly defined as a plantar capsular ligament injury of the first MTP joint. Turf toe is a common injury that may lead to significant morbidity and prolonged recovery times if not identified and treated promptly. Turf toe was first described in athletes playing American football on artificial turf. The incidence of injury has increased with the widespread use of new artificial playing surfaces introduced in the late 1960s combined with lighter more flexible footwear designed for these surfaces, which typically provide less support to the MTP joints. Artificial surfaces have been found to become harder with aging and wear. This harder surface

Fig. 9. Early changes of avascular necrosis demonstrated on MR imaging. Short axis STIR image shows diffuse nonspecific marrow edema (arrow) within the tibial sesamoid. MR shows no fracture or fragmentation in this early case of avascular necrosis.

Fig. 10. Late avascular necrosis of the tibial sesamoid demonstrated on MR imaging. Sagittal T1 (A) and STIR (B) images in a patient who has a previous vertical fracture (long arrows) through the tibial sesamoid demonstrate mixed T1 and bright T2 signal abnormality (short arrow) within the proximal fragment indicating avascular necrosis complicating the fracture. The missed signal on T1 indicates a combination of sclerosis and marrow edema.
combined with the higher coefficient of friction of artificial turf as compared to natural grass has been implicated in turf toe.\textsuperscript{15,29,30} The footwear initially designed for artificial turf was lighter and more flexible allowing increased dorsiflexion of the first metatarsal phalangeal joint than traditional cleats, thus increasing the risk of hyperextension injury. The development of more modern shoes with stiffened forefoot has been shown to reduce injury rate.\textsuperscript{31}

**Mechanism of Injury**

Turf toe is a hyperextension injury most commonly seen in American football athletes playing on artificial turf; however, injuries have been reported in many other sports. The most common mechanism is forced hyperextension of the first MTP joint during a football pile-up. The injury occurs in players lying in the prone position with the first toe planted on the playing surface with the heel elevated, when another player falls across the back of his leg. This forces the MTP joint into hyperextension, injuring the plantar capsuloligamentous structures.\textsuperscript{32} Another less common mechanism is seen in lineman, where valgus and hyperextension forces are introduced as the player repeatedly pushes off from the down position. This is believed to lead to a chronic repetitive-type injury of the plantar plate, and individuals with this mechanism of injury often describe a more insidious onset of symptoms.\textsuperscript{32,33} This type of injury may also be associated with an underlying pes planus deformity.\textsuperscript{33} Other predisposing factors for turf toe include hypermobility of the ankle joint, prior injury to the first MTP joint, and increasing age of the athlete.\textsuperscript{2} There has been recent description of hyperextension injuries at the MTP joints of skimboarders, referred to as “skimboarder’s toe”. This should be differentiated from turf toe because skimboarder’s toe results in dorsal MTJ pain and disruption of the extensor expansion instead of the plantar plate.\textsuperscript{34}

Hyperflexion injuries have also been reported as a mechanism of turf toe; however, hyperflexion of the MTP joints typically results in dorsal capsular injuries, which do not meet the strict definition of turf toe.\textsuperscript{13,32} A separate entity has been described in beach volleyball players, referred to as “sand toe”.\textsuperscript{35} This is a hyperflexion injury involving the first and lesser MTP joints resulting in dorsal capsular injuries that lead to significant disability and prolonged recovery times.\textsuperscript{35}

Turf toe injury is described as a sprain or tear of the plantar capsule–ligament complex of the first MTP joint, the most important component being the plantar plate. The detailed anatomy of the plantar plate and hallucal sesamoid complex is described in an earlier section. Hyperextension results in stretching or tearing of the opposing plantar plate, with the injury most often occurring at its weakest point near the proximal attachment to the metatarsal head neck junction. The injury is usually located just distal to the sesamoids and may allow sesamoid retraction or proximal migration.\textsuperscript{31} Sesamoid fracture or diastasis of a bipartite sesamoid have also been described in association with plantar plate injury.\textsuperscript{15,36} In extreme dorsiflexion, the proximal phalanx may compress the dorsal metatarsal head resulting in a focal osteochondral impaction injury.\textsuperscript{15,33} Dorsal dislocation of the great toe has also been associated with turf toe.\textsuperscript{13,15}

