JIFAF The Journal of the International Foot & Ankle Foundation
internationalfootankle.org/journal

Functional hallux rigidus in high level athletes: Arthroscopic repair by flexor hallucis longus debridement

Brian Carpenter, DPM, FACFAS[1], Michael Gentile, DPM, FACFAS[2], Jacob Russell Hagenbucher, DPM, AACFAS[3]

1 - Professor, Department of Orthopaedics, University of North Texas Health Science Center, Fort Worth, Texas, USA
2 - Fellowship Director, Portland Foot and Ankle Reconstructive Fellowship; Private Practice: Portland Foot and Ankle Institute, Portland, Oregon, USA
3 - Fellow, Portland Foot and Ankle Reconstructive Fellowship, Portland, Oregon, USA

This study aimed at the surgical technique and long-term clinical outcome of releasing the retrotalar pulley and surgical debulking of the flexor hallucis longus muscle belly to restore motion to the first metatarsophalangeal joint. Hallux limitus is defined as a limitation of motion at the first metatarsophalangeal joint. Numerous etiologies have been described, but most are concentrated within the first ray, especially the first metatarsophalangeal joint. We present a series of patients with hallux limitus caused by impingement of the flexor hallucis longus tendon within the retrotalar pulley due to a hypertrophic and/or low-lying muscle belly. Arthroscopic surgical debridement of the retrotalar pulley and surgical debulking of the flexor hallucis longus muscle belly in the posterior ankle compartment resolved all symptoms at the 1st metatarsophalangeal joint and restored normal motion of the first metatarsophalangeal joint allowing all high level athletes to return to their respective sports with no limitations.

Keywords: athletes, hallux limitus, flexor hallucis longus, FHL, first metatarsal phalangeal joint, MTPJ, retrotalar pulley, zone 1, impingement

Functional hallux limitus is a separate and distinct diagnosis from structural hallux limitus. Functional hallux limitus is characterized by a lack of motion of the first, metatarsophalangeal (MTP) joint during gait without a fixed structural deformity in the 1st ray. Functional hallux rigidus is very different from a "trigger toe" where active plantarflexion causes the toe to catch in flexion.

Functional hallux limitus is much more common than most think, but is infrequently recognized [1]. The Flexor Hallucis Longus (FHL) has been mostly described and referred to as a substitute muscle that is used in various augmentation surgical procedures [2]. Although most accepted causes are focused within the first ray, pathology involving the FHL has also been described [3,4,5]. These include hypertrophy of the muscle belly, a low-lying muscle belly, tendonosis, or stenosis tenosynovitis [4]. These same pathologies have also been implicated in posterior medial ankle pain.

Tarsal tunnel syndrome has been documented to occur secondarily to a hypertrophic and long distally extended muscle belly of the flexor hallucis longus as well [5]. In this series of 9 high level athletes (those who were already competing or performing at a professional level in their sport or who have the potential to compete in the Olympics or as a professional athlete) where posteromedial ankle pain was not the source of pain that brought the patients in for treatment it was the pain at the first metatarsophalangeal joint and limitation of dorsiflexion in the first metatarsophalangeal joint or functional hallux limitus and the accompanying symptoms.

Anatomy

With the multiple variations of osseous anatomical relations, especially at the level of the rearfoot complicates adequate functional description [6]. Similar to the other two medial tendons behind the ankle the FHL tendon travels within a fibro osseous tunnel behind the medial malleolus, beneath the flexor retinaculum. The FHL originates from the posterior fibular surface on the distal 2/3 of the bone (Figure 1).

