# Radiology Corner

*The following article is the explanation of last month's radiology case and image. The next case and image will appear in a future issue of* ***Military Medicine****.*

## Turf Toe: Ligamentous Injury of the First Metatarsophalangeal Joint

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### Abstract

Injuries to the metatarsophalangeal (MTP) joint of the great toe have increased in incidence over the past thirty years following the introduction of artificial playing surfaces and the accompanying use of lighter footwear. Although most common in American football players, similar injuries can also occur in other sporting activities including soccer and dance, or following trauma to the great toe. The mechanism of injury is typically hyperextension of the MTP joint, but injuries have also been reported secondary to valgus or varus stress, or rarely as a result of hyperflexion injury (1,2). The abnormal forces applied to the first MTP joint at the time of injury, result in varying degrees of sprain or disruption of the supporting soft tissue structures, leading to the injury commonly referred to as turf toe. The extent of soft tissue disruption is influential in treatment planning and can be used to determine the prognosis for recovery. This report will review the anatomy of the first MTP join, followed by a discussion of the mechanism of injury and the typical clinical presentation of an individual with turf toe. Finally, the role of imaging including radiography and magnetic resonance imaging, and standard treatment options for turf toe will be discussed.

### Introduction

"Turf toe" is defined as a sprain of the soft tissue support structures of the metatarsophalangeal (MTP) joint of the great toe (3). Bowers and Martin first coined the term in 1976 (4) in a study that identified increasing numbers of MTP joint injuries at the University of West Virginia following the replacement of grass with artificial turf on its playing fields. The most common mechanism of injury leading to turf toe is reported to be hyperextension of the MTP joint, however valgus, varus, and hyperflexion injuries have also been implicated as potential mechanisms (3-8). In one study of sports related injuries at a major university, injuries of the first MTP joint ranked third behind ankle and knee injuries for the total amount of lost playing time by athletes (3). Although the number of lost days is less overall than that seen with knee and ankle injuries, the length of recovery for the individual athlete can be considerably longer following an injury to the first MTP joint (1,9). These facts underscore the need for establishing an accurate and timely diagnosis and conventional radiography and MR imaging can both play a significant role in confirming the clinical suspicion of injury as well as in defining the extent of injury and directing the appropriate treatment. There is currently no information in the literature regarding the incidence of

turf toe among the active duty military population however one can assume that the incidence is similar to other young athletically active populations and the subject of MTP joint injuries is therefore worthy of review.

## History

The patient is a 21-year-old service academy football player who sustained a hyperflexion injury to his right first MTP joint during a game. Following the injury, the player complained of pain along the plantar aspect of the MTP joint. There was tenderness to palpation and the inability to push off with the great toe.

## Imaging Findings

Initial radiographs of the foot (Fig. 1) following the hyperflexion injury demonstrate no fracture or dislocation, and the sesamoid bones are in their normal anatomic location. MR imaging (Fig. 2) performed two days later demonstrates intact osseous structures with no fracture or bone contusion. There is extensive soft tissue edema along the plantar aspect of the first MTP joint and the plantar plate is completely disrupted resulting in divergence of the medial and lateral sesamoids. This in turn allows the intact flexor hallucis longus tendon to be abnormally interposed between the medial and lateral sesamoids. Follow up radiograph (Fig. 3) one month later demonstrates proximal migration of the sesamoids when compared with the initial radiograph. This radiographic finding is diagnostic of complete disruption of plantar plate and proximal retraction of the double tendon of the flexor hallucis brevis.

## Discussion

The first MTP joint is a modified hinge joint that is inherently unstable, however, it derives significant stability from a complex array of soft tissue support structures, which include the capsule, collateral ligaments, plantar plate, as well as the flexor and extensor tendons, and two sesamoids bones (10). The soft tissue support structures are very important in maintaining proper function of the first MTP joint as this joint bears the majority of a person's body weight (40-60%) during walking, with an increase in load bearing of up to 2-3 fold during running, and up to an 8 fold increase during jumping (3,9,10). Injury to the supporting soft tissue structures can result in an inability to push off with the great toe, thus limiting the athlete's ability to run or jump.

