

Contents lists available at [ScienceDirect](#)

Asian Pacific Journal of Tropical Medicine

journal homepage: www.elsevier.com/locate/apjtm

Document heading doi:

Application of internal fixation of steel–wire limited loop in early Achilles tendon rupture

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ARTICLE INFO

Article history:

Received 10 August 2013

Received in revised form 15 September 2013

Accepted 15 October 2013

Available online 20 November 2013

Keywords:

Achilles tendon rupture

Steel–wire limited loop

Internal fixation

Ankle function

ABSTRACT

Objective: To explore the clinical effect and safety of internal fixation of steel–wire limited loop in early Achilles tendon rupture. **Methods:** Seventy–six patients respectively with early transected and avulsed types of Achilles tendon rupture were selected and treated with internal fixation of steel–wire limited loop. The patients began to take exercise for their lower limbs through continuous passive motion as early as possible after surgical repair, and the loops were removed after 3–5 months. Six months later, the condition of complications including Achilles tendon re–rupture, wound fistula, wound infection and skin necrosis, cutaneous sensation in sural nerve dominance region, time back to preinjury work or learning as well as time to physical activities were observed. One year later, the therapeutic effect was evaluated, and the maximum circumferences of bilateral legs and ruptured plane circumferences of Achilles tendon were measured. **Results:** The wound of all patients healed well, no complications like Achilles tendon re–rupture, wound fistula, wound infection and skin necrosis occurred, and the cutaneous sensation in sural nerve dominance region was normal. The mean time back to preinjury work or learning as well as to physical activities of all patients were respectively 10 and 22 weeks. Seventy out of 76 patients (92.1%) achieved an excellent effect, and 6 (7.9%) good effect. The excellent and good rate came up to 100%. The maximum circumference in the affected leg decreased to 2 mm averagely compared with the offside, while the ruptured plane circumferences of Achilles tendon in the affected side increased to 2.2 mm compared with the offside. **Conclusions:** For early Achilles tendon rupture, internal fixation of steel–wire limited loop can recover the ankle function better, return to the preinjury state in the shortest time, and has few complications.

1. Introduction

Achilles tendon rupture, a commonly–encountered sport injury, is a rupture occurring in the tissue of Achilles tendon, and usually occurs in unilateral limb. Post–injury swelling covers the depression caused by Achilles tendon rupture, and both plantar tendon and tendon of

flexor pollicis longus compensate the plantar flexion myodynamia in the ankle joint, moreover, X–ray film can not reveal this kind of injury, all of which contribute to the missed diagnosis of some patients at the first visit[1]. Besides, it is difficult to repair the fresh injury due to the particularity of regional anatomy and mechanics, which severely affects the therapeutic effect[2,3]. The conservative treatment has a higher incidence of Achilles tendon disunion and re–rupture, and open surgery can guarantee the repaired quality of Achilles tendon and reduce re–rupture incidence, but has a higher incidence of incision complications[4]. The incision complications through percutaneous repair are few, whereas re–rupture and extension of Achilles tendon usually occur[5].

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Foundation project: It is supported by Scientific Research Planned Project of Taizhou Science and Technology Bureau in Zhejiang; NO. 031212.

At present, there are still some disputes in clinic regarding the best therapeutic regimen of Achilles tendon rupture. In the study, the internal fixation of steel–wire limited loop was used to treat early Achilles tendon rupture, and achieved a good therapeutic effect. Presently reports as follows:

2. Materials and methods

2.1. General data

Seventy–six patients respectively with early transected and avulsed types of Achilles tendon rupture were selected in our hospital from Dec., 2003 to Jan., 2013. The patients with local surgical history, Achilles tendon rupture >1 month, complicated Achilles tendon rupture accompanied by soft tissue injury, senile dementia and psychiatric illness were excluded. Forty–nine out of 76 patients were males, and 26 were females. They were 16–58 years old, and the mean age was 37.5 years old. Achilles tendon ruptures occurring in the left and right were respectively 34 and 42 cases. Sixty–three patients had sharp instrument injury, and 13 ones avulsion. There were 34 workers, 20 business clerks, 13 civil servants, 5 students and 4 police.

