Comparison of Two Surgical Methods in the Treatment of Acute Achilles Tendon Rupture: a Case-control Study

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Research article

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Abstract

Background: The Achilles tendon is the strongest tendon in the human body but also prone to injury and rupture, thereby requiring early diagnosis and treatment to prevent the development of lower limb dysfunction. Currently, the best treatment method for acute Achilles tendon rupture remains controversial. As both traditional incision repair and minimally invasive repair have limitations, we propose a new surgical method: the modified Ma-Griffith method combined with minimally invasive small incision (M-G/MISI). This study aimed to compare the efficacy of M-G/MISI and the modified suture technique (MST) for the treatment of acute Achilles tendon rupture.

Methods: We conducted a retrospective review of the medical records of all patients who underwent treatment for acute Achilles tendon rupture between January 2012 and January 2020 at our hospital. A total of 67 patients were included and divided into two groups: 34 males in the M-G/MISI treatment group and 33 patients (2 females and 31 males) in the MST group. Demographic characteristics, operative details, and postoperative complications were recorded, and data were statistically analysed using SPSS 24.0 for Windows (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0) to compare the treatment efficacy of the two surgical methods.

Results: Although there was no difference in demographic characteristics between the two groups, there were significant differences in the incision length, intra-operative blood loss, post-operative Achilles tendon total rupture score, and post-operative American Orthopedic Foot and Ankle Society score. Post-operatively, there was one case of traumatic Achilles tendon rupture in the M-G/MISI group and one case each of infection and deep vein thrombosis in the modified suture group.

Conclusion: After follow-up, the post-operative recovery of acute Achilles tendon rupture treated with M-G/MISI is better than that with the MST.

Introduction

Although the Achilles tendon is the strongest tendon in the human body, it is one of the tendons most prone to injury and rupture. The annual incidence of Achilles tendon rupture is about 21.5–24.0 cases per 100,000 persons [1]. The rate of acute Achilles tendon rupture is higher in men than in women, and middle-aged men with high activity commonly experience a ruptured Achilles tendon. Previous studies [2, 3] have suggested that the most common site of injury is 2–6 cm above the calcaneal tubercle. A recent study found that most acute Achilles tendon ruptures occur between 5 and 8 cm [4] above the distal end of the calcaneal attachment point. Acute Achilles tendon rupture requires early diagnosis and treatment, otherwise it will lead to lower limb dysfunction, serious consequences to the patients' quality of life and work, and create a heavy economic burden for the family.

At present, acute Achilles tendon rupture is treated either by surgical or non-operative (i.e. conservative) methods. Surgical treatment generally includes traditional enhanced repair or non-enhanced repair, limited small incision surgery, percutaneous minimally invasive surgery, modified percutaneous repair,

and the use of special minimally invasive surgical equipment for Achilles tendon ruptures such as an Achillon Achilles tendon stapler.

Currently, the best treatment method for acute Achilles tendon rupture remains controversial [5]. Patients with severe underlying diseases who are unwilling to undergo surgery are usually treated conservatively. However, the re-rupture rate of conservative treatment is high [6]. Compared with conservative treatment, surgery can reduce the incidence of Achilles tendon re-rupture, but the incidence of other complications related to surgery, such as nerve injury and incision problems, is significantly higher [7–9]. Minimally invasive percutaneous repair is less invasive and can reduce the risk of soft tissue complications [10]. However, because the rupture site of the Achilles tendon is not exposed, some percutaneous repair methods may lead to poor involution of the torn site and weak biomechanical resistance [11].

In view of the problems existing in traditional incision repair and minimally invasive repair, we propose a new surgical method: the modified Ma-Griffith method combined with a minimally invasive small incision (M-G/MISI) surgery. The method is based on percutaneous suture, limited incision under direct vision, and a more reliable suture of the broken end of the Achilles tendon. We also used a lumbar puncture needle, which greatly reduced the cost of surgery for patients. At present, the new method has not been compared with other surgical methods. The purpose of this study was to compare and analyse the efficacy of the M-G/MISI versus the the modified suture technique (MST) for the treatment of acute Achilles tendon rupture.

Materials And Methods

We reviewed and analysed the medical data of patients who underwent treatment for acute Achilles tendon rupture in the Department of Orthopaedics of the Second Affiliated Hospital of Anhui Medical University of China from January 2012 to January 2020. This study was approved by the local institutional review committee, and the necessary informed consent was obtained.

Patients

A total of 67 patients were enrolled in the study, 34 of whom underwent the M-G/MISI treatment, and 33 of whom underwent the MST treatment.

The inclusion criteria included: (1) a diagnosis of acute closed Achilles tendon rupture based on the clinical physical examination and imaging data; (2) age ≥ 18 years; and (3) the patient having undergone either the M-G/MISI treatment or the MST.

Patients with (1) open Achilles tendon rupture; (2) chronic pain of the Achilles tendon; (3) calcaneal fracture; (4) chronic Achilles tendon rupture; or (5) previous local closure of the Achilles tendon were excluded from the study.

