SURGICAL TECHNIQUE

Percutaneous Repair Technique for Acute Achilles Tendon Rupture with Assistance of Kirschner Wire

Ze-yang He, MD¹, Ming-xiang Chai, MD², Yue-ju Liu, MD¹, Xiao-ran Zhang, MD¹, Tao Zhang, MD¹, Lian-xin Song, MD¹, Zhi-xin Ren, MD¹, Xi-rui Wu, MD¹

¹Department of Orthopaedic Surgery and Key Biomechanical Laboratory of Orthopaedics, Third Hospital of Hebei Medical University, Shijiazhuang, and ²First Affiliated Hospital of Xinxiang Medical College, Xinxiang, China

The aim of this study is to introduce a self-designed, minimally invasive technique for repairing an acute Achilles tendon rupture percutaneously. Comparing with the traditional open repair, the new technique provides obvious advantages of minimized operation-related lesions, fewer wound complications as well as a higher healing rate. However, a percutaneous technique without direct vision may be criticized by its insufficient anastomosis of Achilles tendon and may also lead to the lengthening of the Achilles tendon and a reduction in the strength of the gastrocnemius. To address the potential problems, we have improved our technique using a percutaneous Kirschner wire leverage process before suturing, which can effectively recover the length of the Achilles tendon and ensure the broken ends are in tight contact. With this improvement in technique, we have great confidence that it will become the treatment of choice for acute Achilles tendon ruptures.

Key words: Acute Achilles tendon rupture; Kirschner wire; Percutaneous repair

Introduction

Acute Achilles tendon rupture (AATR) is a common ankle injury which usually involves overweight men aged from 30 to 50 years. Patients suffer an Achilles tendon injury usually due to lack of physical exercises and ruptures, frequently occurring when playing badminton. Surgical and conservative treatments are both employed to treat AATR, but surgeons prefer to operate with the aim of improving early ankle movement. The operation includes a traditional open repair, a mini-open suture and the percutaneous technique. However, there is still disagreement over the best treatment for AATR as far as we know.

To avoid sural nerve injuries when the traditional open repair is chosen, a medial longitudinal incision is usually performed. The tendon aponeurosis can be repaired using direct vision to ensure the contact of the Achilles broken ends. Unfortunately, soft tissue complications such as skin edge necrosis, incision infection and superficial wound dehiscence trouble surgeons¹. While a mini-open² suture indeed reduces

the incidence of related complications, it requires a harpoon device known as the Tenolig device (Fournitures Hospitalieres Industrie, Quimper, France), which limits the wide use of the technique. Percutaneous methods have emerged at a historic moment with the aim of exploring a new technique that is both simple and feasible and that also prevents wound complications. Recently, several percutaneous repair techniques have been introduced to treat AATR, with the common characteristic of minimizing lesions of the surrounding soft tissue by percutaneous suturing, protecting the blood supply to the broken ends and reducing the wound complication rate³.

Nevertheless, there are still some imperfections to percutaneous repair. Since the suturing is performed percutaneously, anatomical structures cannot be clearly observed, the sural nerve sometimes injured, especially at the proximal portion of the Achilles tendon⁴. What is more important, a residual gap may remain in the tendon ends⁵, leading to tendon lengthening and re-rupture^{6,7}.

Address for correspondence Xi-rui Wu, MD, Department of Orthopaedic Surgery and Key Biomechanical Laboratory of Orthopaedics of Hebei Province, Third Hospital of Hebei Medical University, Shijiazhuang, China 050051. Tel: 0086-018633046361; Fax: 0086-311-88603626; Email: gukehyz@163.com

Disclosure: The authors have no conflict of interest to declare.

Received 22 August 2015; accepted 7 September 2015

Fig. 1 Arrow a: The proximal end of ruptured tendon. Arrow b: The distal end of ruptured tendon. The longitudinal incision was made on the interval of tendon ends close to distal end of ruptured tendon. Arrows c: Six symmetrical mini-incisions along the medial and lateral edges of the tendon on the proximal tendon.