The medial (tibial) and lateral (fibular) sesamoids are contained within the double tendon of the flexor hallucis brevis muscle, which originates on the cuboid and lateral cuneiform proximally and inserts distally on the proximal phalanx of the great toe via the plantar plate (3,11). The abductor hallucis originates proximally on the calcaneus, while distally its tendon first attaches to the medial sesamoid and then continues on to insert along the medial aspect of the proximal phalanx via the plantar plate forming a portion of the medial joint capsule (11). Laterally the adductor hallucis follows a similar anatomic pattern, inserting onto the base of the proximal phalanx by way of the lateral sesamoid (3). The muscle is a bi-headed structure with the oblique head originating along the proximal portions of the lateral four metatarsals while the transverse head originates across the lateral four MTP joints (11). The first MTP joint is also supported by fan shaped medial and lateral collateral ligaments, each consisting of two subparts, the metatarsophalangeal ligament and the metatarsosesamoid ligament (3). The separate components of the collateral ligaments undergo varying degrees of stress as the joint progresses through its range of motion (3). Along the plantar aspect of the first MTP joint is a thick fibrous structure referred to as the plantar plate (Fig. 4). Distally, the plantar plate has a very strong attachment to the base of the proximal phalanx, while proximally its attachment to the metatarsal neck is relatively loose (3). The joint's function is slightly more complex than a simple hinge joint with the two bones articulating in a sliding motion that results in compression of the articular surfaces when the joint is fully extended.

In approximately 85% of cases, turf toe results from a hyperextension injury of the first MTP joint, although other mechanisms of injury including varus and valgus stress, and rarely hyperflexion have also been implicated. The

incidence of turf toe has increased in American football players since the introduction of artificial turf and the typical injury occurs as follows. While the distal aspect of the players foot is fixed on the ground with the toes doriflexed and the heel protruding into the air, and another player falls across the back of the heel, thus driving the already extended joint into a hyperextened position beyond the range that the supporting structures can tolerate. During forced hyperextension, the medial and lateral sesamoids are pulled distally thereby transferring increased load to the dorsal aspect of the metatarsal head. Depending upon the degree of increased load, the plantar complex beneath the metatarsal head undergoes partial or complete tearing (7). Disruption of the plantar plate results in impaction of the articular surface of the proximal phalanx against the articular surface of the metatarsal head during full extension (7).

Turf toe injuries are classified on the basis of severity (3,7,12). Grade I injuries are the least severe and describe a strain of the capsule without loss of its functional integrity. The patient presents clinically with mild edema but no visible bruising. There is little change in the range of motion and the patient can continue to bear weight. Radiographs are normal, and MR imaging may demonstrate mild surrounding soft tissue edema, however all of the soft tissue components of the capsule remain intact. The prognosis for full recovery is good and the patient can usually continue to play with only mild discomfort (3,7). Grade I injuries may be treated with taping of the toe and the use of a stiff insole in the shoe.

Grade II injuries are more severe and represent partial thickness tearing of the plantar plate and capsular structures. These patients present clinically with ecchymosis and edema overlying the first MTP joint. Range of motion is restricted to a moderate degree the patient experiences pain and may limp with weightbearing. The symptoms may progress over time and athletes with grade II injuries typically loose up to two weeks of athletic participation. Treatment of grade II injuries is usually conservative with pain control, elevation, rest, and icing of the joint. Motion of the joint may be permitted in several days as symptoms permit. Radiographs are typically normal and MR imaging will again demonstrate adjacent soft tissue edema. Fluid signal intensity may be seen extending partially through the plantar plate and capsular structures representing partial thickness disruption of these structures. The sesamoid bones typically remain in normal position.

