

Reconstruction of Kuwada grade IV chronic achilles tendon rupture by minimally invasive technique

Xudong Miao, Yongping Wu, Huimin Tao, Disheng Yang, Lu Huang

ABSTRACT

Background: Transfer of a flexor hallucis longus (FHL) tendon can not only reconstruct the Achilles tendon but also provide ischemic tendinous tissues with a rich blood supply to enhance wound healing. This retrospective study aims to investigate clinical outcomes in patients who underwent repair of Kuwada grade IV chronic Achilles tendon rupture with long hallucis longus tendons harvested using a minimally invasive technique.

Materials and Methods: 35 patients who were treated for Kuwada grade IV Achilles tendon injuries from July 2006 to June 2011 were included in this retrospective study. The age ranged between 23 and 71 years. The duration from primary injury to surgery ranged from 29 days to 34 months (mean value, 137.6 days). All 35 patients had difficulties in lifting their calves. Thirty two were followed up for a mean 32.2 months (range 18–72 months), whereas three were lost to followup. Magnetic resonance imaging (MRI) showed that the tendon rupture gap ranged from 6.0 to 9.2 cm. During surgery, a 2.0 cm minor incision was made vertically in the medial plantar side of the midfoot, and a 1.5 cm minor transverse incision was made in the plantar side of the interphalangeal articulation of the great toe to harvest the FHL tendon, and the tendon was fixed to the calcaneus with suture anchors. Postoperative appearance and function were evaluated by physiotherapists based American Orthopedic Foot and Ankle Society-ankle and hindfoot score (AOFAS-AH), and Leppilahti Achilles tendon ratings.

Results: Results were assessed in 32 patients. Except for one patient who suffered complications because of wound disruption 10 days after the operation, all other patients had primary wound healing, with 28 of 32 able to go up on their toes at last followup. The AOFAS-AH score was increased from preoperative (51.92 ± 7.08) points to (92.56 ± 6.71) points; Leppilahti Achilles tendon score was increased from preoperative (72.56 ± 7.43) to (92.58 ± 5.1). There were statistically significant differences. The result of the total excellent and good rate was 93.8% (30/32). MRI of Achilles tendon showed even signal without evidence of tear or cystic degeneration.

Conclusion: Reconstruction of a chronic Achilles tendon rupture with an FHL tendon harvested using a minimally invasive technique showed good outcomes.

Key words: Achilles tendon reconstruction, flexor hallucis longus tendon, Kuwada grade IV, minimally invasive technique, tendinous transfer

MeSH terms: Achilles tendon, tendon transfer, minimally invasive surgical procedure, ankle injuries

INTRODUCTION

Rapid social and economic development has been accompanied by an increased incidence of sports injuries, including Achilles tendon rupture.^{1,2} This

type of injury has become the second most common type of tendon rupture, with an incidence as high as 6–37/100,000.³ The acute missed diagnosis rate has been estimated at 20–30%.⁴ Chronic Achilles tendon ruptures are often accompanied by various degrees of tendon degeneration and defects. Improper treatment can result in complications, including scarring in the tendon area, continuous chronic pain, bad wound healing and re-rupture. Transfer of a long flexor hallucis longus (FHL)

Department of Orthopaedics, Institute of Orthopaedic Research, Second Affiliated Hospital, School of Medicine, Zhejiang University, Hangzhou 310009, P.R. China

Address for correspondence: Dr. Lu Huang, Department of Orthopaedics, Institute of Orthopaedic Research, Second Affiliated Hospital, School of Medicine, Zhejiang University, Hangzhou 310009, P.R. China. E-mail: huang_lu@zju.edu.cn

Access this article online	
Quick Response Code: 	Website: www.ijoonline.com
	DOI: 10.4103/0019-5413.189599

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Miao X, Wu Y, Tao H, Yang D, Huang L. Reconstruction of Kuwada grade IV chronic achilles tendon rupture by minimally invasive technique. Indian J Orthop 2016;50:523-8.

tendon can not only reconstruct the Achilles tendon, but can also provide ischemic tendinous tissues with a rich blood supply to enhance wound healing.⁵⁻⁷ The minimally invasive technique described here provides a tendon sufficiently long to reconstruct large defects of the Achilles tendon, whereas other techniques harvest a short FHL tendon graft.⁸ Our minimally invasive technique also resulted in the exposure of the FHL tendon to direct view, making it relatively easy to perform. We describe here the outcomes in 35 patients who underwent FHL tendon transfer for Kuwada grade IV Achilles tendon injuries.

