



# Arthroscopic Flexor Halluces Longus Transfer and Percutaneous Achilles Tendon Repair for Distal Traumatic Ruptures

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**Abstract:** The Achilles tendon is the largest and strongest tendon in the human body. It is the tendon that most often suffers injury and accounts for 20% of all tendon ruptures. These types of ruptures often occur 2 to 6 cm proximal to the stumps in an area of reduced vascularity. One such injury, the distal acute Achilles tendon rupture, is quite uncommon. For distal repairs, there have been studies that used a pullout technique, a button technique, and the use of local tendons for open-fashion augmentation. Although percutaneous repair and endoscopic flexor hallucis longus (FHL) tendon transfer techniques have been described for both acute midportion and chronic Achilles tendon rupture repair, there are no studies that describe the use of percutaneous sutures and biological augmentation with FHL transfer as a treatment option for acute distal injuries. The purpose of this Technical Note is to describe a novel approach to repair. It combines arthroscopic FHL tendon transfer with a percutaneous Achilles tendon repair technique for traumatic distal ruptures.

The Achilles tendon is the largest and strongest tendon in the human body. Interestingly, it is the tendon that most often suffers injury and accounts for 20% of all tendon ruptures.<sup>1</sup> The estimated incidence ranges from 11 to 37 per 100,000 people.<sup>2,3</sup> These types of ruptures often occur 2 to 6 cm proximal to the stumps in an area of reduced vascularity.<sup>4</sup> One such injury, the distal acute Achilles tendon rupture (DATR), is quite uncommon.<sup>5</sup> Although percutaneous Achilles tendon repair has been described for midportion Achilles tendon ruptures,<sup>6</sup> those rare cases of DATR are more difficult to repair, as the distal stump is nonexistent or too short to hold any sutures.

For DATR repairs, there have been studies that used a pullout technique, a button technique, and the use of local tendons for open-fashion augmentation. More recently, suture anchors have been used to attach the tendon to the bone.<sup>7-9</sup>

Other authors also have applied augmentation techniques in association with acute and chronic Achilles tendon rupture repair techniques. They include flexor hallucis longus (FHL) tendon transfer.<sup>10</sup> Endoscopic FHL tendon transfer is a reliable technique for chronic ruptures with defects greater than 2 cm.<sup>11,12</sup>

Although percutaneous repair and endoscopic FHL tendon transfer techniques have been described for both acute midportion and chronic Achilles tendon rupture repair, there are no studies that describe the use of percutaneous sutures and biological augmentation with FHL tendon transfer as a treatment option for acute distal injuries.

The purpose of this Technical Note is to describe a novel approach to repair. It combines arthroscopic FHL tendon transfer with a percutaneous Achilles tendon repair technique for traumatic distal ruptures.

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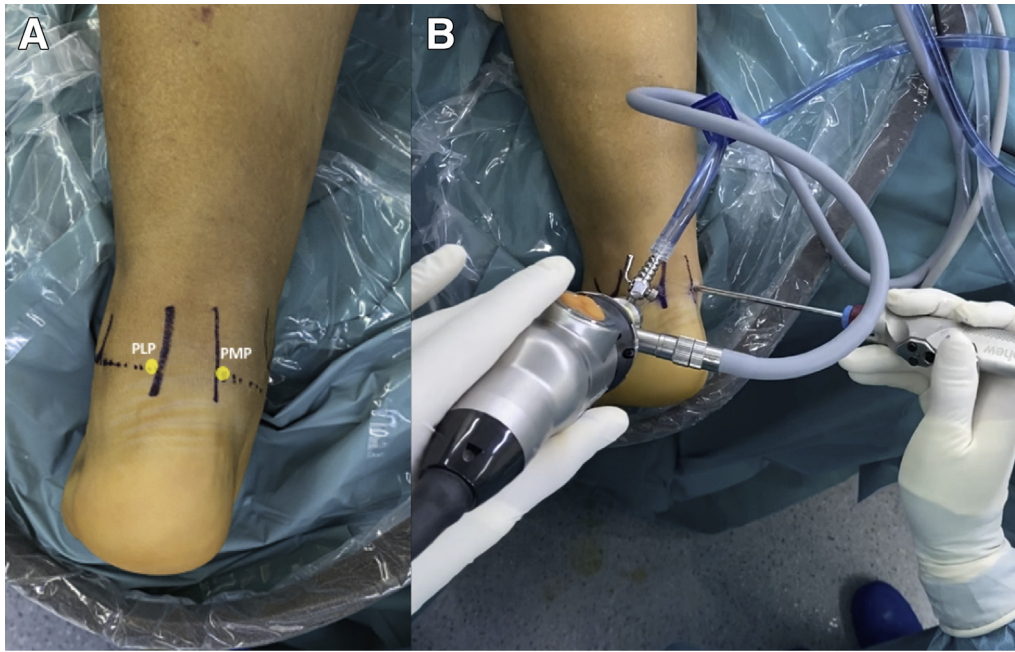
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**Fig 1.** The patient's left foot is positioned prone with the ankle draped and hanging freely over the edge of the table. Posterior view. (A) Posterolateral and posteromedial endoscopic portals. (B) The posterolateral portal is the viewing portal and posteromedial the working portal. A 4.0-mm 30° arthroscopic camera is used for this procedure.

