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ORIGINAL STUDY

Neglected Achilles Tendon Rupture Treated with Flexor Hallucis Longus transfer with two turndown gastrocnemius fascia flap and reinforced with plantaris tendon

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Neglected Achilles Tendon Ruptures are commonly seen by orthopaedic surgeons. In cases resistant to conservative treatment, a variety of surgical procedures have been utilized in the past. The senior surgeon at our institution has utilized a technique employing two turndown fascia flaps fashioned from the proximal Achilles tendon augmented by a tenomyodesis of the flexor hallucis longus and plantaris tendon. The purpose of this study was to assess the clinical outcome of all patients who underwent this procedure.

The medical records of 10 cases that underwent this procedure were retrospectively reviewed. We completed data collection sets using the American Orthopaedic Foot and Ankle Society ankle-hind foot scores, isokinetic evaluation, and postoperative magnetic resonance imaging (MRI) at 1 year of follow-up. The mean American Orthopaedic Foot and Ankle Society ankle-hind foot scores improved from 64.4 ± 3.54. Isokinetic testing at 30°/sec and 120°/sec revealed an mean deficits of 24.5%, respectively, in the plantar flexion peak torque of the involved ankle than non-involved ankle. The flexor hallucis longus tendon, gastrocnemius fascia flap and plantaris were well integrated into the Achilles tendon forming a homogenous tendon, which was confirmed in MRI. Our subjective and objective data indicate that the reconstructive technique using flexor hallucis longus transfer with two turndown gastrocnemius fascia flaps and plantaris tendon is a good option for repairing large gap defect of Achilles tendon.

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INTRODUCTION

The Achilles tendon (AT) is the most commonly injured tendon in the lower extremity demonstrating a peak incidence in middle-aged patients (75% in the range of 30-40 years) (*17*). Up to 27% of these injuries are initially misdiagnosed by physicians and patients possibly being misled by the inconsequential nature of the trauma reported, tolerable pain and a retained ability to plantar flex the ankle (*14*). In such cases, delayed diagnosis leads to a neglected AT rupture, generally defined as a chron-

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ic rupture with a delay of more than 4 weeks prior to diagnosis or treatment (*6*). The final result is reduced power in plantar flexion associated with ankle swelling, pain and impaired mobility. Patients complain of difficulty walking uphill or upstairs and poor balance, which should be considered as indications for a surgical reconstruction.

Compared to acute AT ruptures, there is a strong consensus for surgical reconstruction with neglected AT rupture (*12*). Various surgical techniques have been described for large defect of neglected AT rupture including local tissue augmentation (*8*), free flaps (*21*) or turndown flaps (*4*), local tendon transfers (peroneus brevis (*24*) ; flexor digitorum longus (*18*) and flexor hallucis longus tendon (*29*)), free tissue transfers (gracilis (*19*) and allografts (*5*)), and synthetic grafts (*23*) or combination thereof (*28*).

Hansen (*10*) first described flexor hallucis longus (FHL) tendon transfer for the AT, which was single incision technique to harvest FHL. Wapner *et al* (*29*) reported the FHL tendon transfer technique for reconstruction of chronic AT rupture with dual incision, which locates the FHL tendon through a medial incision over the mid-foot has been noted to be effective and safe. The benefit of this technique is not only mechanical support but also its muscle belly covers the tendon defect and may provide additional blood supply to aid in healing, thereby reducing the incidence of re-rupture and deep infection.