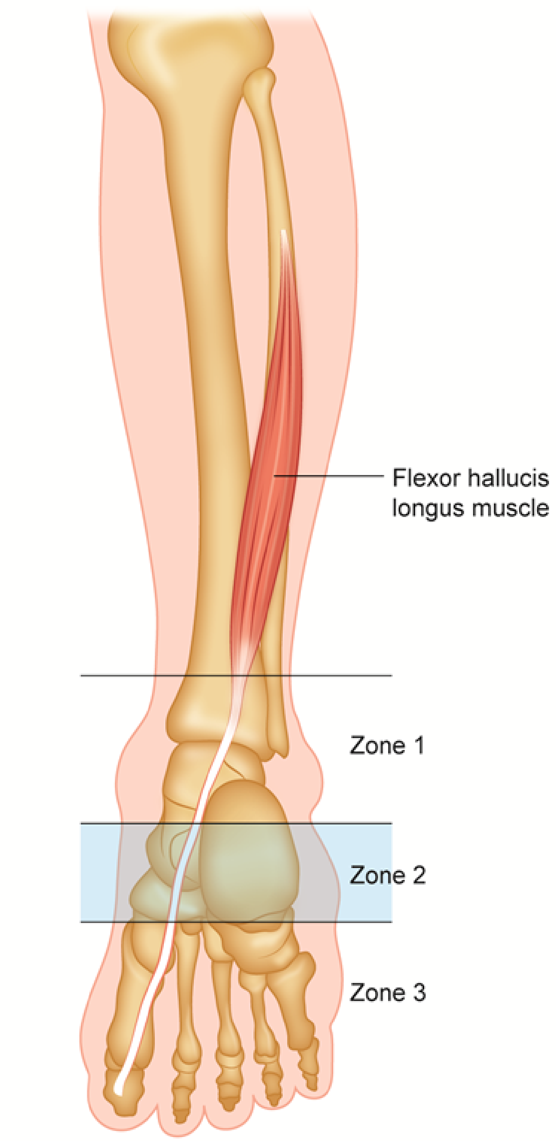

Figure 1 Drawing showing the FHL muscle and tendon from origin to insertion. Zones 1-3 are identified.

It runs distally and crosses the ankle through a flexor retinaculum (retrotalar pulley) at the level of the posterior talar process and the posteromedial talar process where it passes between these. This is a very small constrictive channel and the FHL tendon if thickened due to any of the aforementioned it can become constricted by the retrotalar pulley [7].

The retrotalar pulley extends until the subtalar joint but not beneath it and is 1-1.5mm in thickness and 14-15mm in length [6]. The tendon then passes into the foot by crossing next to the subtalar joint and under the sustentaculum tali. This is the same as a rope passing through a pulley. The FHL tendon is a deep-seated tendon through most of its course and can be divided into 3 zones [8]. The zone 1 tendon passes behind the ankle and can be visualized through the arthroscope, the zone 2 tendon passes underneath the sustentaculum to the master knot of Henry and the zone 1 tendon is from the master knot to the phalangeal insertion [8,9,10].

Etiology, Presentation, and Diagnosis

Forced dorsiflexion at the first metatarsophalangeal joint is common in athletes in a variety of sports. This may have a direct effect on over tensioning of the FHL tendon resulting in pathological changes of the tendon at the posteromedial aspect of the ankle. The sports that have the largest published diagnosis of FHL tenosynovitis are ballet dancers, javelin throwers, football players, soccer players, and runners who go up and mainly down hills [11,12,13]. Athletes through physical activity place recurrent stresses on the flexor hallucis longus which after a workout, the body repairs or replaces damaged muscle fibers through a cellular process where it fuses muscle fibers together to form new muscle protein strands or myofibrils. These repaired myofibrils increase in thickness and number to create muscle hypertrophy. It has been reported that an average of 52% hypertrophy can occur with additional loads being applied to the FHL tendon [14]. Increases in height, weight and body mass index in athletes have been reported in all sports at most positions [15,16]. Dietary supplements commonly being used by athletes also carry the potential to increase muscle performance and muscle hypertrophy through secondary physiological factors [17].