## Surgical Technique (With Video Illustration)

### Arthroscopic FHL Transfer and Percutaneous Achilles Tendon Repair for Traumatic Distal Ruptures

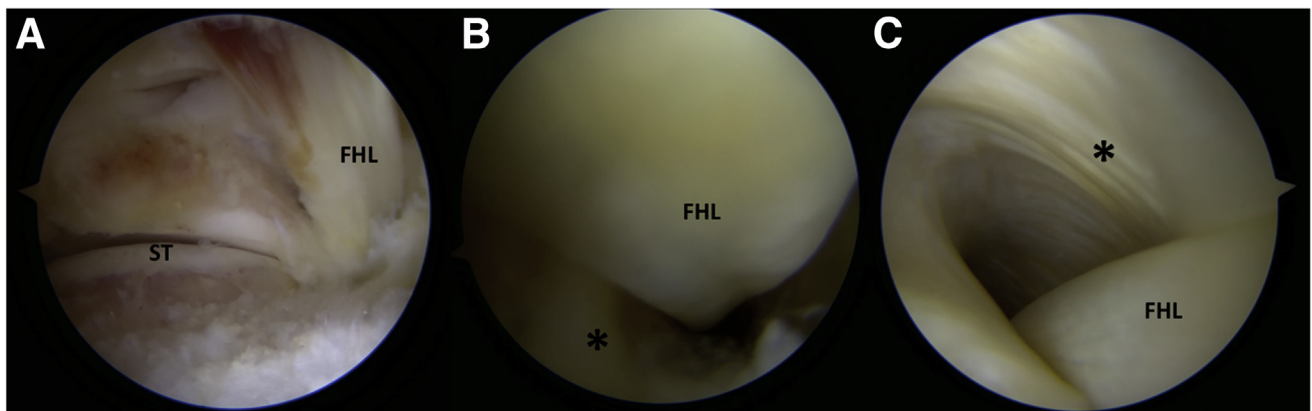
The procedure is performed with the patient under spinal anesthesia with a thigh tourniquet applied. The patient is positioned prone with the ankle draped and hanging freely over the edge of the table. If necessary, a pillow can be placed under the contralateral hip to minimize external rotation of the ankle.

First, the landmarks are drawn. They are the lateral malleolus, medial malleolus, and medial and lateral border of the Achilles tendon. Conventional posterolateral and posteromedial endoscopic portals, as

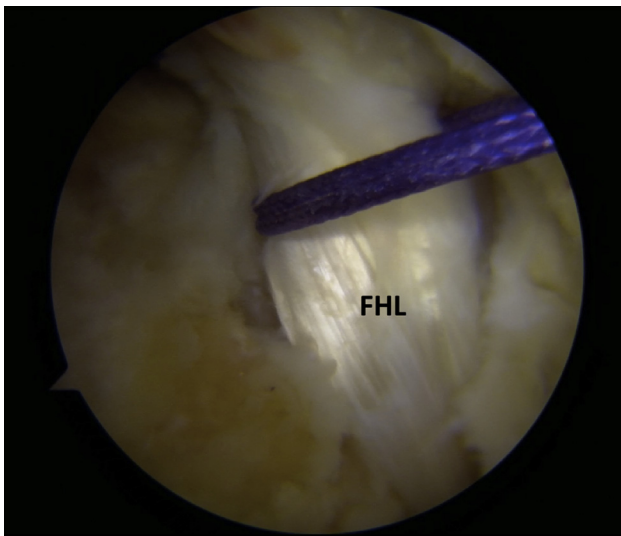
originally described by van Dijk et al.,<sup>13</sup> are used. The posterolateral portal is used as the viewing portal and posteromedial the working portal (Fig 1).