MATERIALS AND METHODS

35 patients who were treated for Kuwada grade IV Achilles tendon injuries between July 2006 and June 2011 were included in study. There were 21 males and 14 females. The mean age was 42.1 years (range 23-71 years). All had unilateral involvement. Twenty seven patients had a history of pushing off their heels forcefully, whereas the other 4 had no history of injury, but chronic pain in tendon area gradually aggravated. The main symptom in all 35 patients was difficulty in walking on toes, with 28 patients also showing tenderness in the region of the tendon gap. Physical examination showed visible or palpable sunken Achilles tendon areas [Figure 1a and b], reducing or eliminating ankle plantar flexion force compared with the healthy side. Thompson test results were positive in 28 feet. X-ray showed soft tissue discontinuity of Achilles tendon [Figure 2a]. Magnetic resonance imaging (MRI) showed that the tendon rupture gap ranged from 6.0 to 9.2 cm. The time from primary injury to surgery ranged from 29 to 1025 days (median, 52 days). Of the 35 patients, 16 had a history of cortisone injections and 14 had a history of type II diabetes without peripheral neuropathy. The mean duration of diabetes was 5.4 years. 5 patients had undergone Achilles tendon rupture repair at other hospitals, with the interval between the two operations being 35, 42, 44, 52, and 72 days, respectively. Written informed consents were obtained from all of the participants in this study.

Operative procedure

Under regional epidural anesthesia, the patient was placed in a prone position and a tourniquet was placed on the upper thigh of the affected limb. The unaffected leg was also painted and draped with sterile towels to adjust the tension of the tendon. 8–10 cm incision was made vertically on the medial side of the Achilles tendon [Figure 1c]. The skin and the subcutaneous layer were incised to form a full-thickness skin flap. The aponeurosis was incised vertically, and the Achilles tendon was everted. Fibrous scar tissue at the ruptured end was completely removed. The

gap of the tendon would be measured first intraoperatively to determine whether it is necessary to harvest FHL to reconstruct after fibrous tissue was removed. If the defect at the stump exceeded 6 cm [Figure 1d], a minimally invasive technique was used to harvest the FHL tendon. The posterior fascial compartment was incised to expose the muscle belly and tendon of the FHL. The FHL tendon was retracted and a neural dissector or flexible steel wire was used to strip the FHL tendon from the hindfoot to the midfoot. The plantar side of the midfoot was marked and a 2–3 cm vertical incision was made on the sole of the foot. The plantar fascia was incised and the FHL and brevis tendons were retracted and exposed while paying careful attention to the separation and protection of nerves and vessels. The nerve retractor was used to retract the FHL tendon simultaneously the interconnecting pieces of the FHL and flexor digitorum longus tendons was cut off. A 1–1.5 cm transverse incision was made at the interphalangeal joint of the great toe, and the distal end of the FHL tendon was cut off [Figure 1e]. The tendon was stretched from the incision at the midfoot, and the full-length FHL tendon was removed from the incision at the hindfoot [Figure 1f]. 3 mm holes were drilled 1 cm from the attached distal part of the Achilles tendon and 1.5 cm from the posterior cortex margin of the calcaneus, from the superior-oblique to the posterior-inferior side. The harvested tendon was fixed to the calcaneal tuberosity using a suture anchor of diameter 5.0 mm. The tension of the tendon was adjusted until it was similar to that of the healthy side. Then tendon was fixed to the calcaneus and the Achilles tendon was repaired [Figure 1g]. Using a suture-weave technique, the remaining FHL tendon was penetrated such that it was 2 cm from the proximal end of the Achilles tendon and sewn up. It was then reversely embedded to the distal end of the Achilles tendon [Figure 1h]. Finally, the three tracts of the transferred tendon were sutured and fixed [Figure 1i]. Following placement of a negative pressure drainage device, the subcutaneous layer and skin were sutured [Figure 1j].