2.2. Surgical method

The patient was in prone position, and an incision was made in his posteromedial leg. With touching sunk Achilles tendon as a center, the incision with length of 4–6 cm was cut open longitudinally 1 cm away from the medial Achilles tendon through “limited exposure” technique^[6], to prevent the soft tissue around Achilles tendon from damage as far as possible to reduce the postoperative scar. The skin, subcutaneous tissue and tendon sheath were pungently incised under the condition of minimum separation of subcutaneous tissue, and turned over together with tendon sheath to form a full thick flap to prevent skin exfoliation or necrosis. For the patient with open injury, the transverse wound was slightly extended longitudinally in the posteromedial leg to expose Achilles tendon rupture and repair its broken ends (Figure 1). The longitudinal incisions with length of 1 cm were respectively made in the bilateral Achilles tendon terminals, and a bone tunnel was drilled in distal Achilles tendon terminals from inside to outside (Figure 2). The soft stainless–steel wire with the diameter of 0.6 mm was twisted to be double–stranded. According to Kessler method, it was first penetrated into the lateral side of proximal Achilles tendon, then went through 2–3 cm from the broken surface, and finally was across Achilles tendon after winding 1/4 circumference forward and laterally. At this moment, some patients could be given medical dacron

patches ($1.5\text{ cm}^2 \times 0.8\text{ cm}^2$) to cushion for preventing the proximal avulsion. The steel wire went through from inside broken surface after winding 1/4 circumference backward, and then its two broken ends were respectively penetrated into distal broken ends of Achilles tendon and went through from a small incision parallel to bilateral Achilles tendon terminals. Then the steel–wire loop was tightened up by the medial steel wire through a bone tunnel in the lateral calcaneal tuberosity to tightly make two broken ends of Achilles tendon anastomosis without tension (Figure 3), and two lock catches were fixed tightly with a forceps clip (Figure 4). Two broken ends were sutured carefully with absorbable catgut according to Bunnell method (Figure 5). Only when there were no cuts and looseness in the steel–wire loop and broken ends after passive functional exercises like extreme plantar flexion and dorsal flexion of the affected foot were taken could the incision be closed (Figure 6, 7). After that, the incision was sutured intermittently with 2/0 catgut, and the tendon sheath of Achilles tendon was first repaired (Figure 8). It should be noted to protect small saphenous vein and sural nerve in the process of suture. Finally, medical sodium hyaluronate was smeared on Achilles tendon surface after the incision was sutured with silk thread (Figure 9). Continuous passive motion was immediately applied to the affected limb to promote its recovery after surgery. 3–4 weeks later, the patient began wearing high–heel shoes to leave the bed to take activities (Figure 10, 11). 3–5 months later, the steel–wire limited loop can be removed.



Figure 1. Achilles tendon was exposed by surgery. It could be seen that Achilles tendon completely ruptured away from 5–6 cm to its terminal, and the broken end was like a hose–tail avulsion, unevenly.



Figure 2. A bone tunnel was drilled in the middle of the calcaneus, and then the soft stainless–steel wire was penetrated into two ends according to the order.

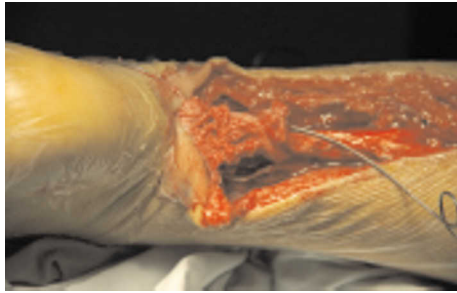


Figure 3. Tightening the stainless-steel wire step by step made the two broken ends of Achilles tendon anastomosis without tension.



Figure 4. Two lock catches were fixed tightly with a forceps clip.



Figure 5. Two broken ends were sutured carefully with absorbable catgut.



Figure 6. Extreme dorsal flexion of ankle joint after surgery suggested that the patient after surgery can immediately get 90 ° functional position and overcome the resistance.



Figure 7. Plantar flexion of ankle joint after surgery.

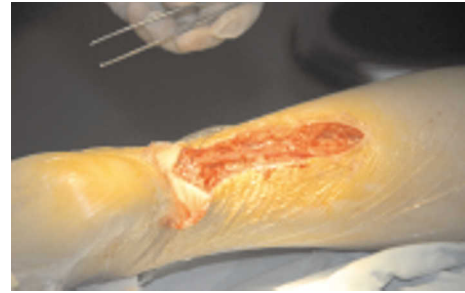


Figure 8. The incision was sutured intermittently from the tendon sheath with 2/0 catgut.



Figure 9. The incision was sutured to close with silk thread.



Figure 10. Anteroposterior ankle X-ray 3-4 weeks after surgery.