A 4.0-mm 30° arthroscopic camera (Smith & Nephew Andover, MA) is used for this procedure. The Rouviere and Canela fascia is opened and posterior soft tissues are removed using a 4.0-mm shaver until the subtalar joint can be visualized. The FHL is localized medially. Passive plantar flexion of the hallux is performed to identify the FHL. The entrance of the FHL into its fibro-osseous tunnel also must be identified (Fig 2).

At this point, a braid suture (VICRYL; ETHICON, Somerville, NJ, a subsidiary of Johnson & Johnson.) is passed around the FHL to traction it if it is necessary (Fig 3).



**Fig 2.** (A) Left foot, arthroscopic view through the posterolateral portal. The Rouviere and Canela fascia is opened and posterior soft tissues are removed until the subtalar joint (ST) can be visualized. The flexor hallucis longus (FHL) is localized medially. (B–C) Entrance of the FHL into its fibro-osseous tunnel. Asterisks in panels B and C shown the entrance of the fibro-osseous tunnel.



**Fig 3.** Arthroscopic view through the posterolateral portal. A braid suture (VICRYL) is passed around the FHL to apply traction if necessary. (FHL, flexor hallucis longus.)

The sectioning of the FHL must be carefully performed to avoid the neurovascular bundle medial to the tendon. It can be done in FHL zone 1 or 2. For zone 2 (Fig 4), a needle is introduced percutaneously in FHL zone 2 under direct arthroscopic visualization. It is necessary to traction the FHL with the braid suture and place the ankle and hallux in plantar flexion to make for harvesting the maximal length from the FHL tendon. Then, the FHL is cut with a percutaneous knife. A retrograde knife can be used if incomplete sectioning of the tendon is performed with a percutaneous knife. Other authors prefer to perform FHL sectioning with a #11 knife or arthroscopic scissors in zone 1 at the

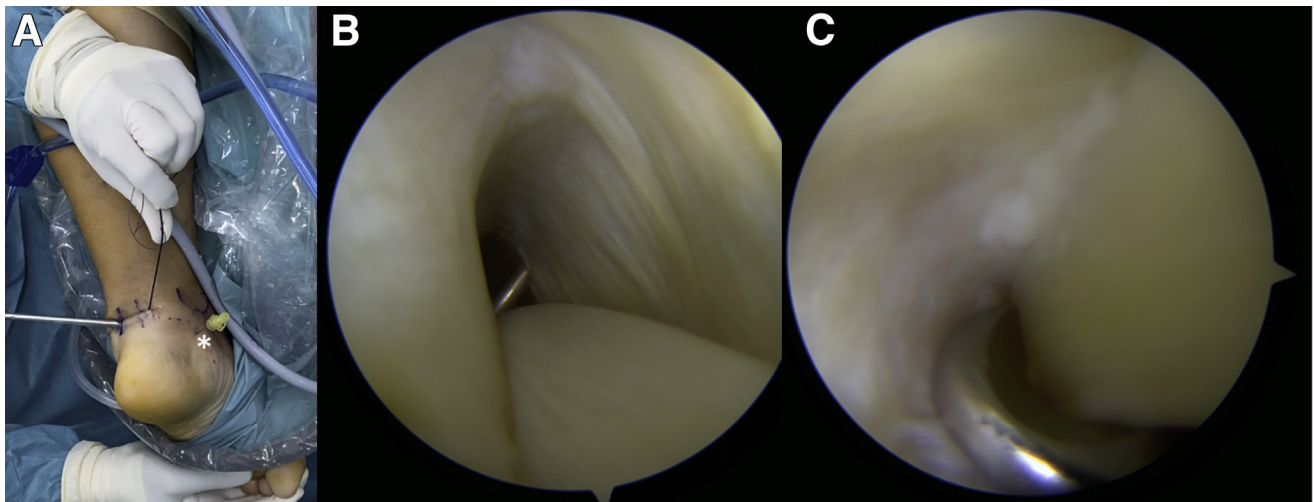
entrance of its fibro-osseous tunnel. The optimal minimal length of the FHL harvest is 15 mm. The FHL harvest is recovered through the posteromedial portal and a high resistance suture loop is put in place.

