

# Endoscopic-Assisted Flexor Hallucis Longus Transfer: Harvest of the Tendon at Zone 2 or Zone 3



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**Abstract:** Flexor hallucis longus (FHL) tendon transfer is indicated for reconstruction of the Achilles tendon with a gap larger than 5 cm. The tendon can be harvested at zone 2 or zone 3 by minimally invasive techniques with the advantage of minimal soft-tissue dissection. The tendon can be harvested under the sustentaculum tali by zone 2 FHL tendoscopy. It is adequate for FHL transfer to the posterior calcaneal tubercle. If a double-thickness reconstruction of a huge gap of the Achilles tendon is indicated, the tendon can be harvested at the level of the hallux by means of a tendon stripper. However, the interconnection tendon of the master knot of Henry can be split together with the FHL or flexor digitorum longus tendon instead of being cut. Zone 2 FHL tendoscopy can be used to release the split tendon to complete the FHL harvest.

A gap at the Achilles tendon can be the result of chronic rupture of the tendon or can occur after excision of a diseased tendon segment for severe calcified tendinosis or infection of the tendon.<sup>1,2</sup> Flexor hallucis longus (FHL) transfer is indicated if there is a significant gap of more than 5 cm or loss of contractility of the triceps surae. It is also relatively indicated in patients with significant heel cord pain associated with severe tendinosis of the tendon. FHL transfer can yield relief of the workload of the Achilles tendon during propulsion and bring in vascularity to aid healing of the tendon.<sup>3</sup> The FHL tendon is a deep structure except at the level of the hallux. Its course can be divided into 3 zones: The zone 1 FHL tendon is posterior to the ankle. The zone 2 FHL tendon is from the fibro-osseous orifice of the posterior talar tubercles, under the sustentaculum tali, to the master knot of Henry. The zone 3 FHL tendon is distal to the master knot of Henry to its phalangeal insertion.<sup>4-6</sup> Different lengths of the FHL tendon can be obtained depending on the zone in

which the tendon is harvested. The tendon can be harvested under the sustentaculum tali (zone 2) endoscopically.<sup>2,3,7</sup> It is adequate for FHL transfer to the posterior calcaneal tubercle. If a double-thickness reconstruction of a huge gap of the Achilles tendon is indicated, the tendon can be harvested at the level of the hallux (zone 3).<sup>1</sup> However, the interconnection tendon of the master knot of Henry can be split together with the FHL or flexor digitorum longus (FDL) tendon.<sup>1</sup> Zone 2 FHL tendoscopy is indicated to release the split tendon to complete the tendon harvest.<sup>1</sup> Our technique of zone 2 FHL tendoscopy for FHL tendon transfer is described.

## Technique

The patient is placed in the prone position, with a thigh tourniquet applied to provide a bloodless operative field. A 4.0-mm 30° arthroscope (Dyonics; Smith & Nephew, Andover, MA) is used for this procedure.

In the case of FHL tendon harvest under the sustentaculum tali (zone 2), zone 1 and zone 2 FHL tendoscopy is performed.<sup>2-13</sup> Zone 1 FHL tendoscopy is performed with posteromedial and posterolateral portals. The posterolateral portal is located on the lateral side of the Achilles tendon, just above the posterior calcaneal tubercle. The posteromedial portal is located at the intersection point between the medial border of the Achilles tendon and the line joining the undersurface of the sustentaculum tali and first metatarsal. The FHL tendon is identified at the posterior ankle, and the tendon is traced distally to the fibro-osseous orifice at the posterior talar tubercle. A Wissinger rod is