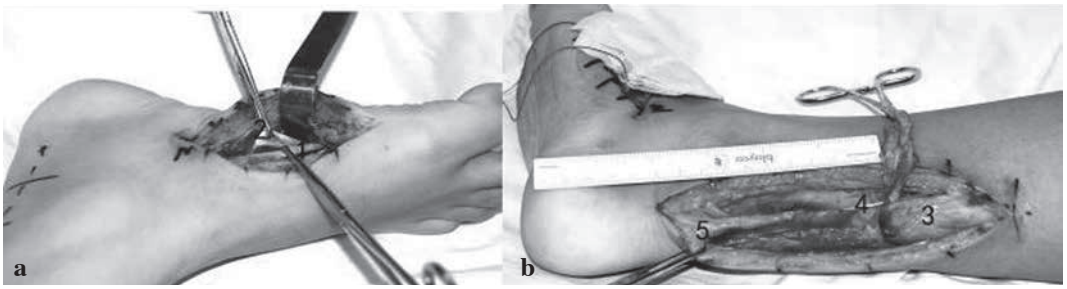
We are reporting another new technique involving the use FHL transfer reinforced with two turndown gastrocnemius fascia flaps and plantaris tendon for primary reconstruction of neglected AT rupture. The purpose of this study was to report the management of 10 patients presenting with neglected AT rupture treated with the described method. Ankle plantar flexion torque deficit was assessed using isokinetic evaluation.

PATIENTS AND METHODS

From January 2008 to January 2011, the senior surgeon performed all 10 cases. Ten patients, eight men and two woman, underwent FHL transfer with two turndown gastrocnemius fascia flaps reinforced with plantaris tendon. The mean age of patients was 35.5 years (range from 22 to 55). The mean time of injury to surgical intervention was 5.3 months (range from 4 to 8). The diagnosis of neglected AT rupture was made initially by clinical findings and confirmed by Magnetic Resonance Imaging. The authors feel that Magnetic resonance imaging (MRI) is an essential component for surgical planning in evaluating the size of tendon defect (Fig. 1). The feet were fixed in the neutral position during MRI examination. The length of the defect, which was measured preoperatively on MRI, varied from 4cm and 10cm (mean rupture length 6.6 cm). Postoperative MRI image were performed to observe the incorporation of the FHL tendon, gastrocnemius fascia flap, plantaris tendon and AT after one year flow-up.

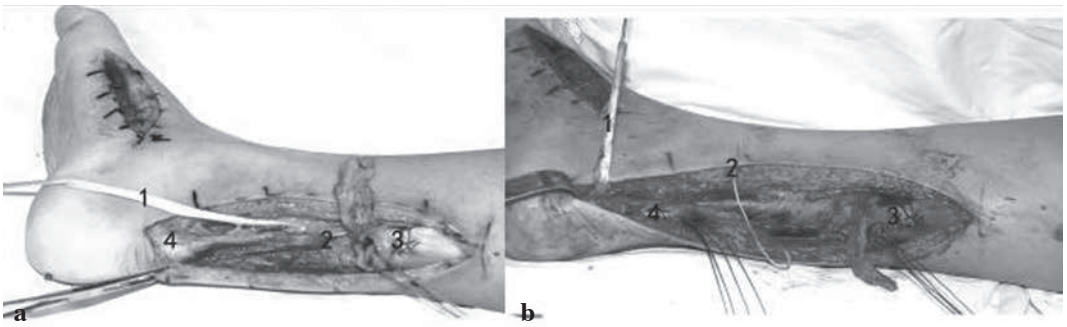
Fig. 1. — Sagittal T2 MRI shown a neglected Achilles tendon complete rupture with retracted tendon ends. The arrow shown the large gap of AT.

Ankle and foot function were assessed using the American Orthopaedic Foot and Ankle (AOFAS) Ankle-Hind foot scores, both preoperatively and postoperatively. Strength assessment was also performed using Cybex isokinetic system. Range of motion and muscle strength were tested from neutral to maximal ankle dorsiflexion



1. FHL 2. FDL 3. Proximal stump of AT 4. Plantaris tendon 5. Distal stump of AT.

Fig. 2. — (a). The flexor hallucis longus (FHL)can be observed medially and the flexor digitorum (FDL) was observed deeper in the wound laterally. (b). The diseased Achilles tendon and scar tissue were excised and discarded.



