

# Flexor hallucis longus tendon transfer through a single incision in the treatment of chronic Achilles tendon rupture with large defect

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## Research article

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# Abstract

**Background** To evaluate the medium-to-long term clinical outcome of flexor hallucis longus tendon transfer through a single incision in the treatment of chronic Achilles tendon rupture with a defect greater than 5 cm. **Methods** Clinical data of patients treated with flexor hallucis longus tendon transfer due to chronic Achilles tendon rupture between January 2009 and December 2016 were reviewed retrospectively. All cases were presented with Achilles tendon rupture for more than 4 weeks after injury. The defect of the Achilles tendon was greater than 5 cm after debridement in all patients. Clinical outcomes were assessed with AOFAS Ankle-Hindfoot Scale (AOFAS-AH), Achilles tendon Total Rupture Score (ATRS) and AOFAS Hallux Metatarsophalangeal-Interphalangeal Scale (AOFAS-HM). **Results** 18 patients were followed successfully for 24-83 months (mean follow-up time of 43.2 months) and 5 were lost. According to the complete datasets obtained from 18 patients, none of the tendons re-ruptured during the follow-up. The AOFAS-AH and ATRS at last follow-up visit was  $94.4 \pm 3.2$  (87-100) and  $89.6 \pm 5.9$  (72-98) respectively, which revealed statistically significant improvement from the preoperative score of  $58.2 \pm 6.3$  (49-70) and  $53.3 \pm 7.3$  (42-68). The AOFAS-HM at last follow-up visit was  $90.1 \pm 5.2$  (77-97). **Conclusion** The flexor hallucis longus tendon transfer through a single incision is a safe and simple method for chronic Achilles tendon rupture with minimal morbidity and complications.

## Background

The Achilles tendon (AT) rupture is one of the most common tendon injuries following the rupture of patellar ligament and quadriceps femoris tendon [1, 2]. It often occurs in people 30–39 years old especially the so called “weekend warrior”. Patients can still perform 30° of plantar flexion after the rupture of AT because the tibialis posterior muscle, fibular muscle and flexor digitorum muscle have a synergistic effect on ankle plantar flexion. Therefore, it is easy for this injury to be ignored by both patients and doctors. Approximately 25–27% of acute AT ruptures became chronic ruptures because of wrong or missed diagnosis, leading to severely impaired function of the foot and ankle and even more complicated treatment [3, 4].

There are multiple surgical options for the treatment of chronic AT rupture, for example, the Lindholm method, Bosworth method, V-Y extension, repair with autologous tendon transfers and so on. However, most surgical methods have the disadvantages of high rate of re-rupture, obvious adhesion, and various soft tissue complications [5–8]. To date, there is no gold standard method for chronic AT ruptures. Although there are some studies on the application of flexor hallucis longus tendon (FHLT) transfer in the reconstruction of AT for large defects [9–12]. Whether FHLT transfer is superior to other autologous tendons or allogeneic tendons remains controversial. This article aimed to describe our surgical experience and review its medium-to-long term clinical outcomes.

## Methods

## Patients

All patients with chronic AT rupture who were treated at Affiliated Hospital of Southwest Medical University with FHLT transfer between January 2009 and December 2016 were retrospectively analyzed. The diagnosis of chronic AT rupture was defined as delayed or neglected diagnosis for more than 4 weeks after injury, it was confirmed by clinical examination and MRI scan.

## **Inclusion Criteria And Exclusion Criteria**

The inclusion criteria were patients diagnosed with chronic AT rupture, defect of the ruptured AT greater than 5 cm after debridement, performed with FHLT transfer. The exclusion criteria were patients with acute AT rupture (duration < 4 weeks), with systemic disorder and with neurologic problems. With the inclusion criteria and exclusion criteria, a total of 23 patients were invited for study inclusion. 18 patients responded to the invitation and 5 patients were lost to follow-up because their telephone number had changed and could not be contacted. The characteristics of the remaining 18 patients were summarized in Table 1.

Table 1  
Characteristics of Patients.