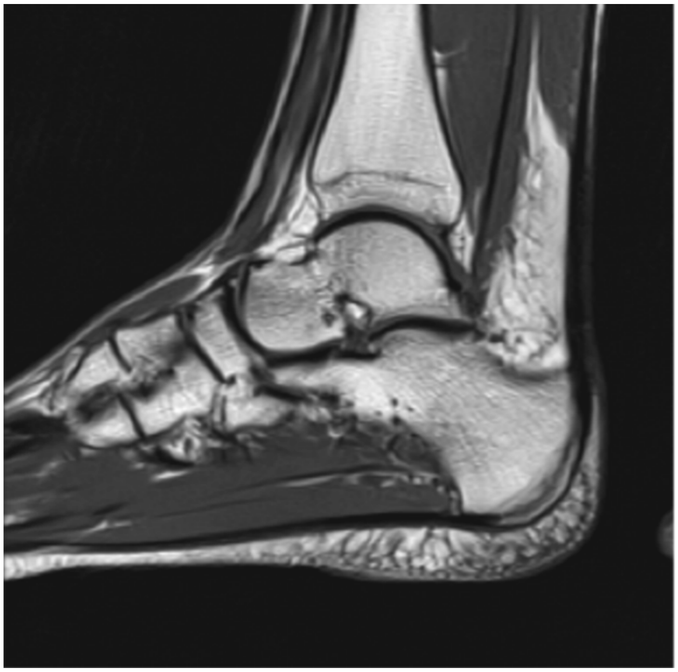

Figure 2 Sagittal plane T1 image showing distal extension of the FHL muscle into the retrotalar pulley.

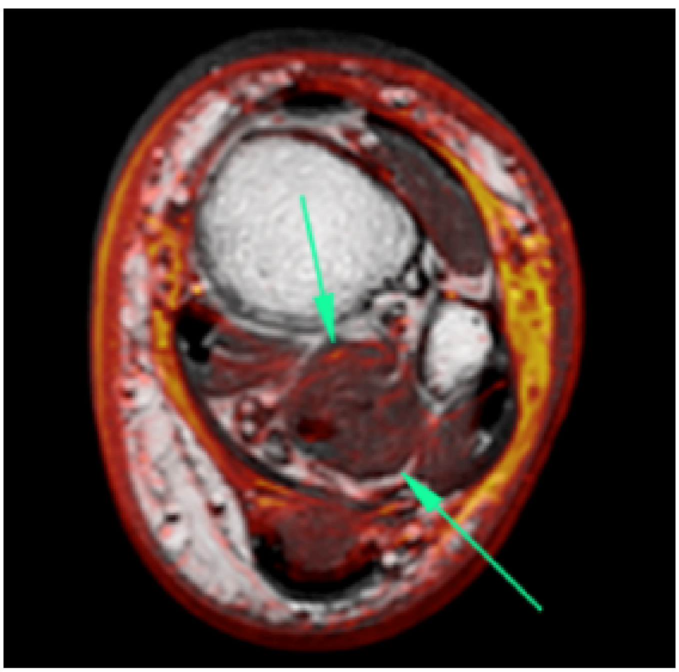

Figure 3 Transverse plane color fusion MRI showing FHL muscle belly hypertrophy.

Forced dorsiflexion of the 1st MTP joint can result in traumatic damage of the FHL tendon in the posterior ankle as it passes through the channel. In many athletes, especially ballet dancers, a forced repetitive dorsiflexion can result in overuse injuries [18].

Figure 4 Sagittal plane color fusion MRI showing FHL muscle belly hypertrophy and fluid around the retrotalar pulley.

Injury to the FHL tendon can also be explained at this level as this is the tendon's avascular zone, zone 1, and the pressure caused by the length of the tunnel and retinaculum on it [19].

Athletes suffering from functional hallux limitus secondary to FHL impingement can have pain either at the 1st MTP, the posteromedial ankle, or both. In our observations by arthroscopic treatment we have discovered that the fibro-osseous tunnel (retrotalar pulley), causes constriction in patients with high activity levels and also in those who have a long and enlarged muscle belly that comes into contact with the pulley and tunnel [20]. First, the 1st MTP joint range of motion is evaluated by holding the subtalar joint in neutral and the ankle in a slightly plantarflexed [21]. Following this, the ankle is placed into a neutral position and the 1st MTP is again evaluated. This test has been called Tomassen's test and Tomassen's sign is reflective of FHL impingement causing a functional hallux rigidus [21].

If the range of motion (ROM) is restricted with this maneuver, impingement of the FHL tendon in the retinaculum of the posteromedial ankle can be the source of the limited dorsiflexion.