1. FHL 2. Plantaris tendon 3. Proximal stump of AT 4. Distal stump of AT.

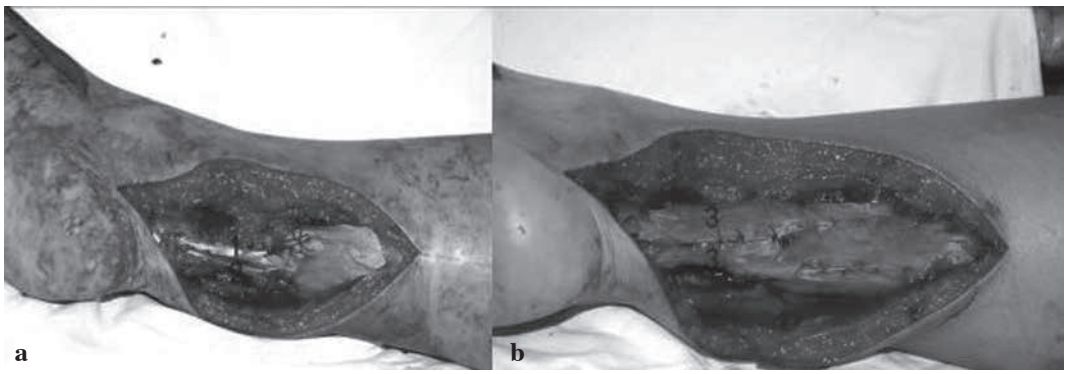
Fig. 3. — (a). The FHL tendon pulled out from the midfoot into the posterior incision.(b). The FHL tendon pulled out from the superior hole out the medial hole through the tunnel. The plantaris tendon freed from its insertion.

and plantar flexion at 30 deg/sec and 120 deg/sec. For testing, five repetitions were completed at 30 deg/sec and 10 repetitions at 120 deg/sec. Range of motion, work, power, and torque were calculated for each set of repetitions.

The surgical technique was modified from the two-incision technique described by Wapner et *al* (*29*). A 5-cm medial incision was made over the mid-foot from the navicular to the first metatarsal, just above the abductor hallucis. The abductor hallucis muscle was reflected inferiorly. The origin of the flexor hallucis brevis was identified and it was released to gain access into mid-foot. The flexor digitorum longus (FDL) and FHL tendons was then identified (Fig. 2). The interconnection between two tendons was released. The FHL tendon was then transected at level of the mid-shaft of the first metatarsal just proximal to its division. The proximal portion of FHL was tagged with a suture. The distal part of FHL tendon was sewn into the FDL tendon to maintain great toe flexion.

A second 15cm longitudinal incision was made posterior medially just anterior to AT, starting from the level of its musculotendinous junction and extending to the superior aspect of the calcaneus, and the AT was inspected after the paratenon was opened. Sharp debridement of any scar tissue was then performed until healthy tendon creating a flat surface for apposition (Fig. 2).

With the AT and muscle belly reflected, the deep posterior compartment fascia was indentified over the muscle of the FHL muscle. A longitudinal fasciotomy was created. After retracting the posterior tibial artery and vein, and the tibial nerve medially, the FHL tendon was then pulled out from the mid-foot into the posterior incision (Fig. 3). Two 4.5 mm drill holes were created in the posterior body of the calcaneus. One was made superiorly just anterior to the AT insertion approximately



1. FHL 2. Plantaris tendon 3. Two gastrocnemius fascia flap.

Fig. 4. — (a). The FHL tendon and plantaris tendon woven into from distal to proximal stump of Achilles Tendon. (b). Two proximal turndown flaps were utilized to cover the defect of the Achilles Tendon.