Characteristics	Patients(n = 18)
Gender	
Male	15(83.3%)
Female	3(16.7%)
Mean Age (year)	40.9(25– 58)
Location	
Left	7(38.9%)
Right	11(61.1%)
Smoking	
Yes	10(55.6%)
No	8(44.4%)
Hormone	
Yes	6(33.3%)
No	12(66.7%)
Cause	
Missed diagnosis or ignored	7(38.9%)
Small needle scalpel therapy	5(27.8%)
Re-rupture	4(22.2%)
Other reasons	2(11.1%)
Duration between injury and surgery (week)	15.4(5– 28)
Length of defect (cm)	7.3(5– 11)
Follow-up time (month)	43.2(24– 83)
Complications	
Superficial infection	1(5.6%)

## Surgical Procedure

Patients were placed in the prone position with a upper thigh tourniquet after spinal anesthesia. Routine disinfection and draping were performed. An 8–10 cm posteromedial incision was made along the anterior edge of the AT. Any fibrous scar or unhealthy degenerated fibers of ruptured ends of AT were carefully excised leaving only healthy fibers. The ruptured ends could not be apposed after debridement even with the foot in full plantar flexion. Then the FHLT was identified through the bed of the AT and was cut off below the medial malleolus. The proximal end of FHLT was woven for approximately 3 cm with absorbable tendon sutures through Krackow technique [13]. A osseous tunnel was made in the calcaneus with a 6–7 mm diameter drill bit just anterior to the insertion site of AT. Then the woven FHLT was guided into the tunnel by a guiding needle passing through the sole of the foot. The affected foot was maintained in 5–10° plantar flexion position and the guide wire was continually pulled to maintain the tension of the FHLT. Proper tension was adjusted to match the contralateral healthy side. A 3.5 cm absorbable hydroxyapatite screw (Smith & Nephew, USA) was implanted to fix the FHLT into the tunnel. The remaining ends of AT were sutured to the FHLT through side-to-side technique. No other tendon lengthening or turndown procedures were performed. The Surgical process are showed in Fig. 1.

## Postoperative Management

The ankle was maintained in 5–10° plantar flexion position by plaster cast after surgery. The affected limb was elevated, and outside ice compresses was applied. On the second postoperative day, patients were encouraged to perform flexion and extension exercises of the toes of the affected limb and isometric contraction training of the quadriceps femoris and triceps surae under protection of the plaster cast. After 4 weeks, the plaster was removed, and exercise to restore the range of ankle motion was started. Patients were also encouraged to perform weight training under the protection of a weight-bearing brace for another 6 weeks. A gradual return to daily activities was allowed with the rehabilitation programs of muscle strengthening, ankle balance and stability exercises after removing of the brace.

## Outcome Assessment

Foot and ankle functions were assessed before surgery and at the last follow-up visit by members of the medical team. The AOFAS Ankle-Hindfoot Scale (AOFAS-AH), Achilles tendon Total Rupture Score (ATRS) and AOFAS Hallux Metatarsophalangeal-Interphalangeal Scale (AOFAS-HM) were recorded. All of the patients were also asked to present their satisfaction with the surgery through a five-point scale as completely satisfied, moderately satisfied, neutral, moderately unsatisfied and completely unsatisfied.

## Statistical analysis

The analysis was performed with SPSS 17.0 statistical software. Continuous variables were described by mean and standard deviation (Mean  $\pm$  SD) and compared by paired t test if the data were normally distributed. Categorical variables were described by number and percent (N, %). A result was considered to be statistically significant when two-tailed  $P < 0.05$ .

## Results

18 of 23 patients were followed up successfully for a mean of 43.2 months (range 24–83 months). The average time between injury and surgery was 15.4 weeks (range 5–28 weeks). The tendon was harvested through a single incision in all patients and the length of defect was measured to be 5–11 cm (mean 7.3 cm). Delayed healing occurred in one patient due to superficial wound infection which had complete recovery under sensitive antibiotics and daily dressing, no secondary surgery was performed. No patients complained of any symptoms of nerve injury after surgery. None of the tendons re-ruptured during the follow-up.

The AOFAS-AH and ATRS at last follow-up visit was  $94.4 \pm 3.2$  (87–100) and  $89.6 \pm 5.9$  (72–98) respectively, which revealed statistically significant improvement from the preoperative score of  $58.2 \pm 6.3$  (49–70) and  $53.3 \pm 7.3$  (42–68),  $P < 0.05$ . The AOFAS-HM at last follow-up visit was  $90.1 \pm 5.2$  (77–97). The satisfaction survey at last follow-up visit revealed that 11 patients were completely satisfied, 6 patients were moderately satisfied, and 1 patient was neutral. All reviewed patients indicated that they would accept the same surgical treatment again in similar circumstances. The patient data are summarized in Table 2.