Postoperative treatment

After surgery, the affected foot was fixed in a plaster limb brace at 5–10° ankle varus and 25–30° plantar flexion at the ankle to decrease tension in the Achilles tendon. The dressing was changed 1 week after surgery. After 3 weeks, a polymer brace was used to support the position at 15° of plantar flexion and active partial weight-bearing exercises were started. Gait exercises using protective shoes (DARCO Copr. USA) and extension and active ankle exercises were started 6 weeks after surgery. 12 weeks after surgery, the brace and protective shoes were removed and the patients were returned to normal daily life with weight-bearing walking exercises.



Figure 1: Clinical photographs showing the surgical technique: (a) Preoperative lateral Achilles tendon with visible gap (b) preoperative frontal Achilles tendon; (c) preoperative Achilles tendon rupture, with a defect of about 6.0 cm; (d) preoperative Achilles tendon rupture after debridement, with a defect of about 7.0 cm; (e) separation of the flexor hallucis longus tendon by the minimally invasive technique; (f) removal of the flexor hallucis longus tendon from the incision at the mid-hind foot, showing the length available for transplantation; (g) arrow showed the suture anchor was fixed on the calcaneal tuberosity; FHL tendon harvest and Achilles tendon rupture would be sutured together by it; (h and i) reconstruction of the chronic Achilles tendon rupture with the flexor hallucis longus tendon graft; (j) postoperative views of the incisions at the midfoot and lower leg

Followup and curative effect evaluation

Patients were asked to return to the hospital for examination at 2, 4, 6, 8, and 12 weeks postoperatively. Followup X-ray and MRI of the ankle joint were taken [Figure 2b and c]. Wound healing was monitored and guided rehabilitation was started. Afterwards, patients were followed up every 3–6 months to evaluate the function of the ankle joint.

Eighteen months after surgery, postoperative appearance and function were evaluated by the American Orthopedic Foot and Ankle Society-ankle and hindfoot score (AOFAS-AH)

efficacy score^{9,10} and Leppilahti Achilles tendon ratings.¹¹ Efficacy scores on the AOFAS-AH were divided into three categories: Pain, function, and alignment, with each rated as excellent (90–100), good (75–89), fair (50–74) or poor (<50).

Statistical methods

Data were reported as a mean \pm standard deviation, and compared using paired *t*-test. All statistical analyses were performed using SPSS 11.0 software (SPSS, Inc. 233 South Wacker Drive, 11th Floor, Chicago, USA), with a *P* < 0.05 considered statistically significant.



Figure 2: (a) Preoperatively X-ray of ankle joint lateral view, showing the soft tissue discontinuity of Achilles tendon (b) Followup X-ray of ankle joint lateral view and (c) magnetic resonance imaging showing reconstructive Achilles tendon

RESULTS

The time to pull the FHL tendon through the minor incision ranged from 9 to 16 min (mean 11.8 min) and the time to reconstruct the Achilles tendon ranged from 40 to 65 min (mean 52 min). Bleeding during the operation ranged from 20 to 50 mL (mean 32 mL) and postoperative drainage was from 5 to 20 mL (mean 10.2 mL).

Of the 35 patients, 32 were followed up, whereas three were lost to followup. Followup period in the 32 patients ranged from 18 to 72 months (mean 33.2 months). Except for one patient who experienced complications due to wound disruption 10 days after surgery, all other patients showed primary wound healing. The wound in the patient with wound dehiscence was repaired again with delayed union occurring after 6 weeks. The outside of the Achilles tendon appeared smooth in all patients, without hunching or depression. Differences in circumferences 2 cm above the ankle were all within 1 cm. Differences 10 cm below the knee joint were within 1 cm in 27 patients and within 1–3 cm in the other five. None was again ruptured. All patients were capable of lifting their calves and walking on toes after surgery. 18 months after surgery, 28 of the 32 patients had the same strength in both calves, as determined by objective physical examination, whereas 4 remained weaker on the reconstructed side (muscle strength 4/5). Twenty four patients had the same dorsal flexion angle of both ankle joints, whereas 8 were decreased $<10^\circ$. All the patients were satisfied with the resulting ankle function in their normal life.

