Transplantation with Allograft for Rupture of the Flexor Hallucis Longus Tendon with Subsequent Longitudinal Tear of the Flexor Digitorum Longus Tendon at the Master Knot of Henry

A Case Report

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A rare case of closed complete rupture of the flexor hallucis longus tendon with subsequent longitudinal tear of the flexor digitorum longus tendon is reported in a marathon runner. This is also a first case report of flexor hallucis longus transplant with cadaveric posterior tibial tendon allograft. Two minimal incisions distal and proximal to the malleolus allowed for tunneling with urethral dilators to open the tendon sheath for transplantation, avoiding the need for a large incision. Postoperatively, the patient regained active flexion at the interphalangeal joint of the left hallux. Four months after surgery, full range of motion was observed and dynamometric exam revealed 68% of the strength of the contralateral side. The patient was able to resume competitive running after the surgery and performed well in her age bracket. (J Am Podiatr Med Assoc 104(5): 508-513, 2014)

Complete ruptures of the flexor hallucis longus (FHL) tendon are most commonly diagnosed in high-level athletes such as runners,[1-3] ballet dancers,[4] and tennis players[5]; and this population would also be most affected by their lack of function. However, rupture of the FHL tendon can also occur in patients without trauma,[6,7] or to patients with systemic diseases such as diabetes, lupus, gout, systemic lupus erythematosus, rheumatoid arthritis[8], psoriatic arthritis, kidney disease, and Reiter's disease.[9]

Rupture of the FHL tendon can occur at different locations along the length of the tendon. According to E. Gillot and P.S. Ray, rupture of the FHL tendon can be divided into three zones. "Zone 1 is proximal to FHL insertion, distal to sesamoids; Zone 2 is the area between the sesamoids and the master knot of Henry; and Zone 3 is proximal to master knot of Henry."[9(p1)] Previously there was no report on the rupture of FHL tendon at medial malleolus until Henriette Baan's article.[8] Daisuke Noda[10] reported 35 cases of either complete or partial subcutaneous rupture of the FHL tendon. Grispigni[11] also reported two cases of complete subcutaneous rupture of the FHL tendon. Rupture of the FHL tendon can also be a result of hallux valgus surgery[12] or from Akin osteotomy for hallux interphalangeus.[9]

Although cases of complete rupture of the FHL have been reported, this is the first case with subsequent flexor digitorum longus (FDL) tendon tear. Both the FHL and FDL are active during the propulsive period of stance phase to help propel the body forward in late propulsive phase, promoting plantarflexion and supination. The pain the patient experienced while running may be due to injury of both tendons, but the inability to push-off is primarily attributed to the FHL tendon. It is commonly thought that the master knot of Henry, the fibrous connection between the FHL and FDL, will prevent recoiling of one end of the tendon depending on the location of the rupture.[13] If the

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rupture occurs proximal to the knot, the portion of tendon distally will be held in place by the fibrous connection. An injury distal to the knot would prevent contraction of the proximal end. In this case both proximal and distal ends of the FHL tendon retracted. The tendon was found distally between the sesamoid bones and proximally an inch superior to the medial malleolus. The uncharacteristic retraction of both ends may be due to the rupture occurring at the master knot of Henry, simultaneously damaging both the FHL and FDL tendons. Alternatively, the fibrous connection may not have previously existed in this patient, or the master knot of Henry may not hold in an aggressive athlete.

The FHL tendon is often used for transplants. Existing literature questions whether FHL function is necessary for stabilization at toe-off. Anatomically, a natural tenodesis between FHL and FDL was thought to occur in 12% to 29% of patients, allowing the FDL to residually compensate for decreased range of motion at the interphalangeal joint of the hallux.[14] This would allow patients to maintain normal function and avoid the need for a surgical tenodesis. LaRue and Anctil[13] examined this anatomical relationship in 24 cadaver legs, and concluded that this cross-connection may occur less frequently than reported. These authors also question the pertinence of preserving FDL tendon function, theorizing that the intrinsic musculature may provide enough support to the lesser toes. A pedobarographic study of 17 patients with weakness of FHL function did not find significant morbidity due to changes in pressure during forefoot loading. Though literature has not shown FHL function to be absolutely necessary, none of these studies have assessed FHL and FDL function within the population of high-level athletes.