To address out those problems, we have improved the traditional percutaneous repair technique with the application of several Kirschner wires (K-wires). This method provides adequate apposition of the tendon ends by a boating-like leverage of K-wires when involving the proximal end of Achilles tendon. Therefore, we here propose percutaneous repair assisted by K-wires.

Technique

Typical Case

We here introduce a typical case. The patient suffered from AATR after playing badminton. A palpation test and Thompson's test were both positive. This patient was treated by percutaneous repair with K-wire leverage within 3 days after the acute tendon rupture. The affected side was fixed with a plaster cast for 4–5 weeks and the patient was encouraged to full weight-bearing 6 weeks post-operatively. The ankle function returned to normal after 12 weeks, meanwhile the patient could perform a single heel-rise.

Detailed Suturing Technique

After anesthesia, the patient is placed on the operation table in a prone position. A 0.5 cm longitudinal incision is made on the interval of the tendon ends close to the distal end (Fig. 1). Then four and six symmetrical mini-incisions (<5 mm) are made vertically along the medial and lateral edges of the tendon, respectively, on the distal and proximal tendon (Fig. 1). The intervals between each mini-incision are approximately 25–30 mm. A No.1 Coated Vicryl Plus Antibacterial Suture (Ethicon, Somerville, NJ, USA) is selected for the surgery. The needle is inserted into the distal stump of tendon at the very beginning, and figure 8-shaped suturing is performed using the same exit as the entry point (Fig. 2). To prevent forming a dimple fossette, a K-wire can be used to exposure the mini-

incisions during suturing. When the distal end has been sutured, the suture is pulled firmly in a distal to proximal direction to double-check that the suture of the distal end is reliable. Then, the same method may be used to suture the proximal end of the tendon. Since soft tissue is fairly thick (Fig. 3), especially in obese patients, when suturing the proximal tendon, a large needle such as an 11 × 34 round needle should be selected. We were able to ensure whether the needle traversed the layer of tendon by the resistance of round needle. Since the proximal incision is near the medial margin of leg (Fig. 1), this can effectively avoid iatrogenic injury to the sural nerve. The suture is kept in tension during the whole process of surgery, and four surgical knots are made, assisted by the plantarflexion of the foot. Thompson's test is performed to check whether continuity has been reestablished after surgery. The mini-incisions do not have to be sutured but the larger one on the interval must be sutured to avoid having knots exposed on the skin. The involved ankle must be immobilized by a cast for 4–5 weeks before active ankle exercise can take place.

Fig. 2 The purple line indicates the figure-8 shape suture trajectory of the inside tendon.

Fig. 3 Since the soft tissue of the proximal tendon is fairly thick (red arrow), a large curve needle can easily reach the layer of tendon.

Improvements in Technique 1

Four K-wires are inserted symmetrically into the proximal tendon before suturing (Fig. 4). Then the proximal tendon is moved down by boating-like leverage of K-wires which provide a precise apposition of the tendon ends. On withdrawing two K-wires the other two K-wires and another one are pierce transversely through proximal and distal end, respectively, while several rubber bands are wrapped (Fig. 5). Then, suture percutaneously (as was described in detail above) after the tendon gap has disappeared.

Improvements in Technique 2

After the suturing of distal tendon has been finished, several K-wires are used to provide adequate apposition of the tendon ends and recover their continuity by leverage of the proximal tendon (Fig. 6). At this time suturing proximal tendon can begin. (This second technique is only selected if the first one does not work).

From January 2013 to May 2015, five patients were treated using the traditional percutaneous repair technique and five were treated using the modified percutaneous repair technique. All 10 patients were in a short leg plaster slab for 4 or 5 weeks post-operation and did rehabilitation exercises supervised by the surgeon. The follow-up result was that in the traditional percutaneous group, there was one case of lengthening of the tendon. There were no wound complications, lengthening of tendon or re-rupture in modified percutaneous group.