All the patients lost flexor strength in the metatarsophalangeal joint of the great toe, but none experienced limitations in walking in daily life.

Twelve months after surgery, the mean AOFAS score was 92.56 ± 6.71 , significantly greater than the mean score

before surgery (51.92 ± 7.08 ; $P < 0.05$). Mean Leppilahti Achilles tendon rating score was significantly greater after than before surgery (92.58 ± 5.1 vs. 72.56 ± 7.43 ; $P < 0.05$). The results were excellent in 27 patients, good in 3 and fair in 2. No patient experienced injuries to the sural, posterior tibial, and medial and lateral plantar nerves and none had a painful plantar scar. Of the two patients with fair results, one was too afraid of rerupture of the Achilles tendon reconstruction to participate in rehabilitation training. His ankle joint remained stiff 6 months later, for which he was readmitted to hospital to receive rehabilitation training. The other returned to his home town and did not receive rehabilitation training. His ankle joint was also stiff after 1 year. He, therefore, underwent circular external fixation surgery to gain his ankle joint function.

DISCUSSION

Despite the development of many methods of reconstruction, the repair of chronic Kuwada grade IV tendon rupture is difficult.^{4,6,12-16} Autologous tendon transfer is widely used, with the transfer of the FHL tendon to reconstruct the Achilles tendon having several advantages. First, the FHL tendon is the second strongest muscle, after the triceps surae muscle, in the rear part of the lower leg¹⁷ as well as having properties similar to those of the Achilles tendon. In addition, the FHL tendon contracts in synchrony with the triceps surae muscle during walking. Second, the anatomical features and location of the FHL tendon are close to those of the Achilles tendon, simplifying the surgical procedure. In contrast to the peroneus brevis and flexor digitorum longus tendons, use of the FHL tendon avoids separating vessels and nerve tracts, as well as avoiding incision and exposure of the lateral muscular compartment. Third, suturing the FHL tendon into both ends of the Achilles tendon can facilitate its vascular reformation by allowing microvessels to enter chronic ruptured tissues.⁸ MRI has

shown compensatory hypertrophy of the tendon after transfer of the FHL tendon, with this tendon performing the activities of the Achilles tendon.¹⁸ Therefore, transfer of the FHL tendons can be used to reconstruct Achilles tendons with large defects in patients with chronic Achilles tendon rupture and in some patients with apraxia caused by benign lesions those who may have a section of the Achilles removed.

Many techniques are available for transfer of the FHL tendon to repair Kuwada grade IV chronic Achilles tendon rupture. Good clinical outcomes have been reported using a single-incision technique to harvest the FHL tendon.¹⁹ Moreover, complete removal of the Achilles tendon and reconstruction by transfer of the FHL tendon in patients with continuous pain yielded good results.²⁰

These methods, however, have several potential disadvantages, including limited surgical vision when separating the FHL muscle, which may result in damage to the blood vessels and nerves. In addition, the harvested tendons were too short and could therefore only be used for single-tract suture and fixation. A double-incision technique was later developed, in which a second incision was made at the medial side of the sole, yielding a tendon extending from the navicular bone tubercle to the first metatarsal.¹⁴ Since the abductor muscle was covered and shaded by the flexor hallucis brevis tendon on the plantar side as well as accompanying and being connected to the flexor digitorum longus tendon, the incision should extend distally as far as possible to fully expose the FHL tendon and to harvest a sufficiently long fragment. This creates conditions for repairing tendons with many defects. For example, this method was used to reconstruct the Achilles tendon by inserting the FHL tendon from the posterior side of the calcaneus, increasing its vertical distance to the ankle rotation center, followed by mixed suturing of part of the gastrocnemius muscle to increase the plantar torque of the ankle.²¹ AOFAS scores in these patients increased significantly and the results of single foot standing and walking tests were normal. In addition to providing sufficient tendon to fix the end of the calcaneus, this method allows one or two tracts of the tendon to be reversely sutured and fixed to the triceps muscle. This would bridge and fill defects in the tendon area, greatly enhancing the plantar flexion force of the ankle, and meeting patients' everyday needs. Due to the unique anatomical structure of this tendon (e.g., coverage by the abductor muscle, Henry nodules and potential variations, a coverage of the flexor hallucis brevis tendon and surrounding nerves and vessels), however, a long and deep medial incision during midfoot exposure is required to harvest the tendon. This is very difficult to perform on patients in the prone position. The minimally invasive technique described here resulted in the