Although there was one report of conservative treatment for rupture of the FHL tendon,[15] most reported cases of complete rupture are primarily repaired. Three patients with complete ruptures underwent repair, allowing them to return to high-level athletic activity.[1,16,17] However, in this case the tendon ends were not opposable and thus were unsuitable for primary repair. The prognosis for regaining functional capacity of the interphalangeal joint of the hallux with this procedure was poor. Another alternative was suturing of the FHL to the FDL. In a study by Wei et al,[6] a patient sustaining a chronic rupture with unopposable ends recovered 50% flexion strength within 1 year of this surgery. In our present case study, this procedure was not considered due to the accompanying torn FDL tendon and the extreme contraction of FHL tendon ends. Another successful procedure used a graft from the tensor fascia lata muscle.[17] However, the author had attempted two tendon transfers for athletes in the past, and neither functioned as aggressively after that procedure.

Since complete ruptures are uncommon and indications for surgery remain unclear, the goal is commonly pain reduction. Scaduto and Cracchiolo[18] reviewed 31 documented cases of FHL tendon laceration or rupture and found that normal active flexion of the interphalangeal joint of the hallux was restored 61% of the time. They concluded that repair is effective if pain relief without active flexion is the goal. However, many patients presenting with an FHL tendon rupture are runners who, similar to this patient, complained that the combination of pain and their inability to push-off during gait was causing severe athletic disability. The lack of FHL function impacted their daily living, and this population may benefit from full range of motion at the interphalangeal joint of the hallux.

Case Report

A 41-year-old female marathon runner presented with pain at her left hip and gluteal region along with an inability to push-off with her left great toe while walking. She had been struck by a motor vehicle while training and underwent multiple reconstructive surgeries not related to the foot or the ankle. One year after recovery from the incident, she resumed running. But due to the pain and inability to stabilize for toe-off, her running distance decreased from 100 to 50 miles per week. She found that the symptoms were adversely affecting her life. The patient reported a stress fracture of the right calcaneus in May 1998 and removal of a skin cancer lesion on the right ankle. She did not smoke and denied other underlying medical problems. She did not report any history of spine or joint pain. The patient was referred in March 2001 by her sports medicine specialist after exhausting conservative treatment by numerous physicians over a 2-year period in which the tendon injury had gone undiagnosed. The treatments included casting, orthoses, and anti-inflammatory therapy.

At physical examination, mild swelling and tenderness at the first metatarsophalangeal joint and ankle of the left foot were revealed. There was no active flexion at the interphalangeal joint of the hallux, but active extension was normal. Passive flexion and extension did not elicit pain. Both active and passive flexion at the left first metatarsophalangeal joint were ellicitable, but flexion was greatly