Figure 11. Lateral ankle X-ray 3-4 weeks after surgery.

2.3. Index observation

The follow-up visit was performed 6 months after surgery.

The condition of complications including Achilles tendon re-rupture, wound fistula, wound infection and skin necrosis was observed, cutaneous sensation in sural nerve dominance region, time back to preinjury work or learning as well as time to physical activities were inquired. One year later, the therapeutic effect was evaluated, and the maximum circumferences of bilateral legs and ruptured plane circumferences of Achilles tendon were measured.

2.4. Evaluation on the therapeutic effect

The clinical effect was divided into four levels^[7]. Excellent: ankle dorsiflexion 20 °C–30 °C, planter flexion 40 °C–50 °C, flexibly squat, no calf muscle atrophy, muscle strength grades 4–5; good: ankle dorsiflexion 15 °C–25 °C, planter flexion 30 °C–40 °C, the reduction of calf circumference less than 1 cm compared with the unaffected side, capable of squatting under the condition of slightly nervous Achilles tendon; general: ankle dorsiflexion no more than 15 °C, planter flexion no more than 30 °C, powerful treading, the reduction of calf circumference less than 2 cm compared with the unaffected side, limited squat; poor: stiff ankle joint.

3. Results

All patients achieved the follow-up visit, the time ranged from 6 months to 4 years, and the mean time was 22 months. The wound of all patients healed well, no complications like Achilles tendon re-rupture, wound fistula, wound infection and skin necrosis occurred, and the cutaneous sensation in sural nerve dominance region was normal. All patients recovered to the state of preinjury work or learning, and the recovery time was 6–18 weeks, averagely 10 weeks. Besides, they all recovered to the state of preinjury physical activities, and the recovery time was 16–26 weeks, averagely 22 weeks. Seventy out of 76 patients (92.1%) achieved an excellent effect, and 6 (7.9%) good effect. The excellent and good rate came up to 100%. The maximum circumference in the affected leg decreased to 0.0–8 mm compared with the offside, averagely 2 mm. The ruptured plane circumferences of Achilles tendon in the affected side increased to 0.5–3.6 mm compared with the offside, averagely 2.2 mm.

Take one patient for example, two months after surgery, the patient was taken X-ray pictures in anteroposterior and lateral positions, respectively (Figures 12, 13), and meanwhile, his apparent picture about wound healing was also taken (Figure 14). All of them illustrated that his postoperative recovery was pretty good.



Figure 12. Anteroposterior ankle X-ray 2 months after surgery.



Figure 13. Lateral ankle X-ray 2 months after surgery.



Figure 14. The wound healing condition 2 months after surgery.

4. Discussion

Achilles tendon is the longest and strongest tendon in the body, with a length of about 15 cm. It originates from the middle part of the leg, composed of gastrocnemius tendon (lateral 1/3) and soleus tendon (2/3). Achilles tendon angiography confirms that blood supply is sufficient in

adjacent terminals and muscle side, and is less in the middle of the tendon. The wound can cause partial malnutrition and degeneration, consequently leading to Achilles tendon rupture^[8]. It is defined as being neglected if the diagnosis is made at least 4 weeks after the trauma, meanwhile the neglected cases are easily to develop complications, and the functional recovery is poor^[9]. In general, they were treated with various surgical techniques through different tissues for augmentation. In addition, Achilles tendon rupture is closely associated with traumatic causes, and usually divided into three types^[10,11]: a. transected type. It is an open injury caused by cuts. According to the injury degree, it is divided into complete or partial rupture. The rupture with uniform broken surface often occurs about 3 cm above the terminals, and retracts about 3–5 cm proximally; b. avulsed type. It is an open or close injury caused by direct hit or bump. Achilles tendon terminal is avulsed or completely broken 1.5 cm above the terminal. The broken surface is oblique and yet uniform. A small number of tendon fibers are avulsed at the proximal tendon end, and the proximal retraction is more than 5 cm; c. lacerated type. It frequently occurs in actors or athletes. Achilles tendon is completely broken 3–4 cm above the terminal. The uneven broken end with different lengths is like horsetail. It is applicable to take non-surgical treatment, while the former two are suitable for surgery. However, all broken ends need about 6 months to be healed completely whether surgical or non-surgical treatment is performed.