To create the calcaneal bone tunnel (Fig 5), a K-wire with eyelets is introduced through the posteromedial portal from dorsal-medial to plantar-lateral. The optimal zone of insertion is the posterior-superior site of the os calcis. After confirming the optimal point of entry of the K-wire, the calcaneal bone is drilled. The drill diameter depends on the size of the FHL harvest. The tunnel length should be 10 to 15 mm more than the optimal length of the harvest. A 25- to 30-mm long tunnel is usually enough.

Afterwards, the sutures of the FHL harvest are passed through the eyelet of the K-wire. The K-wire is progressed from proximal to distal and is carefully pulled through and retrieved in the plantar zone. In this way, the FHL distal stump is introduced into the calcaneal tunnel. When the harvest is in the calcaneal tunnel, it is fixed with an interference screw with the ankle in moderate plantar flexion (Fig 6).

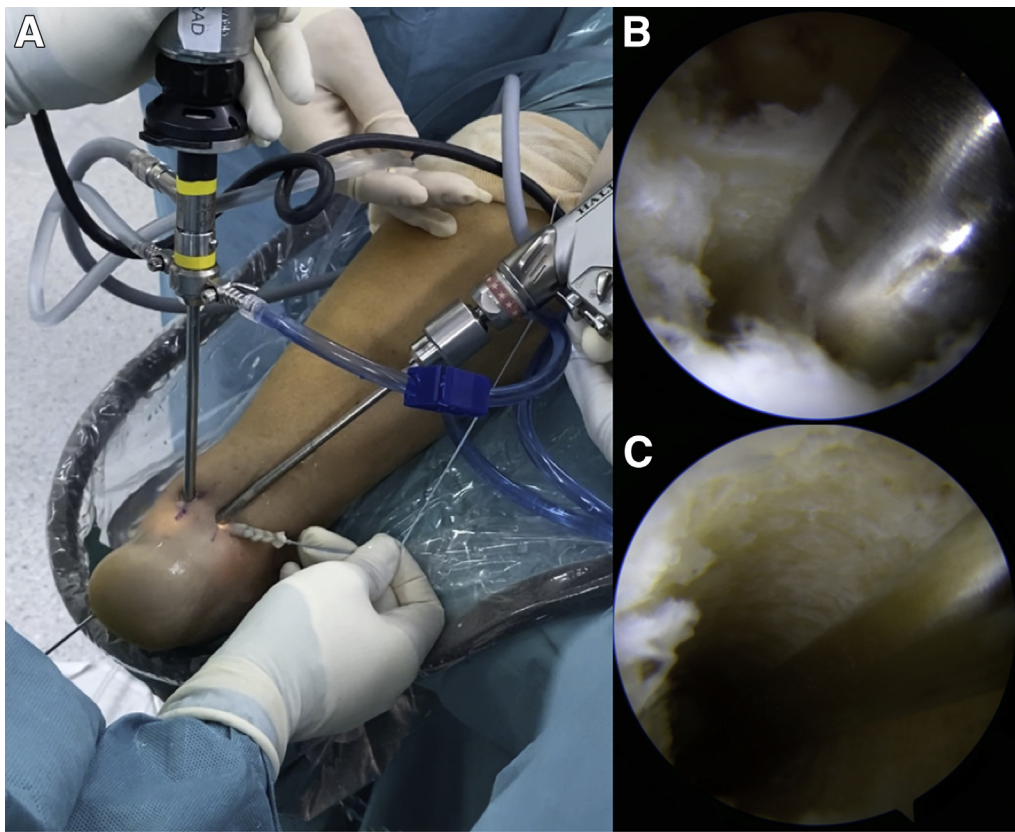
The second surgical step is percutaneous Achilles tendon suturing. The rupture zone is identified and the tendon is then repaired with the modified Bunnel configuration using VICRYL (polyglactin) No. 1 (ETHICON) (Fig 7).