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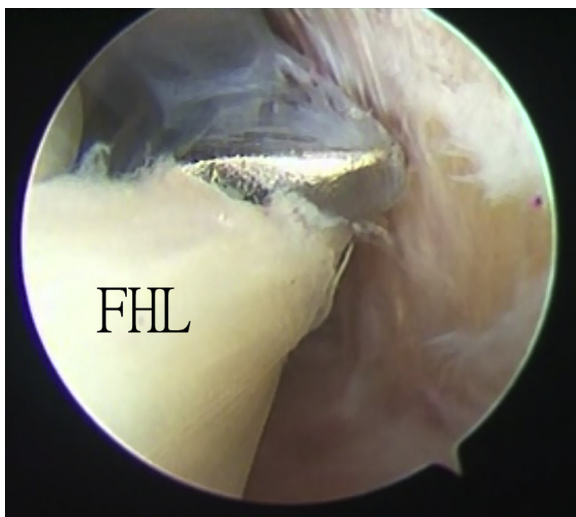
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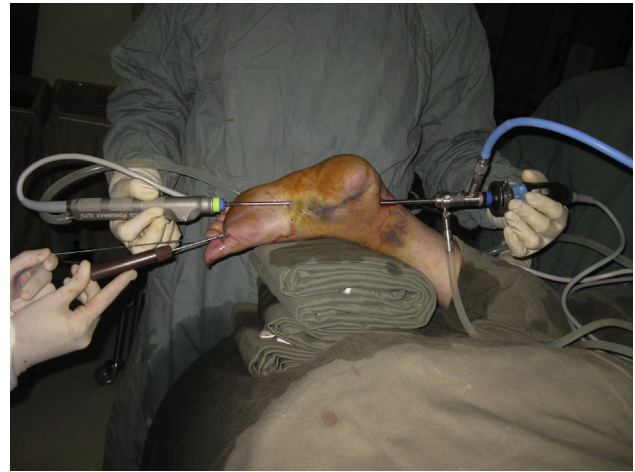
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inserted through the posteromedial portal into the zone 2 tendon sheath under the sustentaculum tali. The rod passes through the tendon sheath and pierces through the plantar aponeurosis. The plantar portal incision is made at this point. The arthroscope cannula is inserted into the posteromedial portal along the rod. The rod is removed, and the arthroscope is inserted into the cannula. Arthroscopic scissors (Acufex; Smith & Nephew) are inserted into the zone 2 tendon sheath through the plantar portal under arthroscopic guidance. The FHL tendon is identified as it moves together with the passive motion of the hallux. The tendon is cut with the scissors (Fig 1). Because the tendon is thick, several bites are needed to complete the cut. The distal tendon segment will be retracted distally by dorsiflexion of the hallux.

In the case of whole-length FHL transfer, the tendon is cut at its phalangeal insertion through a small plantar incision. A stay stitch is applied, and the tendon is stripped proximally to cut the interconnection tendon at the master knot of Henry. When the stripper hits the interconnection tendon, the second and third toes will undergo plantar flexion because of the interconnection of the FHL and FDL tendons at the master knot of Henry. The assistant can perform dorsiflexion of the lesser toe to facilitate the cut of the interconnection tendon. Sometimes, the FHL or FDL tendon is split together with the interconnection tendon instead of a release of the master knot of Henry. Zone 2 FHL tendoscopy is performed with the tendon stripper in situ (Fig 2). The tendon stripper serves as a marker of the FHL tendon. The split tendon is cut by an arthroscopic



**Fig 1.** Endoscopic harvest of zone 2 flexor hallucis longus (FHL) tendon in right foot. The patient is in the prone position. Zone 2 FHL tendoscopy is performed. The arthroscopic scissors are inserted into the zone 2 FHL tendon sheath through the plantar portal. The FHL tendon is cut just proximal to the master knot of Henry.



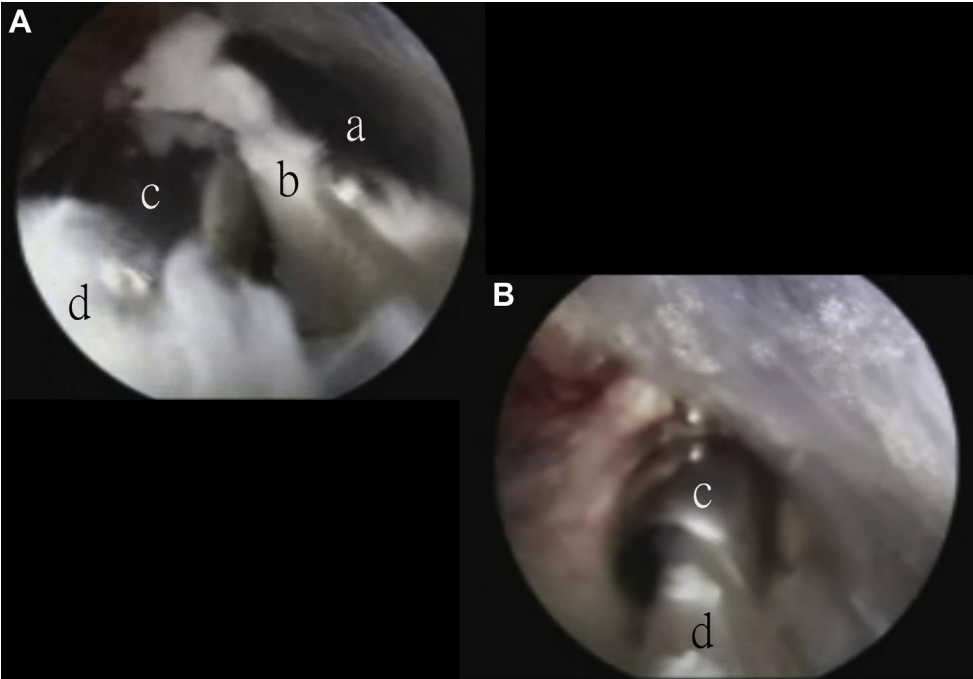
**Fig 2.** Harvest of whole-length flexor hallucis longus (FHL) tendon in right foot. The patient is in the prone position. The FHL tendon is stripped by a tendon stripper through a plantar wound of the hallux. The interconnection tendon of the master knot of Henry is cut by the stripper. If the interconnection tendon is split together with either the FHL or the flexor digitorum longus tendon, zone 2 FHL tendoscopy is performed with the tendon stripper in situ. The split tendon is cut to complete the FHL harvest.