There are various methods to treat early Achilles tendon rupture from simple Bunnell and Kessler end to end anastomosis to complicated reinforcement by fascia, plantar and fibular tendons or artificial tendon transplantation, but the purpose is the same, namely helping the patients return to work and activity in the shortest time and decreasing the incidence of complications. In recent years, the studies revealed that minimal invasive incision, arthroscopic repair and tendon skin suture can evidently reduce the occurrence of postoperative complications, but they all can affect Achilles tendon healing or intensity after healing^[12-14]. In addition, long-term fixation of gypsum plantar flexion easily results in ankle deformation and stiff. Gigante et al compared the therapeutic effects of open surgery with tendon skin suture for treating acute rupture of Achilles tendon, the results demonstrated that tendon skin suture can reduce the occurrence of complications like skin infection and necrosis, but can increase the damage rate of sural nerve^[12].

The internal fixation of steel-wire limited loop is an effective surgical method created by our hospital to treat Achilles tendon rupture. About two years ago, double-stranded steel wire was adopted to perform a surgery.

However, in recent two years, it is replaced by titanium cable twisted by multi-stranded titanium wire (Zimmer Inc). This sort of titanium cable with a needle on one side can be used directly, which makes the surgery more simple and convenience in performance. In a word, based on a lot of clinical practice, it has been found that the internal fixation of steel-wire limited loop has the following unique advantages: a. conducive to broken end anastomosis and repair of Achilles tendon. The proximal broken end is sutured with the steel wire by Kessler method to form a binding force on the tendon bundle, which makes the friction between steel wire and tendon bundle increase so as to reduce the opportunities of steel-wire slippage and tendon splitting and drags the proximal retracted tendon end effectively to make two broken ends connected closely without tension. The tension mainly acts on the binding muscle bundle, and there is no tension at the broken end, hence, it is conducive to endogenous tendon healing. In addition, Kessler suture method can promote tendon healing without influences on blood supply at the broken end within the tendon. Bunnell suture method is applied by catgut at the broken end to ensure smooth anastomosis, meanwhile, medical sodium hyaluronate is applied locally to reduce postoperative foreign-body reaction and scar formation and adhesion; b. taking activities in early period. The limited loop causes stress short circuit. There is no tension at anastomotic ends no matter the treatment is extreme dorsiflexion or plantar flexion, so continuous passive motion exercise can be taken after operation to improve the ankle function; c. preventing postoperative re-rupture. Double-stranded steel wire like a rope not only has sufficient strength to prevent rupture, but also can increase the contact area and friction to prevent splitting or avulsion when passing through Achilles tendon. If the proximal tendon end is weak, medical dacron patches can be cushioned to prevent postoperative proximal avulsion further; if the horsetail shape at the broken end is uneven, it should be cautiously braked 1–3 weeks after surgery; d. preventing postoperative infection. The steel wire is completely placed into the body. Compared with traditional methods (the steel wire was draught from the body and fixed with buttons), it can prevent postoperative infection of steel-wire canal, reduce scar adhesion and facilitate nursing. After the wound heals and the stitches are removed, patients can wear high-heel shoes or sneakers to walk and take exercise. The disadvantage of the method is that another operation should be performed after 3–5 months to remove the steel wire by making a limited incision with length of 1–2 cm along the initial incision scar in the lateral calcaneal tuberosity and at the top of the limited loop. Meanwhile, scar adhesion at the broken end can be appropriately separated to further

ameliorate the ankle function. Besides, some studies have revealed that internal fixation of steel–wire limited loop can effectively treat the avulsion fracture of calcaneal tuberosity, Achilles tendon contracture and foot drop with good ankle function[15,16]. It should be noted that this method is suitable for the patients with at least normal tendon structures with length of 2–3 cm at the proximal end, not applicable to those with muscle–tendon junction rupture.

The results in the study demonstrated that the wound of all patients healed well, no complications like Achilles tendon re–rupture, wound fistula, wound infection and skin necrosis occurred, and the cutaneous sensation in sural nerve dominance region was normal, illustrating that internal fixation of steel–wire loop is reliable and safe for treating early Achilles tendon rupture, and the complications are few. In addition, 76 patients recovered to the state of preinjury work or learning as well as physical activities in the shortest time, and the excellent and good rate came up to 100%, suggesting that this method is conducive to the rapid recovery of ankle function, and the recovery is good.

To sum up, internal fixation of steel–wire limited loop can recover the ankle function of patients with early Achilles tendon rupture better, return to the pre–injury state in the shortest time, and reduce the occurrence of complications, so it can be an effective method to treat early Achilles tendon rupture in clinic.

Conflict of interest statement

We declare that we have no conflict of interest.

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