2.5 cm in depth. A second drill hole was made from the medial side to intersect the first drill hole. The FHL tendon was pull out from the superior hole out the medial hole through the tunnel, then woven into from distal to proximal stump of AT and sutured to it by non-absorbable sutures with the ankle at 10° plantar flexion (Fig. 4). The plantaris tendon was identified in the medial side of AT, freed from its insertion and then woven in two circumferential loops from the distal stump to the proximal stump of AT for additional augmentation (Figs. 3 and 4).

Finally, the two central gastrocnemius fascia flaps, 2 cm wide and 6-10cm long, are turned down and are used to bridge the tendon defect with the ankle in a plantigrade position. These flaps were rotated down and stitched to the remaining stump of the AT with a non-absorbable suture (Fig. 4). In order to adequately cover the suture line in the tendon, the origin of the flaps that are 2-3 cm above the tendon rupture, were fixed to the distal stump with a few interrupted sutures. The incision in the fascia of the gastrocnemius was closed .The paratenon was repaired to help maintain the blood supply for the AT. Wound closure was performed carefully to avoid subsequent skin necrosis and infection.

The foot was splinted with 15° of ankle plantar flexion for 7 days. A short leg cast was then applied to maintain 15° of ankle plantar flexion for 4 weeks. The patient was not permitted to weight bear in this plantar flexion cast. This cast was changed at two weeks to allow for suture removal. After the four weeks in the plantar flexion cast, the patient was then placed in a cam walker with a 30° heel wedge in the boot, and allowed to progress to full weight bearing as tolerated. The heel wedge was composed of 3 removal pieces that were in 10° increments, and patients were instructed to remove 1 wedge every 2 week for 6 weeks so that by the tenth week, they were ambulating in just the boot walker with no heel lift. A rehabilitation program for strengthening, gait training and range of motion was begun the tenth week post-operatively. Athletic activity was restricted for at least 6 months after surgery.

RESULTS

Clinical outcome

This study included a total of 10 patients (8 male : 2 female). All neglected AT ruptures were secondary to trauma. Mechanisms of injury included running, fall and direct impact. The mean tendon defect was 8.1cm (range from 7 to 11) after debridement, which was longer than the MRI measurement.

The average follow-up of the series was 18.1 months (range from 12 to 36). One patient demonstrated delayed healing which resolved with dressing changes after two weeks. No infections, nerve injuries or re-ruptures occurred. There were no patient complaints of ankle stiffness and heel cord tightness. The average interval to return to work was 4 months (range from 3 to 12) and recovery to sports ten months (range from 6 to 18). Of note, FHL to FDL tenodesis was performed in all cases and there were no complaints of plantar flexion weakness of great toe. All patients maintained active flexion of the interphalangeal joint of their

Fig. 5. — The arrow shown FHL tendon, gastrocnemius fascia flap and plantaris well integrated into the Achilles Tendon.

hallux. Furthermore, no interphalangeal joint hyperextension deformity was occurred.

All patients underwent as MRI 1 year postoperatively. The FHL tendon, gastrocnemius fascia flap and plantaris tendon were demonstrated to be well integrated into the AT forming a whole tendon (Fig. 5).

Mean preoperative AOFAS Ankle-Hind foot scores improved from 64.4 (range from 58 to 70) points to 94.3 (range from 88 to 100) points and VAS scores was statistically significant at the last follow-up (Table I). Ankle range of motion was close to the noninvolved ankle with an average of 12°of dorsiflexion (range from 5 to 15°) and 40.5 of plantar flexion (range from 35 to 50°). Residual calf atrophy was a common finding. The averaged Calf girth deficit was 1.5 (range from 0.5 to 2.5) cm. All patients were able to do single-leg stance and maintain their balance (mean, 32.5 seconds ; range from 8 to 50 seconds). The reconstructed side showed little difference with the contralateral control side (mean, 8.5 seconds ; range from 5 to 30 seconds).