At each needle entrance site, a small longitudinal incision is made with a #11 blade so that the needle can pass without entrapping subcutaneous tissue. With a straight needle, the suture is first passed from medial to lateral, distally. Afterwards, the suture is crossed over to the proximal medial skin hole to finally exit through the lateral hole at the height of the rupture. The procedure is repeated with the other end of the suture. This



**Fig 4.** (A) Left foot, posterior view. Sectioning of the FHL. It can be done in zone 1 or 2. For zone 2, a needle is introduced percutaneously in FHL zone 2 under direct arthroscopic visualization. (B) Arthroscopic view. The FHL is cut with a percutaneous knife. (C) A retrograde knife can be used if incomplete sectioning of the tendon is performed. (FHL, flexor hallucis longus.)





**Fig 5.** (A) Left foot, posterior view. The FHL harvest tendon is recovered through the posteromedial portal and a high-resistance suture loop is put in place. (B–C) Left foot, posterior arthroscopic view. Calcaneal bone tunnel drilling. A K-wire is introduced through the posteromedial portal from dorsal-medial to plantar-lateral. A 25- to 30-mm long tunnel is usually enough. (FHL, flexor hallucis longus.)

sequence is performed with the proximal as well as the distal suture. Finally, the ends of the sutures are retrieved and tied medially and laterally at the height of the rupture while maintaining the ankle in 20° of plantar flexion. A clamp is used to ensure that subcutaneous tissue is not entrapped by the suture. The small incisions are closed with a Steri-Strip and a below-knee splint is put in place at 15 to 20° of plantar flexion.

Two weeks postoperatively, the splint is removed, and the ankle is fitted with a Walker-type ankle foot orthosis (DonJoy, Surrey, UK) with 10° of plantar flexion. Once the portals are healed, the sutures are removed. At 2 weeks, the equinus is reduced and the ankle placed in a neutral position in a walker boot. Weight-bearing as tolerated with crutches is then initiated. At 4 weeks postoperatively, the walker boot is removed and free movement of the ankle encouraged. Crutches are usually continued until the patient is comfortable enough to mobilize unaided. Formal physiotherapy is initiated at 4 weeks with exercises that progressively increase the strength and range of motion of the ankle joint.<sup>13</sup> At this time bipodal heel rise test and hallux's dorsal and plantar flexion are seen without limitation (Fig 8).

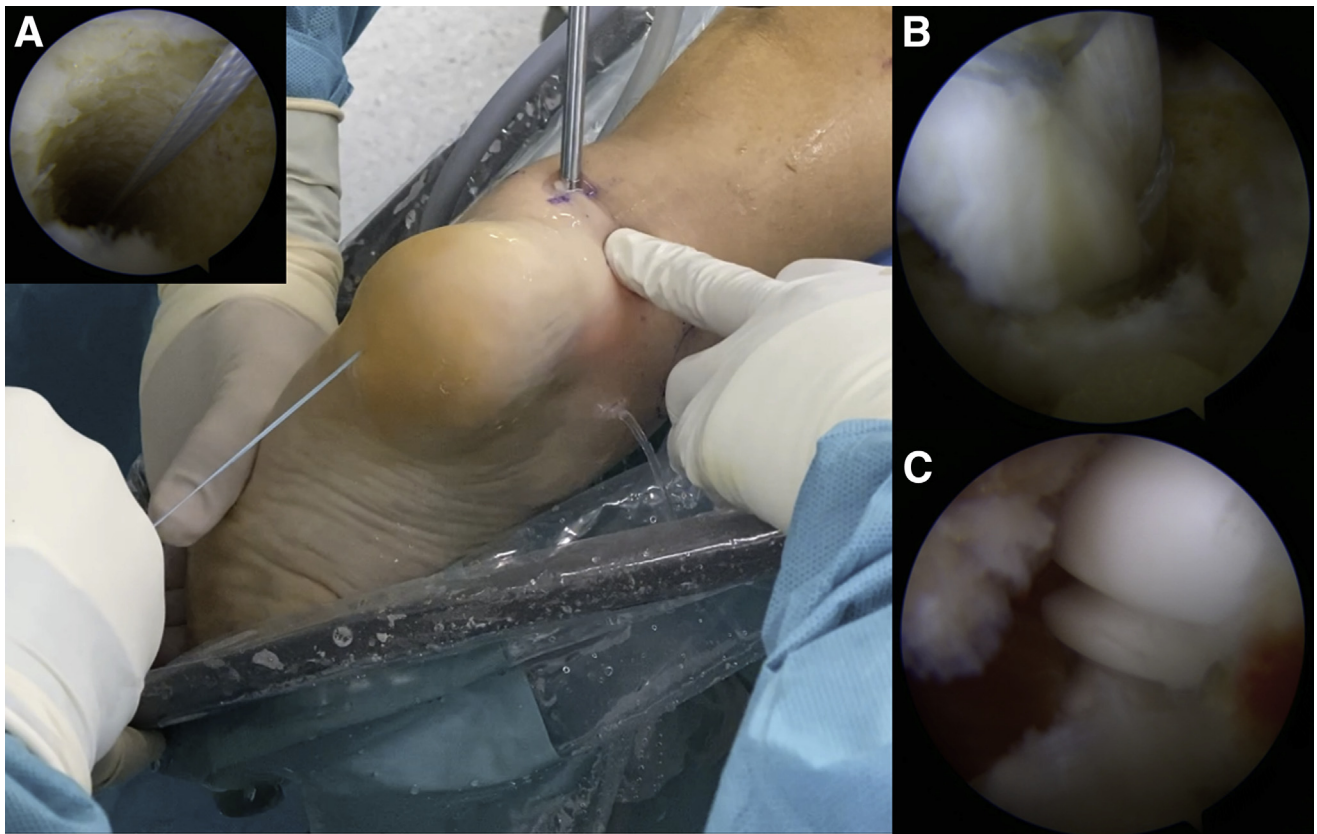
A step-by-step description of the surgical technique is summarized in Table 1.

