

A New Modification of Bosworth's Technique to Repair Infectious Achilles Tendon Rupture

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Abstract

Background The aim of this study was to assess radiographic and clinical outcomes of a new modified approach on the basis of Bosworth's technique in the treatment of infectious Achilles tendon rupture (IATR).

Materials and methods 15 patients (9 males and 6 females; 15 feet; average age of 38.3 years) were included in the study. After infection, the wounds were transferred to our department for treatment (Figure 1). Radiographic and clinical outcome in terms of the American Orthopaedic Foot & Ankle Society score (AOFAS), the Victorian institute of sports assessment Achilles (VISA-A), and the Achilles tendon total rupture score (ATRS) were investigated at 6 months, 12 months, and 24 months postoperatively.

Results Preoperative AOFAS, VISA-A, and ATRS showed statistically significant improvement ($p \leq 0.05$) from 35.03 ± 6.81 (25-45), 21.04 ± 8.17 (5-45), and 20.08 ± 8.93 (6-55) to 90.04 ± 5.32 (82-97), 95.11 ± 3.09 (79-99), and 96.34 ± 3.61 (89-97) at the last follow-up, respectively. All patients could lift heel on one foot and return to work at 12 to 16 weeks after operation (average 14.2 weeks). Overall, No complications such as infection, skin necrosis, sural nerve injury, deep vein thrombosis, and re-rupture of Achilles tendon occurred at last follow-up.

Conclusion The new modified approach of Bosworth's technique provided powerful curative efficacy of infectious Achilles tendon rupture, without severe complications in terms of infection, skin necrosis, sural nerve injury, deep vein thrombosis, and re-rupture of Achilles tendon. Level of Evidence: Level IV, case series.

Introduction

Infectious Achilles tendon rupture (IATR), associated with open damage, wound contamination, and incorrect treatment, is not a rare disease [1]. Fourniols E et al. [2] reported that the estimated rate of infection was between 0.2% and 3.6% after surgical treatment. An infected Achilles tendon is particularly difficult to treat because of the poor vascularity of the tendon as well as the thin surrounding soft tissue. The risk factors reported by Pajala et al. [3] were: age over 60 years old, tobacco use, corticosteroid therapy, diabetes, surgery delayed by more than 7 days, the presence of pain in the tendon before the accident. Various methods are applied to cope with the infectious tendon [4–6], including tendon transfer and negative pressure wound therapy, but the outcomes of these treatments are still unsatisfied. Mosser et al. [7] reported the use of vacuum-assisted closure (VAC) therapy in the treatment of late deep infections after open Achilles tendon reconstruction had achieved good results without any common complications, such as bleeding, re-infection, seroma. However, this technique can only be applied in patients without complete tendon resection. In reality, infectious Achilles tendon rupture would lead to large tendon deficits after radical debridement. In light of this dilemma, we had developed a new modification of Bosworth's technique (MBT), performing a mini-incision near the broken Achilles tendon to repair the tendon with a novel tunnel. The main objective of this study was to describe and assess

radiographic and clinical outcomes of the new modified approach on the basis of Bosworth's technique in the treatment of infectious Achilles tendon rupture.

Materials And Methods

The study was designed as a retrospective trial. Ethical approval and informed consent from every single patient was obtained. 15 patients had received the new modified Bosworth's technique at the Department of Foot and Ankle Surgery, Wuhan Fourth Hospital, affiliated to Tongji Medical College, Huazhong University of Science and Technology, from February 2014 to November 2017.

Eligible patients were included in our study when they met the following criteria: (1) Patients diagnosed with IATR. (2) over 18 years of age and in full possession of their mental faculties. (3) patients were treated with MBT and be follow-up until 24 months. (4) Patients were infected after the first operation of Achilles tendon rupture.