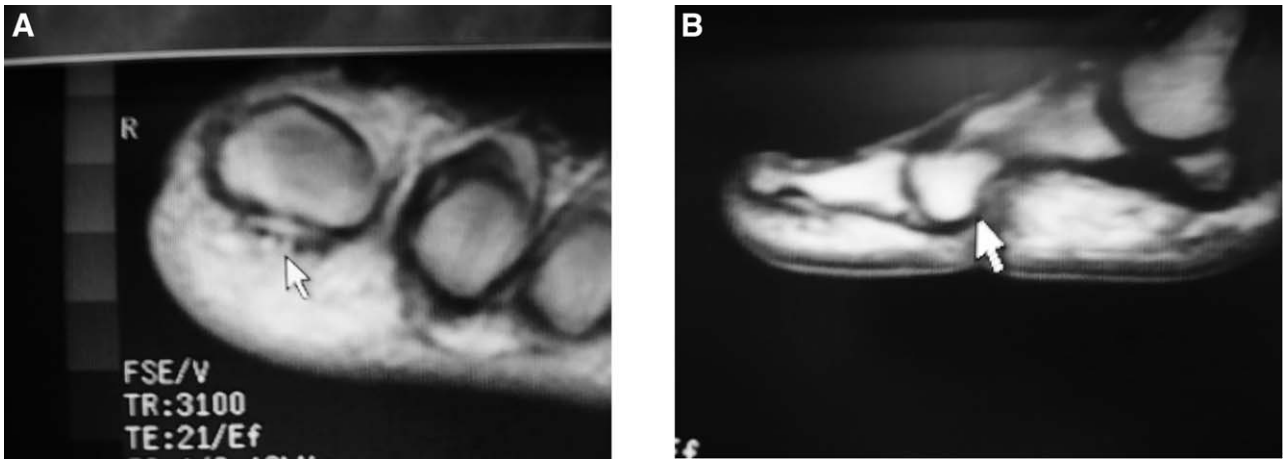

Figure 1. FHL tendon was not seen between the ankle and sesamoid bones in the frontal plane section (A) or the sagittal plane section (B) of the MRI of the patient's left foot.

diminished. The patient's neurological exam was found normal. Injury to a tendon is often associated with increased accumulation of blood and fluid in the affected region. A magnetic resonance image (MRI) obtained from the patient after the previous physical examination demonstrated high-intensity fluid collections surrounding the FHL tendon at the master knot of Henry. In the T-2 phase, there were visible ends of the tendon, which appeared to be retracted and no FHL tendon could be seen between the ankle and sesamoid bones from both frontal plane section and sagittal plane sections of the MRI (Figs. 1A and 1B). However, because of the course of the FHL tendon in the lower extremity, there is no single sagittal view of the MRI that would demonstrate the proximal and distal ends of the ruptured tendon at the same time. Therefore the conclusion that the FHL tendon was ruptured was based mostly on the patient's clinical presentation.

Elective surgery was performed with the goal of allowing the patient to return to high-level athletics. An approximately 4.0-cm curvilinear incision posterior to the medial malleolus was made with two Army-Navy retractors; each retractor is 1.0 cm in diameter. The wound was extended proximally and measured 7 cm, and the FHL tendon was found proximally at the muscle belly (Fig. 2). It was deeply adhered to a mass of scar tissue that was identified cephalic to the posterior ankle. The muscle was extremely atrophied, and the retracted tendon end was decreased in size. A 3.5-cm longitudinal tear of the FDL tendon at the medial malleolus was noted at this time. This tear was primarily repaired. A second incision, 3.0 cm in length, was made on the plantar surface at the interphalangeal joint of the hallux (Fig. 3). This tendon end was also decreased in size. The replaced section of the tendon measured about 20 cm. Urethral dilators were used to dilate the FHL tendon sheath (Fig. 4). The flexor tendon sheaths on the plantar aspect of the foot normally stop at the master knot of Henry and reform again more anteriorly at the level of the distal metatarsal shafts. Therefore, the dilators would have to pass through part of the anatomy without the guidance of a tendon sheath, but clearly, this was not a problem for the patient or the outcome. An allograft of a cadaveric posterior tibial tendon, which had been harvested and cut down to appropriate size, was applied through the dilated tendon sheath. Both proximal and distal necrotic tendon ends were resected. The allograft was sutured to the FHL tendon ends and aponeu-

Figure 2. FHL tendon was found proximally at the muscle belly through a 7.0-cm curvilinear incision posterior to the medial malleolus.

Figure 3. A second incision of 3.0 cm was made on the plantar surface of the interphalangeal joint of the left hallux.