Table 2 provides pearls and pitfalls in performing this procedure. Table 3 shows advantages and limitations. Video 1 shows the whole technique in detail.

## Discussion

Percutaneous Achilles tendon repairs have been described for early acute midportion ruptures, with the percutaneous end-to-end technique with Bunnell or Kessler type sutures being the preferred methods.<sup>14</sup> The main advantage of this technique is that it is minimally invasive. The paratendinous tissues is respected and tendon blood supply maintained, thereby supporting Achilles tendon healing.<sup>15</sup> However, distal Achilles tendon ruptures are technically more difficult to repair with this technique, since the distal stump is too short to hold any sutures or nonexistent.<sup>16</sup> Moreover, even in the presence of a short distal stump, excessive tension between the ends after the percutaneous suture technique heightens the risk of suture failure if the distance between ends of the tendon is greater than 2 cm.

Although endoscopic FHL tendon transfer has been described for chronic Achilles tendon ruptures,<sup>12,16</sup> this may very well be a reliable technique in combination with percutaneous repair in cases of acute distal ruptures in which there is an important gap between ends of the tendon. One of the main advantages of the FHL

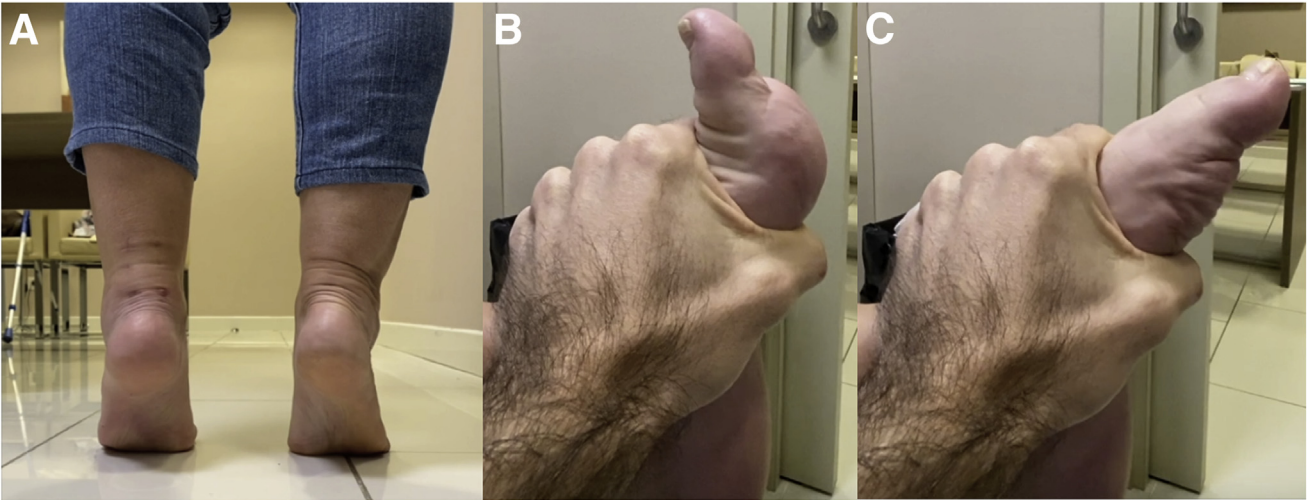


**Fig 6.** Left foot, posterior and plantar view. (A) Sutures of the FHL are passed through the eyelet of the K-wire and progressed to the sole of foot and then collected. (B) Sutures pulled through to the sole of foot, introducing the FHL harvest into the calcaneal tunnel. (C) Arthroscopic view of the FHL tendon fixed with an interference screw with the ankle in mild plantar flexion. (FHL, flexor hallucis longus.)



**Fig 7.** Left foot, posterior view. (A) Percutaneous Achilles tendon suture. Rupture zone is identified and the tendon is repaired with the modified Bunnell configuration using VICRYL (polyglactin) No. 1. (B) The ends of the sutures are collected and tied medially and laterally at the height of the rupture while keeping the ankle in 20° of plantar flexion.





**Fig 8.** (A) Bipodal heel rise test. (B–C) Hallux’s dorsal and plantar flexion without limitations.

transfer described here is that it makes for increased blood supply to the repaired Achilles tendon. Moreover, plantar flexion strength is reinforced with FHL transfer and maintains the normal muscle balance of the ankle. Finally, FHL transfer reduces the tension between the ends of the tendon, thereby minimizing the risk of suture failure during the healing phase.<sup>17</sup>

This is a technically demanding procedure that is limited to patients with a distal Achilles tendon rupture

with an important gap between the ends. In addition, it is not exempt of complications. Regarding complications, the sectioning of the FHL tendon is a critical aspect of the procedure that must be performed carefully. The risk of lateral and medial plantar nerve injury has been reported when the sectioning of the FHL is performed in zone 2.<sup>18</sup> To minimize that risk, localizing the cut zone in the fibro-osseous tunnel with a needle under direct visualization and the use a percutaneous