Patient	1	2	3	4	5	6	7	8	9
Age	21 F	35F	19M	29M	21M	26F	22M	25F	30M
Sport	Steeplechase	Ballet	Heptathlon	Football	Football	Ballet	Sprinter	Soccer	Ballet
Pre op: 1st MPJ ROM ankle plantarflexed	> 70 °	> 70°	> 70°	>70 °	>70 °	>70 °	>70 °	>70 °	>70 °
Pre op: 1st MPJ ROM ankle neutral	15°	15°	30°	25°	20°	10°	15°	25°	5°
Post op: 1st MPJ ROM ankle plantarflexed	> 70°	>70°	>70°	>70°	>70°	>70°	>70°	>70°	>70°
Post op: 1st MPJ ROM ankle neutral	>70°	>70°	>70°	>70°	>70°	>70°	>70°	>70°	>60°
Arthroscopic Surgery Debridement Performed	Pulley	Pulley & muscle belly	Pulley & muscle belly	Pulley, muscle belly & tenosynovitis	Pulley & os trigonum removal	Pulley & muscle belly	Pulley & os trigonum removal	Pulley & tenosynovitis	Pulley & muscle belly

Table 1 Patient dataset.

This may also result in posteromedial ankle pain and the tendon can be palpated during physical examination in the channel posterior to the medial malleolus. In some patients, FHL crepitus can be appreciated towards the end of 1st MTP joint dorsiflexion. Another clue of FHL involvement is the lack of clinical and radiographic evidence of bone impingement within the 1stMTP joint. Magnetic resonance imaging (MRI) plays a key role in confirming the diagnosis due to its sensitivity to soft tissue pathology. FHL tendon abnormalities are best visualized on sagittal and axial images and tenosynovitis, impingement, tendon entrapment, enlarged muscle belly, enlarged os trigonum, and edema are all easily visualized [22]. A diagnostic ultrasound may also be used to diagnose FHL injuries, as it shows the muscle in movement and potential areas of impingement [3]. Imaging the ankle in neutral position aids in visualization of the FHL tendon as it passes through the flexor retinaculum. Tenosynovitis, edema, enlarged muscle belly, impingement in the retinaculum, or tendon tear can be visualized with a good quality MRI (Figure 2 and 3).

A MRI post exertion can be very useful in truly visualizing the impingement and post exertion edema [23] (Figure 4). This functional pathology differs from a checkrein deformity where there is entrapment or fixed tethering of the FHL in the posterior foot just proximal to the retrotalar pulley which has been described secondary to traumatic fractures of the talus, calcaneus, or deep posterior compartment syndrome resulting from fractures of the tibia and fibula [24,25,26].

Patients/Materials and Methods

All patients in this series presented to the two senior authors' clinics with 1stMTP joint pain and/or stiffness during physical activities and were high level athletes; no patients that met these criteria were excluded. A Tomassen test was performed on each patient and a positive Tomassen sign was documented (Table 1). No crepitus was seen with first MTPJ ROM on any patient. A weight bearing three-view foot X-ray with an added sesamoid axial view was performed on each patient and none had degenerative changes, fracture or spurring in the first MTPJ or the sesamoids. In addition, subjective evaluation revealed posteromedial ankle pain in some of these patients. All patients were diagnosed with functional hallux limitus due to impingement of the retrotalar pulley. MRI was utilized to clarify and confirm the presence of FHL pathology. Being a high level athlete, all the patients had been through months of therapy by either a trainer or physical therapist or both. Once the diagnosis was confirmed surgical intervention was undertaken.

Figure 5 Showing the flexor retinaculum and the FHL tendon with tenosynovitis.

Surgical Technique

The procedure is performed with a 4.0mm 30 degree arthroscope. The patient is placed in the prone position with the foot hanging off the end of the bed under general anesthesia. The posterior lateral (PL) portal placement is established by drawing a line from the most distal tip of the fibula to the Achilles tendon parallel to the sole of the foot. The posterior medial (PM) portal is placed at the same level but medial to the Achilles tendon. Using a "nick and spread technique" the PL portal is established and the hemostat is taken down to the level of bone. The trajectory of dissection is towards the apex of the 1st inter-metatarsal space. Once you come into contact with the posterior tibia the hemostat is removed and the blunt trocar and cannula are inserted. The PM portal is now established in a similar manner. The shaver is then introduced at a right angle to the camera and slid to the end of the cannula. It is critical that the open side of the shaver is aimed laterally to avoid inadvertent damage to the FHL tendon or neurovascular structures. After slightly backing away from the posterior tibia, a field of view is established by shaving the fat in small circles until the shaver is visualized and then the posterior ankle is seen. The FHL tendon is then identified and arthroscopic examination can commence. Careful attention should be taken to stay lateral to the medial edge of the FHL tendon to avoid the neurovascular structures.