exposure of the FHL tendon in a direct view, allowing the surgeon to operate separately using a 3 cm incision, which was relatively easy to perform on patients in the prone position. In addition, a small scar on the plantar side had little influence on the protection of the foot arch.⁷

This technique of FHL tendon transfer had little effect on great toe function, including on flexion force, especially in patients aged over 30 years.²² Six of 7 patients resumed active exercises,¹⁴ and clinical and foot stress image analysis in 16 non athletes showed that tendon transfer had a negligible effect on flexion force after surgery,²³ suggesting that the flexor hallucis brevis tendon had a compensatory effect. Straightening of the interphalangeal joint transferred the thrust to the distal phalanx.

The minimally invasive technique we describe can result in the harvesting of the FHL tendon from a midfoot or forefoot incision, depending on the length required for reconstruction. Since the junction of the muscles must be cut off, a midfoot incision is necessary to harvest a full-length FHL tendon; otherwise, incising only the interphalangeal part of the great toe to harvest the FHL tendon through retraction will not be successful.

Similar to other regular reconstructions of the Achilles tendon, reconstruction using the FHL tendon may result in complications, such as wound dehiscence, infections and sural nerve injury. Other related complications may include improper tension adjustment of the Achilles tendon, weakened foot propulsion caused by the graft being too loose and too long and varus deformity of the foot caused by the graft being too tight. Other potential complications may include incision infection, dehiscence, painful plantar scar formation, medial and lateral plantar nerve and vessel injuries and weakened plantar flexion force as a result of the tendon being transferred.^{8,19,20}

There are several important considerations when performing the surgery. Thorough debridement is necessary. After determining the resection range, based on preoperative symptoms, abnormal MRI results and intraoperative findings, the Achilles tendon tissues, the surrounding areas of dysplastic fibrosis and degenerated scar tissues should be thoroughly debrided, since the lack of debridement may result in residual postoperative pain.⁴ The nerves and vessels should be sufficiently exposed and protected. A study of nerve injuries in 24 cadavers from which the FHL tendons had been removed showed that 8 (33%) had injuries to the medial and lateral nerves, with 2 (8.3%) having a complete injury.²⁴ The proximal end of the graft should be embedded at least 2 cm into the Achilles tendon to prevent fracture and avulsion of the joint area.

The technique described here is not suitable for professional athletes and sports enthusiasts since their great toes have higher requirements.¹⁰ In non-athletes, however, this less invasive method is suitable not only for the reconstruction of chronic Achilles tendon rupture with large defects but also for other benign lesions that require the resection of a large area of the affected Achilles tendon.²⁵ Further research is necessary to determine the long term effects of this minimally invasive method on patients' daily activities and to compare this method with other methods used to reconstruct the Achilles tendon.

Financial support and sponsorship

This study was supported by Zhejiang Provincial Medical Technology Program of China (No. 2014KYB107) and Zhejiang Provincial Natural Science Foundation of China (No. LQ15H060002).

Conflicts of interest

There are no conflicts of interest.