**Clinical Presentation of Turf Toe Injuries**

Individuals with turf toe most commonly present after an acute injury and typically describe worsening pain and disability over the subsequent
Clinical presentation and extent of disability varies depending on the severity of the injury. Physical examination reveals swelling, hyperemia, and point tenderness over the plantar surface first MTP joint. Pain and guarding limits active range of motion, but passive range of motion may be increased due to plantar plate disruption. Functional disability is a result of impaired push-off, and football players may complain of difficulty assuming the “down” position. The duration of impairment depends upon the severity of injury and may persist from a few days to many weeks.

Treatment and recovery time varies significantly depending on the severity of injury. Turf toe injuries are categorized based on severity. Grade 1 injury is defined as a stretching type injury (sprain) of the plantar capsular–ligamentous complex without loss of functional integrity. Individuals presenting with a Grade I sprain typically complain of mild tenderness and swelling along the plantar aspect of the MTP joint but without ecchymosis. Athletes are able to bear weight and are usually able to continue playing. Treatment is symptomatic with rest, ice, compression, and elevation (RICE), taping or a stiff insole. A Grade 2 injury is defined as a partial tear of the plantar capsular–ligamentous complex. This manifests clinically as mild to moderate tenderness, edema, and ecchymosis. Athletes are usually limp with
weight bearing and are unable to compete. Recovery time can be as long as 2 weeks. Treatment includes RICE and immobilization with or without crutches.\(^{13,14,31,33}\) Grade 3 injury is defined as a complete tear of the plantar plate, and it may have associated injuries including: osteochondral impaction of the dorsal metatarsal head, sesamoid fracture, diastasis of a bipartite sesamoid, sesamoid retraction/proximal migration, or MTP joint dislocation.\(^{13,31,33}\) Athletes present with severe tenderness, swelling, and ecchymosis, and may be out of play for 4–6 weeks or longer. These individuals require long term immobilization in a cast or boot; they may require surgery depending upon their response to conservative management and the presence associated injuries.\(^{13,31,35,36}\)

**Imaging of Turf Toe Injuries**

Evaluation with radiographs and MR imaging plays an important role in confirming the presence of and grading the extent of plantar plate injury, evaluating for associated injuries, and in guiding appropriate clinical management.\(^{14}\) Initial evaluation of turf toe injury usually begins with radiographs which may demonstrate soft tissue swelling, avulsion fractures, sesamoid fractures, diastasis of bipartite sesamoids, proximal migration of the sesamoids (Fig. 13) due to plantar plate disruption, or MTP joint dislocation.\(^{13,15,29}\) Stress views may be useful in demonstrating ligamentous laxity or disruption.\(^{13}\) Comparison views of the unaffected hallux may also be of benefit.\(^{13}\) Follow-up radiographs may demonstrate interval proximal migration on the sesamoids, indicating complete disruption of the plantar plate.\(^{14}\) Chronic turf toe injuries may result in hallux rigidus, which manifests as dorsal spurring at the MTP joint.\(^{7}\) Arthograms to evaluate for capsular injury have been performed historically; however, MR imaging is more useful in directly assessing the plantar soft tissues.