Table 2  
AOFAS-AH, ATRS, AOFAS-HM and Satisfaction of Patients.

Evaluation index	Before surgery	Last follow-up	t	P
AOFAS-AH (points)	$58.2 \pm 6.3$ (49–70)	$94.4 \pm 3.2$ (87–100)	27.6	0.000
ATRS (points)	$53.3 \pm 7.3$ (42–68)	$89.6 \pm 5.9$ (72–98)	27.9	0.000
AOFAS-HM (points)		$90.1 \pm 5.2$ (77–97)		
Satisfaction (cases)				
Completely satisfied		11(61.1%)		
Moderately satisfied		6(33.3%)		
Neutral		1(5.6%)		
AOFAS-AH: American Orthopaedic Foot and Ankle Society Ankle-Hindfoot Scale; ATRS: Achilles tendon Total Rupture Score; AOFAS-HM: American Orthopaedic Foot and Ankle Society Hallux Metatarsophalangeal-Interphalangeal Scale				

## Discussion

AT rupture tends to occur approximately 2–6 cm above the insertion of the tendon because the blood vessel distribution and blood supply are relatively poor [14]. The main reason for the AT rupture is the degeneration of AT fibers caused by poor blood flow and mechanical factors. Obesity, local repeated block therapy, application of hormones, and oral contraceptives also have potential impacts on the

occurrence of AT rupture [15, 16]. At 4 weeks after injury, highly vascularized collagen scar tissue fills the retraction gap of the ruptured AT, which is the earliest manifestation of chronic healing [17]. Therefore, it is generally accepted that the diagnosis of chronic AT rupture was defined as delayed or neglected diagnosis for more than 4 weeks after injury [18].

The nonoperative treatment of chronic AT rupture is only suitable for high-risk patients with surgical contraindications who do not have high needs for ankle function. The ankle plantar flexion can be partially strengthened with an ankle foot orthosis, however, the normal physiological gait cannot be restored. The prognosis of nonoperative treatment is poor compared to surgical options, and patient satisfaction is less than 55% [1].

Surgical repair of chronic AT rupture has been widely accepted by clinicians. Various surgical treatments have been reported in the literature, including direct suture, triceps tendon rotation flap, V-Y extension, tendon transfer, repair of scar tissue, artificial tendon transplantation, and allograft tendon transplantation [5–8, 19]. However, neither a uniform standard nor evidence-based support has been established [20–22]. Generally, a surgical plan can be constructed based on the length of the defect according to Kuwada and Myerson classifications [14, 23]. However, there are still controversies regarding the surgical methods for large defects of AT. The incidence of re-rupture after conventional surgical treatment is high. Moreover, conventional surgical treatment has disadvantages such as difficult procedure requiring skill, poor graft strength and poor blood supply particularly when the defect of AT rupture is greater than 5 cm. The reconstruction of AT with large defect using FHLT transfer was firstly reported by Hansen in 1991 [24]. This technique has been gradually recognized and continually improved over the years. Studies have shown that FHLT transfer is a safe and effective surgical approach for patients with chronic AT rupture [25–28]. However, the evidence of this technique is insufficient due to the limited number of reports and cases, and the lack of long term follow-up data.

It has been reported that the FHLT can be harvested through a single incision or double incisions. However, which incision is better and whether the distal end of the FHLT needs to be sutured to the FDLT remains controversial [29–31]. In this study, all the 18 tendons were harvested through a single posteromedial incision. According to our experience, harvesting FHLT through a single incision can be sufficiently long to prevent excessive muscle tension after transfer. The technique is simple and safe, no more incisions are need which may potentially increase the risk of infection and medial plantar nerve injury. However, note that the FHL is located on the deep side of the tarsal tunnel, posterior tibial blood vessels and nerve in the tunnel should be carefully protected when a single incision is made.

Reconstruction of AT with FHLT transfer could reduce the plantar flexion strength of the hallux, resulting in reduced balance or strength of propulsion theoretically [26, 32]. Richardson et al reported decreased distal phalangeal pressure and FHL weakness in 22 patients, but no difference was found in plantar pressure of the first or second metatarsal head [29]. We also noticed the slight weakness of hallux in all patients postoperatively, but the plantar flexion of the distal phalanx could be performed in some of the patients. The postoperative AOFAS-HM at last follow-up visit was relatively high. All patients recovered to

their pre-injury daily activities and no patient complained of functional disorder or any noticeable weakness in this study. It is worth mentioning that one amateur football player returned to the pitch for football match 1 year after surgery. The reason for this phenomenon may be existence of flexor hallucis brevis and abnormal branch of other congenerous muscles. The tenodesis of FHLT to FDLT resulting in floating halluces with hyperextension and alignment problems were reported in some studies [26, 27]. Some authors do not routinely perform a tenodesis of FHLT to FDLT, they also noticed the weaker hallux postoperatively, but it was not a clinical issue for most patients [32]. However, it is uncertain whether this technique is suitable for athletes and sports participants who have a high need for movement.