Operative Protocol

After admission, all patients completed relevant preoperative examinations. Preoperative MRI examination of Achilles tendon confirmed that Achilles tendon had been broken again (**Figure 2**). All patients were surgically treated by a single, senior surgeon (Zhenhua Fang, ZHF) with the aim of eliminating infection completely and repairing the broken Achilles tendon. First stage debridement was performed strictly in accordance with aseptic technology. The infected and necrotic lesions involved Achilles tendon broken ends and surrounding soft tissue skin (**Figure 3**) were thoroughly removed during the operation. After the operation, aseptic dressings were bandaged. Some patients with skin defect were treated with vacuum sealing drainage. After debridement, the wound was bandaged with sterile dressing and treated with anti-infection and dressing change after operation. After 4-5 weeks of treatment, the wound was clean and the granulation tissue was fresh, while the blood routine, CRP and ESR were normal, the second stage operation was performed to repair the Achilles tendon. All operations were performed by the same physician. The prone position, ankle metatarsal flexion 30 degrees, palpation to determine the location of Achilles tendon rupture ends, distal incision along the original incision (**Figure 4**), proximal incision in the back of the leg (**Figure 5**), then took a small incision, respectively, exposed the ruptured Achilles tendon and proximal gastrocnemius muscle and its complete fascia, removed the surrounding granulation tissue, resect the scar tissue on both sides of the Achilles tendon broken ends until exposed to the right side. The length of Achilles tendon defect (**Figure 6**) was measured in normal tendinous and fascial tissues. Tendon defects ranged from 6 to 10 cm, with an average of 7.2 cm. According to the location of the rupture end of Achilles tendon and the length of the defect, a proximal incision was designed, and a part of gastrocnemius muscle and deep fascia was transversely cut with a width of about 1.5 cm (**Figure 7**). The deep fascia and some tendons were cut longitudinally and distally on both sides of the incision. The proximal tendons were cut through a suture and knotted (**Figure 8**), then subcutaneously established by bone stripping. The tunnel (**Figure 9**) was threaded with a suture needle from the tunnel to the proximal end of the Achilles tendon rupture (**Figure 10**). The distal end of the suture

was stretched to tear out a proper length of gastrocnemius myofascial flap (**Figure 11**). The pulled fascial flap was cross-knitted and sutured with the suture thread, and was butted to the distal end of the Achilles tendon to reconstruct the Tendon defect. If the Achilles tendon termination was ruptured, the tendon was fixed in the calcaneal tubercle (**Figure 12**) with interfacial screw. The fascial flaps were interlaced and knitted proximally on both sides of the tail line. Finally, the tendon was sutured and fixed on the innate fascia of the gastrocnemius muscle. The rupture end of the Achilles tendon was sutured with non-absorbable suture and Bunnell method. The 2-0 absorbable suture was used to strengthen the tendon Suture made the broken end smooth, sutured the aponeurosis tissue carefully, and sutured the subcutaneous tissue and skin layer by layer. Negative pressure drainage tube (**Figure 13**) was routinely placed in the incision.

Postoperative management was standardized. After operation, long leg plaster was fixed at the position of metatarsal flexion of ankle joint and knee flexion at 30 degrees. Three weeks after operation, the wound was removed and fixed with short leg plaster in the neutral position of ankle joint. The broken leg plaster was carried out gradually. After six weeks, the plaster was removed and the ankle joint function and leg muscle strength were trained. Eight weeks of walking with crutches were carried out step by step. Three months after operation, the patient began to walk with crutches. Exercise was performed on the toes or heels, and there was no movement restriction 6 months after operation.

Outcomes

Baseline demographic and clinical characteristics (gender, age, injury, and type of operation) were recorded for all patients (**Table 1**).

Statistical analysis

All statistical analyses were performed using IBM SPSS Statistical software (version 22, IBM, Somers, NY, USA). The data was presented as the mean \pm standard deviation (SD) for continuous variables and as numbers for categorical measures. Paired sample *t* test was used to compare the measurements before and after the surgery. $P < 0.05$ was considered as significant difference.

Results

Radiographic Outcomes

In our study, we did not find any patient who had a calcified lesion or osteolytic lesion of the calcaneus insertion by radiographs . The shape and continuity of the healed Achilles tendon was similar with the original tendon on the postoperative MRI examination at a mean of 13 months (range, 8 to 38 months).

Clinical Outcomes

Clinical outcome after IATR treated with MBT using the American Orthopaedic Foot&Ankle Society score (AOFAS), the Victorian institute of sports assessment Achilles (VISA-A), and the Achilles tendon total

rupture score (ATRS), which averaged more than 90 points, was favorable (**Table 2**). No complications occurred, such as infection, skin edge necrosis, sural nerve injury, deep vein thrombosis and so on. No re-rupture of Achilles tendon occurred at the last follow-up, and all the wounds healed in the third week. All patients could perform the single heel rise test and return to work 12 to 16 weeks after operation (average 14.2 weeks).