Figure 6 Showing the FHL tendon after debridement of the tendon and of the retrotalar pulley.

The release of the flexor hallucis longus tendon is accomplished by the resection of the flexor retinaculum and debridement of the tendon and if necessary the muscle belly. The retinacula portion of the sheath/pulley consists of fibrous tissue condensations that wrap around the flexor tendon. The latter can be accomplished efficiently with a coblation wand or with a shaver [27] Figures 5-7).

This is followed by debridement of any pathology adjacent to the FHL. This may include removal of an os trigonum or Steida's process if it had been previously diagnosed and was planned for debridement/removal. At this point the tendon should pass freely through the canal and is confirmed by direct visualization during passive maximal motion at the 1st MTP joint. If there is pathology to be addressed within the first ray it is then addressed. This would involve rotating the patient into the supine position.

The postoperative course is dictated by whether there was osseous work within the first ray. If not, patients are allowed to be partial weight bearing as tolerated in a cam walker boot and early ankle and 1st MTP joint ROM exercises are initiated. If there is any weakness or ROM issues at either the ankle or the 1st MTP joint specific physical therapy should be performed.

Figure 7 Arthroscopic image showing low lying muscle belly in contact with retrotalar pulley.

Results

No patients were lost during the follow-up full-length evaluations. The mean follow-up duration was 29.5 ± 8.32 months (range 19 to 49). The FHL tendon was debrided and the retrotalar pulley was released at zone 1 in all patients. An os trigonum was removed in 2 patients; a muscle belly debulking was performed in 5 patients. After debridement the 1st MTPJ was placed through ROM with the ankle at maximum dorsiflexion and there was no inhibition or impingement visualized through the arthroscope. All patients had greater than 70 degrees of dorsiflexion in this position in the operating room.

All patients at their last follow-up evaluation had maintained greater than 70 degrees of dorsiflexion at the 1st MTPJ with the ankle dorsiflexed and 5 of the patients had better ROM at the 1st MTPJ than on the contralateral limb. One patient had a minor complication (lasting less than a month postoperatively) of paresthesia on the plantar foot that quickly resolved on its own. No skin complications or healing issues were observed.

No patients reported any great toe complaints or symptomatic deficits of flexion strength as a consequence of the FHL debridement and associated procedures.

Discussion

Arthroscopic treatment of FHL tenosynovitis in 60 feet by Ogut, et al. reported a low complication rate of 3.4% and an improvement of AOFAS scores by 56.7 points to a final score of 85.9 points after a mean follow up of 26.7 months [28]. In comparison to open surgery, posterior ankle arthroscopy results in significant improvements in foot and ankle patient-reported outcome scores, an earlier return to sport, and a lower rate of complications with the most common complication being sural nerve neuropraxia [29,30]. There are some limitations to our study as there is no control group and the small number of cases. The other direct limitation to this procedure is the arthroscopic skill needed by the surgeon, with the improvements in technology this continues to become a more reliable procedure. MRI and clinical examination proved reliable in our patients but the gold standard for verifying impingement syndrome is intraoperatively viewing under direct visualization of the endoscope [31]. Current evidence with our patients shows that posterior arthroscopic debridement is a safe and effective method for treating a variety of FHL pathologic conditions and functional hallux limitus caused by FHL impingement. By the release/debridement the FHL tendon is freed up allowing full-unrestricted dorsiflexion at the 1st MTPJ in all phases of gait. All patients in our series returned to their sport/profession with normal first MTP joint motion and no first MTP joint pain and have had no recurrences to date.

Funding Declaration: No funding was received in study design, data collection and analysis, decision to publish, or preparation of this article.

Declaration of Conflicting Interests: The author(s) declare no potential conflicts of interest in regards to the authorship, research, and/or publication of this article.

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