Discussion

In summary, treatment of AATR remains controversial in the medical field. Open repair, which lead to higher rates of post-operative complications, especially wound complications, can obtain better functional outcomes than conservative methods. The traditional percutaneous technique can avoid effectively several of the risks of open repair, but in most cases a gap remains between tendon stumps. Doral *et al.* have argued that the indirect visualization and manipulation of the tendon stumps did not provide an adequate conjunction, thus influencing functional recovery of tendon post-operation⁸. Therefore, Blankstein *et al.* have proposed percutaneous repair of AATR with ultrasound assistance to permit the accurate apposition visually⁹. Other authors have also argued for endoscopy-

Fig. 4 Four K-wires are inserted symmetrically into the proximal tendon along the direction of arrow a. Then the tendon ends can achieve precise apposition (arrow c) using the boating-like leverage of K-wires along the direction of arrow b.

Fig. 5 Several rubber bands (red arrow) are wrapped round the K-wires, which provide an adequate apposition of tendon stumps.

assisted percutaneous suturing. However, the above modified technique is complex and expensive^{10,11}.

Modified Percutaneous Repair Technique

In the light of these realities, we propose an improved new percutaneous repair technique assisted with K-wires. Not only does this new technique give full play to the superiority of percutaneous repair, but it effectively makes up for its defects and is simple and less costly than alternatives. Its theoretical basis is as follows: the tendon gap length increases as a result of the gastrocnemius contraction when the Achilles tendon ruptures. Intraoperatively, we can touch the gap reduction or disappearance after the proximal tendon is moved down by leverage with K-wires, which provides an adequate apposition of the tendon stumps. Afterwards we suture percutaneously, meanwhile maintaining the tension in the tendon. This improved new technique could reduce several other complications, such as re-rupture and tendon lengthening, together with wound complications post-operation.

Fig. 6 Before suturing the proximal tendon, several K-wires (yellow line) are used to provide adequate apposition of the tendon ends by leverage of the proximal tendon along the direction of the red arrow.

However, the new technique can be selected only for a rupture located 2–6 cm from the tendon insertion, and it cannot be used for the junction of the muscle belly and tendon or an old Achilles tendon rupture. It can also be applied to a tendon insertion rupture by drilling into calcaneus; however, we have not encountered such cases during therapy.

Suture Technique and Suture Line

In addition, we employ the modified Bunnell suture technique (Fig. 2), which is designed and widely used on the basis of open surgery. The proximal portion of Achilles tendon is thin, but the suture passes through the tendon parallel and diagonally, making more pullout strength and it is convenient for percutaneous repair with less possibility of re-rupture. Some scholars suggest it will have a better conjunction of tendon ends if two stitches are utilized in the operation and if the two knots are tied on both sides of the tendon stumps. We prefer to use one stitch intra-operatively, and to tie the knot on one side of the ends. During the process, we tighten the suture to make the fixation as firm as possible and maintain suture tension. We are concerned that using two knots will increase the incidence of soft tissue complication. In our study, we have found that one stitch is strong enough, and there are no increase of the post-operative complications. We prefer to use No.1 Coated Vicryl Plus Antibacterial Suture. It has been previously reported that local pain and s.c. nodules occur due to the use of a non-absorbable suture¹². The suture we use leads to few soft tissue complications. It will retain 75% of its total tension 2 weeks after surgery and 50% of its total tension 4 weeks afterwards. In addition, it is completely absorbed after 70 days. In a reciprocal relationship the healing of the Achilles tendon makes up for the decline in the strength of the suture. Moreover, the suture contains Irgacare MP (one of the highest purity forms of triclosan) and it can produce an antibacterial zone around the suture to protect it from the colonization of bacteria. The suture also effectively kills the bacteria common in surgical infections.

Finally, several authors have recommended using an above the knee cast with a knee flexion to relax the gastrocne-

mius, which further reduces the gap distance^{13,14}. However, recent studies have indicated that tendon gap distance decreases by only 1 mm with a knee flexion in the order of 30°¹⁵. Furthermore, this method has no clinical significance on the magnitude of change in gap distance and increases the risk of a thromboembolism because it is cumbersome. Therefore, we propose a cast below the knee and metatarsophalangeal joint with maximum plantarflexion of the ankle for 4–5 weeks. In this method, partial muscle contraction promotes blood circulation and prevents a thromboembolism and, when coupled with an elastic bandage improves comfort. Post-operatively, functional exercise is similar to that recommended in open repair but the time to remove the plaster and undertake weight-bearing exercise is 1–2 weeks earlier than with traditional open surgery.