Discussion

IATR's treatment is a major challenge for ankle surgeons. It can be caused by many reasons, such as open injury of Achilles tendon, chronic Achilles tendon re-rupture, local tissue defect and peripheral vascular nerve injury. The probability of infection will greatly increase in those patients with risk factors such as old age, hyperlipidemia, diabetes mellitus and steroid use [8,9]. If not handled properly, the clinical results after treatment of a deep infection have been poor and often devastating[10]. In such situation, it often leads to long-term wound healing, Achilles tendon exposure, poor prognosis, clinical treatment is quite difficult. Several different methods have been applied in the treatment of IATR[3,10–13]. In our study, we treated postoperative infection of the Achilles tendon with two stages. In the first stage, a radical debridement were carried including infected Achilles tendon broken ends and surrounding soft tissue skin, while anti-infection measuers were taken postoperation; and in the second stage, we used modified Bosworth method to repair the ruptured Achilles tendon after infection control. However, the duration was long after infection control, so the second stage repair was often chronic rupture.

Chronic Achilles tendon rupture can not be sutured directly because of the retraction and degeneration of the broken end and the part removed at the first stage. Traditional surgical repair methods include V-Y gastrocnemius tendon flap plasty and Achilles tendon reconstruction (including autologous materials, allogenic materials and synthetic materials). Although V-Y tendon lengthening was proposed as early as 1975, it is not widely used in clinic. Studies have shown that the plantar flexion of V-Y tendon lengthening is significantly weaker than that of the healthy side, and has a great impact on the blood supply and biomechanical strength of Achilles tendon, and meantime V-Y tendon downward movement should not exceed 5 cm [14,15–17]. Tendon transposition is widely used and advisable at present[8, 16, 18–20]. It can achieve good results, but at the same time it will lead to loss of function. Peroneus brevis tendon transfer will lead to ankle valgus weakened [18–19], flexor digitorum longus tendon will weaken toe flexion and backward pedal [20–21], flexor hallucis longus transfer has a small diameter and insufficient strength, and will also lead to toe forward-medial displacement and toe flexion weakened [20,22–23]. Achilles tendon reconstruction, whether autologous tendon transplantation materials, allogeneic materials or synthetic materials, not only increases the complexity and cost of surgery, but also lacks blood supply of free tendon, which is prone to degeneration and reduce its own strength [24–28].

In the present study, a new modification of Bosworth's Technique was applied to treat infectious Achilles tendon rupture. This technique obtained good functional improvement with a high level of patient satisfaction. In our study, the mean AOFAS, VISA-A and ATRS score increased from 35.03, 21.04, and 20.08 to 90.04, 95.11 and 96.34 at the last follow-up. Many scholars reported satisfactory functional

recovery after Bosworth procedure [28, 29]. No major complications have been reported in our case series at the final follow-up. The use of gastrocnemius tendon aponeurosis reversal repair not only has the same homology with Achilles tendon, but also has a wide range of materials. It has obvious advantages in the treatment of large segment Achilles tendon defect. It was conducive to infection control because of allowing more thorough debridement. During the first stage, it could completely remove the hypertrophic scar tissue at the broken end of Achilles tendon. Proper and tension-free suture is not only conducive to healing, but also increases the strength of Achilles tendon, meanwhile, reducing the premature degeneration of Achilles tendon, and preventing the re-rupture of Achilles tendon after operation. At the same time, it also retains the blood supply of gastrocnemius inverted muscle belly, and provides an active muscle flap for the rupture of Achilles tendon, which is conducive to tendon healing and is not easy to scar degeneration. The reversed gastrocnemius tendon flap has the same homology with the Achilles tendon. Therefore, the appearance and flexibility of the reversed gastrocnemius tendon after operation are similar to those of the normal Achilles tendon. In this study, a calcified lesion or osteolytic lesion of the calcaneus insertion was reported by radiographs, and the shape and continuity of the healed Achilles tendon was similar with the original tendon on the postoperative MRI examination. Triceps muscle atrophy is slight, and muscle strength recovery is not significantly different from that of the healthy side. More important, the modified Bosworth technique not only effectively reduced the surgical trauma, but also decreased the incidence of postoperative infection and the possibility of adhesion between muscle and subcutaneous. Compared with pure Bosworth, the length of skin wound was obviously minor and the postoperative appearance was more beautiful.