MR imaging is ideal for grading the extent of plantar plate injury, which is usually best depicted on sagittal and short axis axial T2-weighted images through the first MTP joint. Grade I injury demonstrates soft tissue edema and swelling along the plantar aspect of the first MTP joint. There may be mild thickening and edema within the plantar capsular structures, but no partial or full thickness tear will be present (Fig. 14). Grade II injury reveals a partial thickness tear/disruption of the plantar capsule (Fig. 15), and a Grade III injury manifests as a complete disruption of the plantar capsular structures and may demonstrate associated sesamoid pathology, such as edema or fracture, diastasis, or proximal migration (Fig. 16). Associated osteochondral lesions of the dorsal metatarsal head may also be demonstrated and a thorough evaluation of the adjacent musculotendinous structures should be performed.\(^{7}\) Coronal (long axis) images are best suited for evaluation of the collateral ligaments; sagittal and short axis images are useful in evaluation of the surrounding tendons and sesamoid bones.\(^{12,13,15,37}\) Disruption of the plantar plate

---

**Fig. 13.** Complete disruption of the plantar plate resulting in proximal migration of the sesamoids. (A) AP radiograph in the immediate post-injury period shows normal position of the tibial (short arrow) and fibular (long arrow) sesamoids. (B) AP radiograph approximately one month after injury shows proximal migration of the tibial (short arrow) and fibular (long arrow) sesamoids, indicating a complete disruption of the plantar plate distal to the sesamoids.
intersesamoid ligament may allow interposition of the flexor hallucis longus tendon between the sesamoids resulting in divergence of the medial and lateral sesamoids on axial images.\textsuperscript{14}

**Treatment of Turf Toe**

Turf toe was initially thought to have low morbidity but is now known to result in significant short and long-term morbidity and disability.\textsuperscript{33} One study showed that while ankle inversion injury is a much more common injury amongst American football players, turf toe actually results in more lost game time, which indicates the importance of this injury.\textsuperscript{2} Turf toe is usually treated successfully with conservative management, and surgery is reserved for refractory or complicated cases.\textsuperscript{36} Conservative therapy usually includes RICE. Rest is very important to allow the injury to heal; however, the implications of a turf toe injury are often underestimated and noncompliance is frequently encountered.\textsuperscript{33} Support or immobilization with tape, orthotics, walking boot, or casting may be required depending on the severity of injury.\textsuperscript{29,36} Physical therapy with early mobilization is beneficial to preserve range of motion, however, returning to practice too early results in prolonged recovery.\textsuperscript{33}

Surgery is rarely indicated, but it may be required if there is poor response to conservative management or other associated injuries are present. Surgical indications include: sesamoid fracture, diastasis of a bipartite sesamoid, proximal migration of sesamoids, loose body, chondral flap, or failure to respond to conservative management.\textsuperscript{13,32,36} Capsular-ligamentous repair and resection of the distal fragment of a sesamoid fracture/diastasis may be performed.\textsuperscript{33}

**SUMMARY**

Numerous distinct pathologic entities involving the hallucal sesamoidal complex and capsular structures of the first MTP joint can result in

---

**Fig. 14.** Grade I sprain of the plantar plate. Short axis (A) and sagittal (B) images through the first metatarsophalangeal joint reveal soft tissue edema (long arrows) within the plantar plate and superficial to the plantar plate. There is no capsular disruption with no evidence of a partial or full thickness tear of the capsular structures. Fibular sesamoid (short arrow).

**Fig. 15.** Grade II partial thickness tear of the plantar plate. Short axis T2 image (A) shows a partial tear of the plantar plate (long arrow) between the fibular sesamoid and flexor hallucis longus tendon (arrow heads). The medial aspect of the plantar plate (short arrows) demonstrates soft tissue edema and a stretching type injury but remains intact. Sagittal T2 image (B) shows partial thickness disruption of the lateral sesamoidal phalangeal ligament (long arrow) with adjacent soft tissue edema, but some fibers remain intact. The fibular sesamoid (short arrow) is partially retracted.
metatarsalgia of the first MTP joint. Although history and clinical presentation are very important in establishing a working differential for the etiology of pain, there is often significant overlap with regard to clinical presentation and physical findings. Targeted imaging to include radiographs, nuclear medicine bone scan, CT and MR imaging can play a pivotal role in accurately diagnosing the source of pain.

REFERENCES