Plaster Cast Technique

Recently, with the increasing number of patients with AATR owing to the rise in fitness consciousness, finding a simple, safe, and effective method is particularly significant. We consider that the K-wire-assisted percutaneous repair of AATR described here to be a reproducible, inexpensive, safe, and effective technique. Meanwhile, studies with large sample sizes and long-term follow up needed to confirm its clinical efficacy.

Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Video S1 Percutaneous repair technique for acute Achilles tendon rupture with assistance of Kirschner wire.

References

1. Holm C, Kjaer M, Eliasson P. Achilles tendon rupture—treatment and complications: a systematic review. *Scand J Med Sci Sports*, 2015, 25: e1–e10.
2. Bartel AF, Elliott AD, Roukis TS. Incidence of complications after Achillon® mini-open suture system for repair of acute midsubstance achilles tendon ruptures: a systematic review. *J Foot Ankle Surg*, 2014, 53: 744–746.
3. Henríquez H, Muñoz R, Carcuro G, Bastías C. Is percutaneous repair better than open repair in acute Achilles tendon rupture? *Clin Orthop Relat Res*, 2012, 470: 998–1003.
4. Giannetti S, Patricola AA, Stancati A, Santucci A. Intraoperative ultrasound assistance for percutaneous repair of the acute Achilles tendon rupture. *Orthopedics*, 2014, 37: 820–824.
5. Fujikawa A, Kyoto Y, Kawaguchi M, Naoi Y, Ukegawa Y. Achilles tendon after percutaneous surgical repair: serial MRI observation of uncomplicated healing. *AJR Am J Roentgenol*, 2007, 189: 1169–1174.
6. Soubeyrand M, Serra-Tosio G, Campagna R, Molina V, Sitbon P, Biau D. Intraoperative ultrasonography during percutaneous Achilles tendon repair. *Foot Ankle Int*, 2010, 31: 1069–1074.
7. Hockenbury RT, Johns JC. A biomechanical in vitro comparison of open versus percutaneous repair of tendon Achilles. *Foot Ankle*, 1990, 11: 67–72.
8. Doral MN, Bozkurt M, Turhan E, et al. Percutaneous suturing of the ruptured Achilles tendon with endoscopic control. *Arch Orthop Trauma Surg*, 2009, 129: 1093–1101.
9. Blankstein A, Israeli A, Dudkiewicz I, Chechik A, Ganel A. Percutaneous Achilles tendon repair combined with real-time sonography. *Isr Med Assoc J*, 2007, 9: 83–85.
10. Chan KB, Lui TH, Chan LK. Endoscopic-assisted repair of acute Achilles tendon rupture with Krackow suture: an anatomic study. *Foot Ankle Surg*, 2009, 15: 183–186.
11. Chiu CH, Yeh WL, Tsai MC, Chang SS, Hsu KY, Chan YS. Endoscopy-assisted percutaneous repair of acute Achilles tendon tears. *Foot Ankle Int*, 2013, 34: 1168–1176.
12. Ingvar J, Tägil M, Eneroth M. Nonoperative treatment of Achilles tendon rupture: 196 consecutive patients with a 7% re-rupture rate. *Acta Orthop*, 2005, 76: 597–601.
13. Fruensgaard S, Helmig P, Riis J, Stovring JO. Conservative treatment for acute rupture of the Achilles tendon. *Int Orthop*, 1992, 16: 33–35.
14. Keller J, Rasmussen TB. Closed treatment of Achilles tendon rupture. *Acta Orthop Scand*, 1984, 55: 548–550.
15. Qureshi AA, Ibrahim T, Rennie WJ, Furlong A. Dynamic ultrasound assessment of the effects of knee and ankle position on Achilles tendon apposition following acute rupture. *J Bone Joint Surg Am*, 2011, 93: 2265–2270.