Certainly, our study has some degree of limitations, including: (1) this study is a retrospective study, and its inherent limitations may also affect the judgement of curative effect; (2) it was conducted in a single center, which is associated with a lower external validity; (3) the number of patients are limited and the time of follow-up is short, which results will be not totally correct.

Conclusions

The modified Bosworth method for the infectious Achilles tendon rupture allowed radical debridement, provided powerful strength and achieved excellent functional improvement without common complications in terms of infection, skin necrosis, sural nerve injury because of the minimally invasive procedure. Meantime, this technique was easy to learn and may therefore be suitable for less experienced foot and ankle surgeons. It could be considered an effective alternative for infectious rupture of the Achilles tendon.

Footnotes

Abbreviations

IATR: infectious Achilles tendon rupture; MBT: modification of Bosworth's technique; American Orthopaedic Foot & Ankle Society score (AOFAS); VISA-A: Victorian institute of sports assessment Achilles

ATRS:the Achilles tendon total rupture score.

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Declarations

Declaration of Conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

The study was designed as a retrospective trial. Ethical approval and informed consent from every single patient was obtained.

Ethics approval and consent to participate: The study was approved by the clinical research ethics committee of Wuhan Puai Hospital. Reference No. 2013–049-02.

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Authors' contributions: QW and YX participated in the design of the study; QW and ZF carried out data curation; JW and ZF performed the statistical analysis; YX and LL carried out investigation; QW and LL carried out project administration; JW and ZF operated software; GL carried out supervision; JW and GL carried out validation; QW and YX conceived of the study, and participated in its design and coordination and helped to draft the manuscript; ZF and LL participated in the sequence alignment and drafted the manuscript. All authors read and approved the final manuscript.

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Tables

Table 1 Demographic data of the patients

Characteristics	Value
Total (male/female) (n)	15(9/6)
Age (years, mean)	38(20-75)
Injury	
Sports(basketball/Badminton/football)	5/3/1
Local direct force	2
Steroid treatment	3
Slip	1
Previous Treatment (Surgical repair)	15
Interval from injury to second repair surgery [months,mean (range)]	4.5(3-8)
Follow-up time [months, mean(range)]	18.5(13-38)
Deficit [cm-mean (range)]	7.2(6-10)

Table 2 Functional scores of patients preoperation and at last visit

	Preoperation(n= 15) Mean (range)	At last visit (n= 15) Mean (range)	P value
AOFAS score	35.03±6.81 (25-45)	90.04±5.32 (82-97)	0.00
VISA-A score	21.04±8.17 (5-45)	95.11±3.09 (79-99)	0.00
ATRS score	20.08±8.93 (6-55)	96.34±3.61 (89-97)	0.00

Abbreviations: AOFAS American Orthopaedic Foot and Ankle Society, VISA-A Victorian Institute of Sports Assessment Achilles, ATRS Achilles tendon total rupture score

Figures



Figure 1

Seven weeks after the repair of Achilles tendon rupture, infection occurred in the wound. The wound with a length of about 1 cm in the middle of the wound was not healed, and a small amount of secretion and necrotic exudate were squeezed out. Thompson Test(+).



Figure 2

MRI showing chronic Achilles tendon rupture with retraction and gapping between the tendon ends.



Figure 3

The appearance after thorough removal of the rupture end of Achilles tendon and surrounding soft tissue skin involved by infection and necrosis into operation.



Figure 4

The distal incision and the parts of Achilles tendon were performed after debridement.



Figure 5

The proximal incision and gastrocnemius muscle and fascia were exposed



Figure 6

The gap was measured to be 7 cm after resection of scar tissue on both sides of the rupture end of Achilles tendon.



Figure 7

Proximal incision was made to transversely cut off part of gastrocnemius muscle and deep fascia with a width of about 1.5cm intraoperation.



Figure 8

Use a 1-0 suture through the proximally incised tendon as a traction line.



Figure 9

Between distal and proximal incisions, subcutaneous tunnels were constructed by bone dissection.



Figure 10

A long suture needle was used to thread the tendon from the subcutaneous tunnel to the proximal end of the Achilles tendon rupture.



Figure 11

The suture pulls the myofascial strip distally, tearing out the appropriate a length of the fibular myofascial flap.



Figure 12

The insertion point of the Achilles tendon was ruptured and the tendon was fixed into the calcaneal tubercle with interfacial screws after drilling.



Figure 13

Appearance of sutured skin during operation