shaver (Smith & Nephew) to complete the FHL release. The FHL tendon is protected by the stripper head during the release of the split tendon (Fig 3). The proximal tendon segment can be retrieved through the posteromedial portal through zone 1 FHL tendoscopy for subsequent tendon transfer (Video 1, Fig 4).

## Discussion

A gap at the Achilles tendon can be treated with direct repair; tendon advancement; local tendon transfer; or implantation of autograft, allograft, or synthetic material.<sup>14,15</sup> The treatment of choice depends on the size of the gap after debridement of the tendon ends and the contractility of the triceps surae. For a gap larger than 5 cm, local tendon transfer is the preferred treatment.<sup>15</sup> The FDL,<sup>16</sup> FHL,<sup>17-19</sup> and peroneus brevis<sup>20-22</sup> have been used for Achilles tendon reconstruction. FHL transfer is preferable because the FHL is a durable tendon with stronger muscle and has the same line of pull as and fires in phase with the triceps surae.<sup>15,19,23</sup> Traditionally, a long medial longitudinal incision with extensive dissection has to be performed to harvest the FHL tendon and to transfer it to the posterior calcaneal tubercle. With advancements in flexor hallucis tendoscopy, the FHL tendon can be harvested at a level just proximal to the master knot of Henry without extensive soft-tissue dissection.<sup>2,4-7</sup> The whole length of the FHL tendon can be harvested by stripping the master knot of Henry.<sup>1</sup> Zone 2 FHL tendoscopy also has a role if the interconnection tendon is split together with the FHL or

**Fig 3.** Harvest of whole-length flexor hallucis longus (FHL) tendon in right foot. The patient is in the prone position. The interconnection tendon is split together with the FHL tendon in this case. Zone 2 FHL tendoscopy is performed with the stripper in situ. (A) Arthroscopic view showing that the arthroscopic shaver (a) cuts the split tendon (b) and the stripper head (c) protects the FHL tendon (d). (B) Arthroscopic view after the split tendon is cut. The FHL tendon is free from any connection.



FDL tendon. Although this technique is attractive because of its advantages as a minimally invasive procedure, it is technically demanding. The surgeon should also be aware of the potential complication of injury to the medial and lateral plantar nerves. During zone 2 FHL tendoscopy, the arthroscope is inserted into the zone 2 FHL tendon sheath through the posteromedial portal. The arthroscope is then fixed in position between the orifice of the tendon sheath and the posteromedial portal. If the ankle is in a position of dorsiflexion, the tibial nerve at the tarsal tunnel will

tense up and compress onto the shaft of the arthroscope. The nerve fibers of the lateral plantar nerve are on the lateral side of the tibial nerve at this level and are first affected by compression injury.<sup>24</sup> Therefore ankle dorsiflexion should be avoided during zone 2 FHL tendoscopy (Table 1). The medial plantar nerve is close to the zone 2 FHL tendon and the master knot of Henry. It can be injured during insertion of the Wissinger rod for establishment of the plantar portal in zone 2 FHL tendoscopy and stripping of the master knot of Henry during harvesting of the whole-length FHL tendon. The passage of the rod should be gentle, and no resistance should be encountered before the plantar aponeurosis is reached. Moreover, no debridement should be



**Fig 4.** The whole length of the flexor hallucis longus tendon is harvested and retrieved through the posteromedial portal for subsequent tendon transfer.

**Table 1.** Pearls for Endoscopic Harvest of FHL Tendon at Zone 2 or Zone 3

During zone 2 FHL tendoscopy, the ankle should not be in a position of dorsiflexion to minimize injury to the lateral plantar nerve at the tarsal tunnel.
The insertion of the Wissinger rod during establishment of the plantar portal can damage the medial plantar nerve at the sole. Insertion of the rod should be gentle, and no resistance should be encountered until the plantar aponeurosis is reached.
The medial plantar nerve can be injured during harvesting of the whole-length FHL tendon.
Several bites are needed to complete the cut of the FHL tendon at zone 2 with the arthroscopic scissors.
The tendon stripper serves as the marker and protector of the FHL tendon during endoscopic release of the split interconnection tendon.

FHL, flexor hallucis longus.



performed at the fascial layer deep to the flexor digitorum brevis muscle because the medial plantar nerve is not protected by a tough fibrous tendon sheath in this zone.<sup>5,6</sup>

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