Grade III injuries are the most severe and this grade of injury may be used to describe either chronic effects of a disrupted capsule (12), or to describe an acute injury with complete disruption of the capsuloligamentous complex. In grade III injuries the plantar plate may be completely avulsed from the metatarsal neck and impaction of the metatarsal head may occur during full extension of the joint (7). If there is a bipartite sesamoid, the component pieces may separate (3, 12) or the sesamoid itself may fracture (3). In severe injuries the sesamoids may diverge or migrate proximally (3, 13). These patients present with severe pain and tenderness to palpation and restricted range of motion. Marked edema and ecchymosis is usually present. The patient typically avoids weightbearing because of severe pain. The athlete will loose a minimum of 4-6 weeks of playing time and treatment may required prolonged immobilization or surgery (7). Radiographs may demonstrate an associated capsular avulsion, compression fracture; sesamoid fracture, diastasis, or proximal migration. Comparison films with the contralateral foot or pre-injury radiographs may be helpful in detecting sesamoid abnormalities (13). MR imaging is also capable of demonstrating each of these potential osseous abnormalities. In addition, MR imaging can demonstrate the extent of injury to each component of the capsuloligamentous structure, including the plantar plate, collateral ligaments, as well as the flexor and extensor tendons (14). MR imaging can also demonstrate the integrity of the articular surface of the MTP joint (7).

Radiography and MR imaging can be useful adjunctive tools in the evaluation of clinically suspected first MTP joint injuries. Specifically MR imaging can demonstrate the extent of soft tissue injury, which in turn can help direct proper treatment of the turf toe injury and can also help predict the length of recovery time that will be required for the athlete.

Figures

Figure 1. AP radiograph of the foot immediately following the injury demonstrates no significant osseous abnormality.

Figure 2. MR images through the level of the of the first metatarsophalangeal joint two days later. T1-weighted axial (2a) and T2-weighted axial image (2b) demonstrates soft tissue edema along the plantar aspect of the first metatarsal joint. There is mild diastasis of the medial and lateral sesamoids (short arrows) and interposition of the flexor hallucis longus tendon (long arrow) between the two sesamoids. T2-weighted sagittal image (2c) demonstrates complete disruption of the plantar plate (arrow) with surrounding high signal intensity consistent with adjacent soft tissue edema.

Figure 3. AP and oblique radiographs of the foot one month following the initial radiograph reveals interval migration of the medial and lateral sesamoids (arrows) in a proximal direction. This finding is consistent with complete disruption of the plantar plate as well as disruption of the double tendon of the flexor hallucis brevis.

Figure 4. Line drawings of the first metatarsal phalyngeal joint demonstrate the relationship of the plantar plate and the adjacent soft tissue support structures of the joint as viewed from a plantar surface (4a) and as an axial section (4b).