Isokinetic Assessment

Data were obtained at 2 testing angular velocities, 30 deg/sec and 120 deg/sec concentrically, with 5 and 10 repetitions, respectively. Tests were conducted on both ankles and started always with the non-operated ankle. For each angular velocity, the peak torque (Newton-meters) was recorded. Isokinetic testing at 30 deg/sec and 120 deg/sec revealed an average decrease of 24.5% and 34.5%, respectively, in the plantar flexion peak torque of the involved ankle compared with the non-involved ankle (Table II).

DISCUSSION

The neglected AT rupture may present a greater need for reconstruction and augmentation techniques as an end-to-end repair my not be achievable. Although the most appropriate reconstructive techniques remain controversial, reconstruction for defects of AT become necessary if the treatment is delayed more than 4 weeks and the proximal end of the tendon retracts creating a large defect (*13*). V-Y tendon advancement and turndown flaps can be utilized to cover the tendon defect after debridement but these provide only static support.

There are many benefits of using the FHL over other dynamic tendon transfers (*29*). Anatomically it is close to the AT, next strongest muscle to the triceps surae, acts in phase with the triceps surae providing plantar flexion, its axis of contraction is in line with the AT, and it may increase the vascularity of reconstruction with myodesis of the low-lying FHL muscle belly. As such, in cases where direct apposition of the tendons ends is not possible or in the presence of a nonfunctional or degenerated gastrocnemius-soleus unit, the FHL provides a valuable solution.

Since its introduction more than 20 years, the transfer of the FHL has found widespread use in treating chronic and irreparable AT disease. Bevilacqua NJ (*2*) reviewed the previous papers and concluded the FHL is an ideal tendon to use and is well suited for tendon transfer to augment neglected Achilles tendon repairs. The double-incision technique described by Wapner *et al* (*29*) allows a

Table I. — Comparison of preoperative and postoperative score results (n = 10 feet in 10 patients)

Variable	Preoperative	Postoperative	*p* Value
AOFAS score	64.4 ± 3.54	94.3 ± 3.46	.008
VAS score	4.33 ± 1.11	1.89 ± 1.17	.011

Abbreviations : AOAFS, American Orthopaedic Foot and Ankle Society ; VAS, visual analog scale.

Table II. — Strength testing results (n = 10 feet in10 patients)

Variable	Operated	Non-operated	Mean difference	%Deficit	*p* Value
Mean peak PT torque at 30°/sec	43.67 ± 13.0	66.67 ± 27.7	23	34.5	.008
Mean peak PT torque at 120°/sec	28.3 ± 9.45	37.5 ± 11.0	9.2	24.5	.007

Abbreviation : PL, plantar flexion.

greater tendon length to be harvested. Wilcox *et al* (*30*) described a dual-incision technique for harvesting the FHL tendon. The authors reported on 20 patients at a mean follow-up of 14 months and concluded the FHL tendon transfer for augmentation is a reasonable option for treatment of chronic Achilles tendinosis and rupture. Tashjian *et al* (*27*) completed a study on 14 fresh-frozen cadavers to evaluate the length of the FHL tendon with both a single- and double-incision techniques. The authors found that with a single incision procedure, the average tendon graft length was 5.16 cm, whereas it was 8.09 cm with the double incision. Panchbhavi (*22*) has described a minimally invasive at the base of big toe approach for FHL harvest demonstrating more tendon length than the double incision technique. Amlang *et al* (*1*) also reported a direct plantar approach for FHL tendon harvest using of a double-incision. Endoscopic assisted FHL transfer in the management of chronic rupture of AT was reported by Luia TH (*16*).

In agreement with these authors, we believe the double incision technique is the best way to obtain the maximum length of FHL for a large gap defect. In addition it allows tenodesis of the distal part of FHL to the FDL, preserving active flexion of the big toe and avoids a possible cock-up deformity.

In the cases presented in this study the senior surgeon felt that FHL transfer alone was insufficient for reconstruction of defects greater than 5 cm, and V-Y myotendinous advancement or a fascial turndown flap was necessary. Turndown flaps to bridge the tendon defect have become a good option for many surgeons due to ease harvesting, reliability of the tissue and excellent results. The turndown technique was first described by Christensen in 1953. Subsequently, the use of 2 peripheral turndown flaps was described by Lindholm (*15*).