**Table 1.** Arthroscopic Flexor Hallucis Longus (FHL) Transfer and Percutaneous Achilles Tendon Repair for Traumatic Distal Ruptures

Step	Description
1	The patient is positioned prone with the ankle draped and hanging freely over the edge of the table.
2	Conventional posterolateral and posteromedial endoscopic portals as originally described by van Dijk are used. The posterolateral portal is the viewing portal and posteromedial the working portal. A 4.0-mm 30° arthroscopic camera is used for this procedure.
3	The Rouviere and Canela fascia is opened and posterior soft tissues are removed until the subtalar joint can be visualized. The FHL is localized medially using passive plantar flexion of the hallux to identify it.
4	A braid suture (VICRYL) is passed around the FHL to traction it if it is necessary.
5	It is important to pull on the suture that was passed around the tendon and perform ankle plantar flexion and hallux plantar flexion to allow maximal harvesting length of the FHL tendon.
6	FHL sectioning can be performed in FHL zone 2 or 1: <ul style="list-style-type: none"><li>• For zone 2, the FHL is sectioned percutaneously under direct arthroscopic visualization with a percutaneous retrograde knife.</li><li>• For zone 1, the FHL is sectioned at the entrance of its fibro-osseous tunnel with a #11 knife or arthroscopic scissors.</li></ul>
7	The FHL harvest is recovered through the posteromedial portal and a high resistance suture loop is put in place.
8	The calcaneal bone tunnel entrance is created through the posteromedial portal, from dorsal-medial to plantar-lateral with a K-wire with eyelets. The posterior-superior site of the os calcis is the optimal zone of insertion. Then, the calcaneal bone is drilled. The tunnel should be 10-15 mm longer than optimal length of the harvest. A 25-to 30-mm long tunnel should be enough.
9	The sutures of the FHL harvest are passed through the eyelet of the K-wire and K-wire is progressed to the sole of foot and then collected.
10	The sutures are carefully pulled through to the sole of foot, which makes for the introduction of the FHL harvest into the calcaneal tunnel. It is fixed with an interference screw with the ankle in mild plantar flexion.
11	The percutaneous Achilles tendon suture rupture zone is identified and marked.
12	At the site of each needle perforation, a small longitudinal incision is made with a #11 blade so that the needle can pass without entrapping subcutaneous tissue.
13	The tendon is then repaired with the modified Bunnel configuration by suturing with VICRYL (polyglactin) No. 1 (ETHICON, Inc).
14	The ends of the sutures are collected and tied medially and laterally at the height of the rupture while keeping the ankle in 20° of plantar flexion.
15	A clamp is used to make sure that subcutaneous tissue was not entrapped with the suture.