Figure 5. Allograft was sutured to the FHL tendon ends and aponeurosis with a Bunnell and lateral trap suture technique.

rosis with a Bunnell and lateral trap suture technique (Fig. 5). Both the FHL and FDL functioned upon stimulation of the tendon. Furthermore, some degree of flexion of FHL tendon was restored because of the interconnections of FHL and FDL tendons distally after tenoplasty was made.[19]

Postoperatively the patient was immobilized in a below-the-knee cast for 4 weeks after which the patient was placed in a CAM walker (United Surgical Partners International, Addison, Texas). At this time, the patient demonstrated active flexion at the interphalangeal joint of the left hallux (Fig. 6). The patient began active toe exercises, stretching, and physical therapy. Four months after surgery, the patient's physical therapist reported that the patient regained a full range of motion, and a dynamometric exam performed by the same physical therapist revealed that the patient regained 68% of her strength of the contralateral side. The patient was able to resume competitive running after the surgery and performed well in her age bracket.

Figure 4. Urethral dilators were used to dilate the FHL tendon sheath.

Discussion

Ten cases of complete rupture of the FHL tendon have been reported to date. Six of these cases occurred in high-level athletes, five in runners and one in a competitive soccer player.[1,2,3,16,17,20] All injuries were isolated ruptures. There has been only one report of three cases of FHL tendon injury at the master knot of Henry.[21]

Many authors, such as Ilan Elias,[15] and David Richardson,[22] preferred a single-incision technique over a double-incision technique because it is less

Figure 6. The patient demonstrates active flexion at the interphalangeal joint of the left hallux postoperatively.

invasive, has less risk of potential wound complications, and no risk of damaging the medial plantar nerve at the master knot of Henry. Wilcox et al and Wapner et al (cited by Elias[15]) both used the double-incision technique. However, Wilcox et al reported a loss of range of motion of 2 degrees and 7% of plantarflexion strength; Wapner et al reported a 29.5% decrease in strength at 30 degree/sec, 41.8% decrease in torque, 51% work generated by plantarflexion of the ankle compared to the non-operated side.[15] In this particular case study, we used the double-incision technique with a successful outcome.

Although MRI was a helpful modality for diagnosing a ruptured tendon, chronicity of the tendon resulting in lack of inflammatory fluid collection at the area could make the MRI interpretation challenging. Also, topography of the FHL tendon (found deep and next to the medial neurovascular bundle) may contribute to a challenging interpretation of the pathology.[23]

Transplanting with allograft has been previously explored especially to repair chronically ruptured Achilles tendon. According to Maffulli et al,[24] Matus-Jiménez,[25] Lepow,[26] and Kocabey,[27] the tendon allografts used were Achilles and peroneus brevis tendons to repair chronic Achilles tendon ruptures. Lewis[28] reported a case of using two Achilles tendon allografts to repair chronic patellar rupture. Parodi[29] also reported a use of gracilis tendon allograft to fix soft-tissue tendon loss after reconstruction of Achilles tendon rupture. Kim[30] reported using posterior tibialis tendon allograft for chronic posterolateral instability of the knee. Zielaskowski[31] added an interesting case report of using fascia lata allograft to repair extensor hallucis longus tendon rupture. However, there has not been a report of using a cadaveric allograft to repair a rupture of FHL tendon with laceration of FDL tendon at the master knot of Henry. This is the first case report for the repair of FHL tendon rupture and FDL tendon tear at the master knot of Henry using posterior tibial tendon allograft. Allograft allowed the surgeon to repair the problem without sacrificing other structures of the lower extremity, which is beneficial for active athletes. With this procedure, the traditional goals of FHL rupture treatment, pain reduction, and reestablishing the normal range of motion at the interphalangeal joint were met. This self-motivated patient was able to return to marathon running, performing more competitively after the procedure than at any point even prior to her injury. The exceptional result may prompt further studies using FHL tendon transplants.

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