In recent series, some authors proposed FHL transfer combined with turndown flap for chronic AT tendon rupture, allowing for stronger augmentation and allowing the FHL to serve as a scaffold for healing (*20,28*). The addition of the two turndown gastrocnemius fascia flaps to cover tendon stumps provides a firm connection between the distal and proximal stumps, and previous studies concluded that it is suitable for repairing chronic AT ruptures (*26*). Although several publications discuss the transfer of the FHL tendon combined with turndown flap (*20,28*), to our knowledge there was no reported on FHL tendon combined with turndown flap reinforced with plantaris tendon for AT rupture. The plantaris tendon was added to restore strengthening of plantar flexion with suture on stump of AT in our series. Biomechanically, Ilhami *et al* (*11*) reported that as long as the plantaris graft's site is close to the repair zone, the healed tendon is stronger and more similar to a normal tendon.

Our results, using subjective and objective assessment methods, demonstrate that relatively good

results can be expected after surgical reconstruction of neglected AT rupture. The average preoperative and postoperative AOFAS scores of 64.4 and 94.5, respectively, showed a statistically significant increase. MRI has been suggested as a good postoperative tool for evaluation of interposition of FHL tendon, gastrocnemius fascia flap and AT. In our study, postoperative MRI confirmed a good consolidation of the tendon postoperatively in all of patients. This is similar to findings described by other authors (*9,25*).

In comparing our clinical results, Cybex strength testing revealed deficits in plantar flexion peak torque in all 10 patients with this procedure at 30 deg/sec and 120 deg/sec, 24.5% and 34.5%, respectively. Wapner *et al* (*29*) reported average decreases of 41.8%, 51.0%, and 29.5% in plantar flexion torque, work, and power, respectively, on Cybex testing at 30 deg/sec after FHL transfer. The good isokinetic results may be related to the modification of surgical technique, by incorporating the gastrocsoleus fascial flap and plantaris tendon. The plantaris tendon augmentation may add more stability to the Achilles tendon rupture, which was also confirmed with biomechanical test by Gebauer *et al* (*7*).

There was no major morbidity associated with this procedure. The re-rupture rate after surgical repair of acute Achilles ruptures is 1.4-3.7% (*3*). But no case of re-rupture occurred in our study. Potential morbidity of FHL harvesting is the loss of hallux interphalangeal plantar flexion strength, which is universal in all patients having FHL transfer. Also the potential for contracture at the IP joint if tenodesis the FHL to the FDL was over tightened. We feel this was not observed in our patients because of tenodesis of the distal stump to the FDL with lesser toe was performed with the toes all held in neutral position. Minor complications as hematomas, superficial wound infections and sural nerve irritations were also not noted in our patients.

This procedure also has some disadvantages. The plantaris tendon maybe absent in some patients. When using this construct for neglected AT ruptures with large defect care must be taken not to over enlarge the construct so that closure of the calf wound does not result in excess tension along the suture line. Ensuring that the reconstruction is not too bulky or bulbous in its dimensions can decrease the risk of dehiscence.

Another limitation of this study was the lack of a control group. Studies involving more cases and control group are needed. In addition, the main limitation of our series is a retrospective study and the small number of cases included.

In conclusion, for neglected AT rupture with large gap, the authors feel the reconstructive technique described in this study provides another good option. Transfer of the FHL to treat neglected AT rupture associated with two turndown flaps and plantaris tendon yielded good clinical and functional outcomes with a high satisfaction and relatively low complication rate. Patients in this study had excellent pain relief and were satisfied with their results after surgery. The described technique is advantageous in that it is simple to perform. The technique described here has been found to be reliable for repairing the large gap defect of AT.

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