**Table 2.** Pearls, Pitfalls, and Risks**Pearls**

- Place a support/pillow under the contralateral hip to minimize external rotation of the ankle.
- Perform passive plantar flexion of the hallux to identify the FHL during the arthroscopic procedure.
- Pass a braid suture around the FHL to traction it if it is necessary.
- Before sectioning the FHL harvest, traction the FHL with the suture that was passed through the K-wire eyelet, perform ankle plantar flexion and hallux plantar flexion to allow for harvesting the maximal length from the FHL tendon.
- Make tunnel 10-15 mm longer than the optimal length of the harvest (usually, a tunnel length of 25-30 mm).
- Carefully pull the sutures through to the sole of the foot to avoid traumatic FHL tendon deterioration.
- Fix the FHL with the ankle in mild plantar flexion.
- Make a small longitudinal incision with a #11 blade so that the needle can pass without entrapping subcutaneous tissue.
- Avoid being too ambitious with sutures tension to avoid suture rupture. The objective is to bring the ends of the suture closer.
- Use a clamp to ensure that subcutaneous tissue is not entrapped by the suture at the end of the percutaneous suture procedure.

**Pitfalls and risks**

- Risk of medial plantar nerve injury when the FHL harvesting is performed in zone 2.
- Problems with the length of the FHL harvest in zone 1 if plantar flexion and traction is not performed.
- Optimal position of calcaneal bone tunnel.
- Tension estimation when the FHL harvest is fixed.
- Risk of sural nerve injury during percutaneous Achilles tendon repair.

FHL, flexor hallucis longus.

knife to perform the cut is recommended. if necessary, complete the section with a retrograde knife. If the sectioning is performed in zone 1, the risk of harvesting a short tendon is present if the cut is made too proximally. To minimize this risk, pass a suture around the FHL tendon to traction it and perform plantar flexion of the ankle and the hallux when the tendon is harvested. An important issue with this technique is that partial flexion of the hallux is maintained even though the FHL tendon is sectioned. This is explained by the cut being made proximal to the knot of Henry while

**Table 3.** Advantages and Limitations**Advantages**

- The arthroscopic technique minimizes soft-tissue injury.
- FHL transfer makes for increased blood supply to the repaired Achilles tendon.
- Plantar flexion strength is reinforced with the FHL transfer.
- The FHL transfer maintains the normal muscle balance of the ankle.
- The percutaneous repair technique respects the paratendineous tissues and aids in Achilles tendon healing.

**Limitations**

- Only indicated in patients with distal acute Achilles tendon ruptures in whom conservative treatment or termino-terminal suturing is not possible.
- Technically demanding procedure.

FHL, flexor hallucis longus.

keeping the connections between the flexor digitorum longus and FHL.<sup>18</sup>

Relative to percutaneous Achilles tendon repair complications, sural nerve injury is the most common complication reported. It has an incidence from 5% to 18%.<sup>19,20</sup> Most of them are transitory sural nerve injuries. To minimize this complication, skin incisions must be carefully placed and meticulous soft-tissue dissection with a mosquito clamp is recommended.<sup>19</sup>

In conclusion, endoscopic FHL tendon transfer and percutaneous Achilles tendon repair is a reliable combination for patients with distal acute tendon ruptures in whom there is a significant gap between the ends of the tendon.

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