At present, there is still no uniform standard for the time and angle of postoperative plaster fixation for FHLT transfer surgery. Most previous studies fixed the ankle joint in a 5°-30° plantarflexion position with a plaster for 2–6 weeks after surgery, then adjust the angle to 0° gradually or following with a weight-bearing boot for another 4–6 weeks. The time and angle of fixation differed according to the surgeons' experience. Initially, we fixed the ankle joint in a 15°-20° plantar flexion position with a plaster within 4 weeks after surgery, and then the angle of the ankle plantar flexion is gradually adjusted to 0° under the protection of a weight-bearing brace for another 6 weeks. However, among the first 7 patients who were followed up in this study, 3 patients started to walk on their full weight without the support of a weight-bearing brace after removing of the plaster. No tendon re-rupture, ankle movement disorder, or any other discomfort could be observed after a mean follow-up of 9–12 months. Then we adjusted the rehabilitation program, the ankle joint of remaining patients were fixed in the 5–10° plantarflexion position using a plaster cast for 4 weeks. Patients were encouraged to perform exercises to improve the range of ankle motion as well as weight training under the protection of a weight-bearing brace after removing of the plaster. The brace was removed another 6 weeks later, and normal walking was gradually regained with the avoidance of strenuous exercise. None of the patients complained of tendon re-rupture, ankle movement disorder or other discomfort. The early postoperative rehabilitation exercises after FHLT transfer for reconstruction of AT may be beneficial.

The main limitations of this study are its retrospective nature with a small case series which could lead to potential sampling bias, unable to follow up all patients with a comprehensive clinical review, and the lack of a control group. The strength are that the patients of this study were followed up for a relatively longer period, averaged 43.2 months, and the preoperative and postoperative clinical evaluation were compared.

## **Conclusion**

The FHLT transfer for chronic AT ruptures through a single insion is a safe and simple method with low risk of morbidity and complications. Although the harvest of FHLT may results in potential weakness of plantar flexion strength in hallux, most patients could recovered to their pre-injury daily activities with a high level of satisfaction.

## **Abbreviations**

AT: Achilles tendon

FHLT: Flexor hallucis longus tendon

AOFAS-AH: American Orthopaedic Foot and Ankle Society Ankle-Hindfoot Scale

ATRS: Achilles tendon Total Rupture Score

AOFAS-HM: American Orthopaedic Foot and Ankle Society Hallux Metatarsophalangeal-Interphalangeal Scale

FDLT: Flexor digitorum longus tendon

## **Declarations**

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### **Authors' contributions**

WDQ and LXB designed the study. XYB, DY and WDQ performed all the surgeries. LC and XFF contributed to the data collection, outcomes evaluation and data analysis. XYB and LC completed the draft of the manuscript. WDQ and LXB reviewed and edited the manuscript. All authors read and approved the final manuscript.

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### **Availability of data and materials**

The datasets used and analyzed in this study are available from the corresponding author on reasonable request.

### **Ethics approval and consent to participate**

Not applicable.

### **Consent for publication**

Not applicable.

### **Competing interests**

The authors declare that they have no competing interests.

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## Figures



**Figure 1**

Surgical procedure of FHLT transfer for chronic AT rupture through a single incision a Debridement of the ruptured ends of AT b Actual length of the defect of ruptured AT c Recognize the FHL d Cut off and weave the FHLT e Drill a osseous tunnel just anterior to the insertion site of AT in the calcaneus f Guide the FHLT into the tunnel and fix that with a absorbable hydroxyapatite screw g Suture the proximal and distal ends of AT to the FHLT respectively



**Figure 2**

Functional recovery of an amateur football player suffered from chronic AT rupture in the right side a The appearance of lower extremity when standing with feet b The standing heel rise test of healthy limb and operated limb c The plantar flexion appearance of bilateral hallux showed distal phalangeal dysfunction in the operated limb