Figure 1

Figure 2a

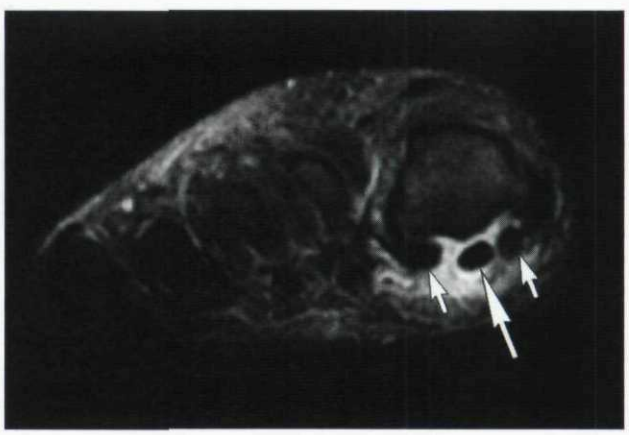

Figure 2b

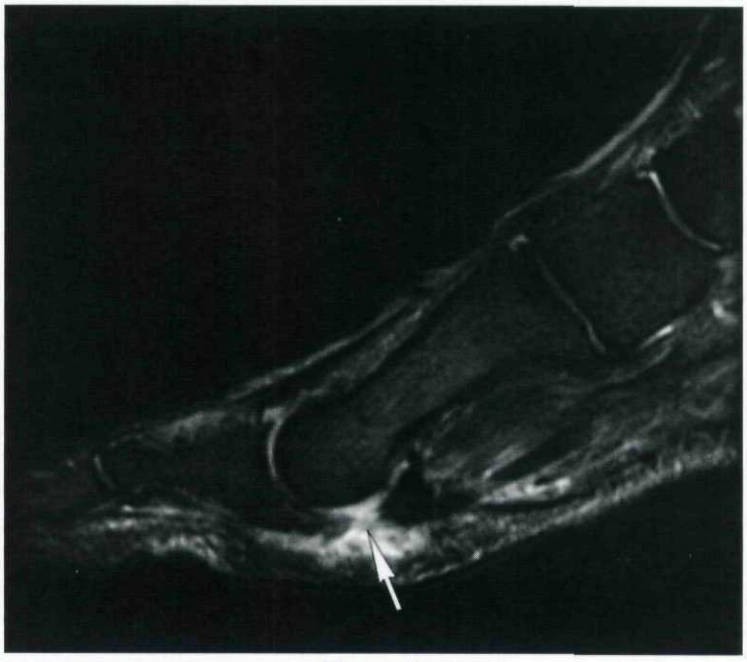

Figure 2c


Figure 3

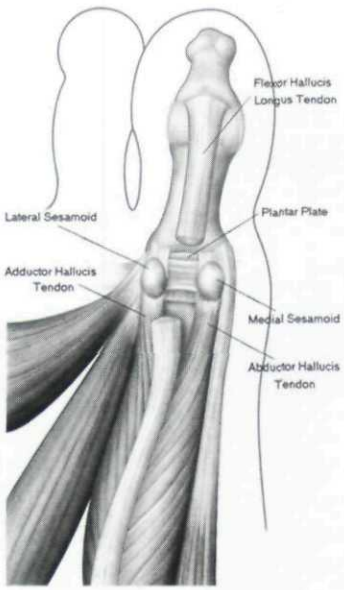


Figure 4a

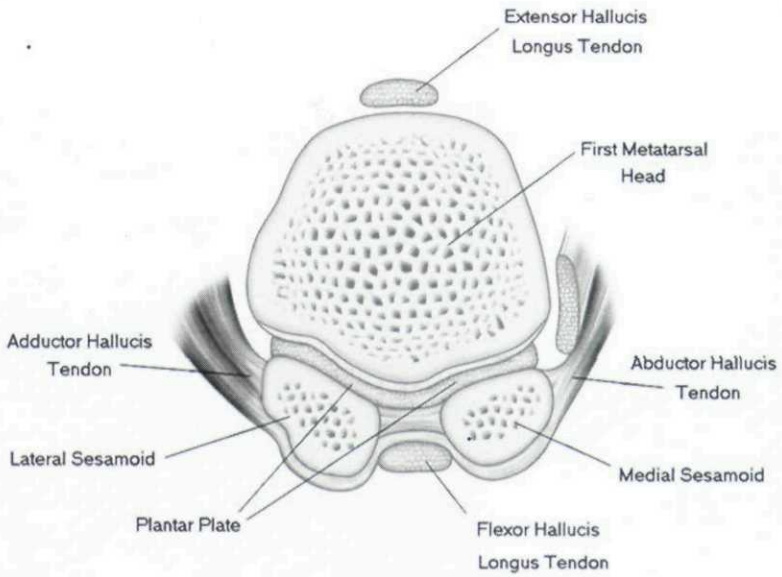


Figure 4b

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