REFERENCES

- Suchak AA, Bostick G, Reid D, Blitz S, Jomha N. The incidence of Achilles tendon ruptures in Edmonton, Canada. *Foot Ankle Int* 2005;26:932-6.
- Mazzone MF, McCue T. Common conditions of the Achilles tendon. *Am Fam Physician* 2002;65:1805-10.
- Padanilam TG. Chronic Achilles tendon ruptures. *Foot Ankle Clin* 2009;14:711-28.
- Maffulli N, Ajis A. Management of chronic ruptures of the Achilles tendon. *J Bone Joint Surg Am* 2008;90:1348-60.
- Panchbhavi VK. Percutaneous techniques for tendon transfers in the foot and ankle. *Foot Ankle Clin* 2014;19:113-22.
- Elias I, Besser M, Nazarian LN, Raikin SM. Reconstruction for missed or neglected Achilles tendon rupture with V-Y lengthening and flexor hallucis longus tendon transfer through one incision. *Foot Ankle Int* 2007;28:1238-48.
- Panchbhavi VK, Yang J, Vallurupalli S. Minimally invasive method of harvesting the flexor digitorum longus tendon: A cadaver study. *Foot Ankle Int* 2008;29:42-8.
- DeCarbo WT, Hyer CF. Interference screw fixation for flexor hallucis longus tendon transfer for chronic Achilles tendonopathy. *J Foot Ankle Surg* 2008;47:69-72.
- Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. *Foot Ankle Int* 1994;15:349-53.
- Ibrahim T, Beiri A, Azzabi M, Best AJ, Taylor GJ, Menon DK. Reliability and validity of the subjective component of the American Orthopaedic Foot and Ankle Society clinical rating scales. *J Foot Ankle Surg* 2007;46:65-74.
- Leppilahti J, Forsman K, Puranen J, Orava S. Outcome and prognostic factors of Achilles rupture repair using a new scoring method. *Clin Orthop Relat Res* 1998;346:152-61.
- Martinelli B. Percutaneous repair of the Achilles tendon in athletes. *Bull Hosp Jt Dis* 2000;59:149-52.
- Pintore E, Barra V, Pintore R, Maffulli N. Peroneus brevis tendon transfer in neglected tears of the Achilles tendon. *J Trauma* 2001;50:71-8.
- Wapner KL, Pavlock GS, Hecht PJ, Naselli F, Walther R. Repair of chronic Achilles tendon rupture with flexor hallucis longus tendon transfer. *Foot Ankle* 1993;14:443-9.
- Frenette JP, Jackson DW. Lacerations of the flexor hallucis longus in the young athlete. *J Bone Joint Surg Am* 1977;59:673-6.
- Den Hartog BD. Surgical strategies: Delayed diagnosis or neglected Achilles' tendon ruptures. *Foot Ankle Int* 2008;29:456-63.
- Silver RL, de la Garza J, Rang M. The myth of muscle balance. A study of relative strengths and excursions of normal muscles about the foot and ankle. *J Bone Joint Surg Br* 1985;67:432-7.
- Hahn F, Meyer P, Maiwald C, Zanetti M, Vienne P. Treatment of chronic Achilles tendinopathy and ruptures with flexor hallucis tendon transfer: Clinical outcome and MRI findings. *Foot Ankle Int* 2008;29:794-802.
- Mann RA, Holmes GB Jr, Seale KS, Collins DN. Chronic rupture of the Achilles tendon: A new technique of repair. *J Bone Joint Surg Am* 1991;73:214-9.
- Martin RL, Manning CM, Garcia CR, Conti SF. An outcome study of chronic Achilles tendinosis after excision of the Achilles tendon and flexor hallucis longus tendon transfer. *Foot Ankle Int* 2005;26:691-7.
- Wegrzyn J, Luciani JF, Philippot R, Brunet-Guedj E, Moyen B, Besse JL. Chronic Achilles tendon rupture reconstruction using a modified flexor hallucis longus transfer. *Int Orthop* 2010;34:1187-92.
- Mahajan RH, Dalal RB. Flexor hallucis longus tendon transfer for reconstruction of chronically ruptured Achilles tendons. *J Orthop Surg (Hong Kong)* 2009;17:194-8.
- Coull R, Flavin R, Stephens MM. Flexor hallucis longus tendon transfer: Evaluation of postoperative morbidity. *Foot Ankle Int* 2003;24:931-4.
- Mulier T, Rummens E, Dereymaeker G. Risk of neurovascular injuries in flexor hallucis longus tendon transfers: An anatomic cadaver study. *Foot Ankle Int* 2007;28:910-5.
- Lee K, Moon JS, Seo JG, Lee WC. One-stage treatment of deep infection following repair of Achilles tendon rupture with flexor hallucis longus transfer. *Knee Surg Sports Traumatol Arthrosc* 2009;17:313-5.