Surgery

An experienced orthopaedic surgeon performed all the operations using an M-G/MISI (Fig. 3). With the patient in a prone position and under general anaesthesia, a 2–3 cm incision was made on the medial side of the Achilles tendon (Fig. 1b1, A to point B). Then, after cutting the skin and subcutaneous and peri-tendon tissue in turn, the hematoma at the broken end was removed, and the broken end of the Achilles tendon was carefully exposed. Tissue forceps were used to organise the broken end and lengthen the incision, if necessary. The M-G/MISI was used to suture the distal and proximal Achilles tendons with the help of a lumbar spinal needle and polydioxanone synthetic absorbable suture (PDS) Ⅱ line (Fig. 1a2). At the distal end of the Achilles tendon, a 2 mm Kirschner needle was used to drill holes vertically along the Achilles tendon, and the broken end was pulled with tissue forceps. The Kirschner needle was inserted (Fig. 1b1, C) and drawn out (Fig. 1b1, D) so that the lumbar spinal needle was crossed symmetrically through the broken end of the Achilles tendon until the lumbar spinal needle finally pierced out at the broken end of the Achilles tendon. At the proximal end of the Achilles tendon, the broken end was pulled with tissue forceps, the tendon was crossed 3 cm from the broken end, and the lumbar spinal needle was inserted and pulled out so that the lines on both sides were equal. Using the same method described above, the lumbar spinal needles were finally drawn out symmetrically at the medial and lateral side of the broken end of the Achilles tendon. With the ankle in a plantar flexion position, the distal and proximal PDS Ⅱ lines were tightened. At the broken end of the Achilles tendon in the AB incision, the knot was fastened from the inside and outside of the Achilles tendon, and then an absorbable suture was used to strengthen the suture at the broken end.

Another experienced orthopaedic surgeon performed all the MST treatments. Under continuous general anaesthesia, the patients were placed in the prone position with a knee flexion of 30°. Using the broken end of the Achilles tendon as the centre, a 5 cm incision was made at the medial edge of the Achilles tendon. Incision of the skin to expose the deep fascia and the Achilles tendon aponeurosis was cut to the adventitia of the Achilles tendon. After exposing the broken end of the Achilles tendon, the blood clot was thoroughly removed, and the ruptured Achilles tendon was lifted, exposing the deep muscle tissue of the Achilles tendon. The deep muscle tissue of the Achilles tendon was then sutured with 2 – 0 absorbable suture, thus building an "Achilles tendon bed" to facilitate the recovery and healing of the Achilles tendon's blood supply. Then, the cauda calcaneus tendon was combed, and the broken end was divided into 4–7 bundles according to the anatomical level of the Achilles tendon. A 5 – 0 Prolene suture was used to suture one end of the long tendon bundle and the other end of the short tendon bundle vertically and intermittently to maintain the physiological length of the Achilles tendon. To avoid excessive metatarsal flexion of the ankle caused by Achilles tendon shortening, the Achilles tendon bundle was sutured as much as possible. The adventitia of the Achilles tendon and the Achilles tendon aponeurosis were sutured with 3 – 0 and 2 – 0 absorbable sutures, respectively. After touching the Achilles tendon to determine good continuity and examining the foot extension to ensure that the broken end of the Achilles tendon was anastomosed firmly, the operative field was rinsed, and the incision was closed layer by layer.

Post-operative management

After the operation, the affected limb was raised and the patient received symptomatic support treatment including detumescence and analgesia. The affected limb was fixed with either a plaster slab below the knee brace or a functional brace. Crutch walking was allowed, provided the affected leg was non-weight-bearing. Post-operative instructions included functional exercises to strengthen the hip and knee joints, normal flexion and extension of the toes, and active prevention of venous thrombosis of the lower extremities. The details are as follows: exercise of the hip and knee joints within two weeks after the operation; removal of stitches two weeks after the operation; flexion and extension of the toes within five weeks after the operation; removal of plaster external fixation and partial weight-bearing with crutches five weeks after the operation; complete weight-bearing nine weeks after the operation; jogging permitted 12 weeks after the operation; patients were allowed to resume normal activities six months after the operation.

Follow-up evaluation

During the post-operative re-examination of the patients, the chief surgeon inquired and tested their recovery and scored and recorded these using the American Orthopedic Foot and Ankle Society (AOFAS) score [12] and the Achilles tendon rupture score (ATRS) [13]. The ATRS is a reliable and effective method for measuring the results reported by patients. These included 10 questions, each with a score of 0–10, for a total score of 100, which indicates a full recovery; the higher the score, the fewer the symptoms and functional limitations.

Statistical analysis

The evaluation consisted of the patient's sex, affected side, age, operation time, incision length, blood loss during the operation, hospital stay, injury to operation time, AOFAS score, and ATRS. All statistical data were analysed using SPSS 24.0 for Windows. Descriptive data were reported as mean, median, standard deviation, and range. For statistical testing, a t-test of the mean of two samples was used. For all measurements, significance was considered at $p < 0.05$.

Results

All 34 patients in the M-G/MISl group were male and their follow-up time ranged from 6 to 50 weeks (mean (SD): 22.15 (10.29) weeks). In the modified suture treatment group, there were 2 females and 31 males; their follow-up time ranged from 9 to 36 weeks (mean (SD): 21.24 (8.07) weeks).

Except for the Hospital stay, there was no significant difference in the demographic characteristics between the groups (Table 1). However, there was a significant difference in the surgical incision length ranges and the average blood loss between the M-G/MISl (range, 2–6 cm; mean (SD): 3.79 (1.80) cm; 16.47 (13.23) ml, respectively) and the modified suture treatment groups (range, 4–8 cm; mean (SD): 5.788 (0.99) cm; 34.55 (13.01) ml, respectively) ($p < 0.05$). There was no significant difference in hospital stay between the two groups ($p > 0.05$). There was no difference in the zero and third month follow-up AOFAS scores between the two groups, but there was a difference in the mean score at the sixth month: M-G/MISl group, 97.03 (2.71) vs. modified suture group, 93.18 (2.04) ($p < 0.05$). Moreover, while there was

no significant difference between the first and third month follow-up ATRS of the two groups, there was a significant difference in the mean score of the sixth month: M-G/MISI group, 96.71 (3.51) vs. modified suture group, 93.18 (2.54) ($p < 0.05$; Table 2).

In this study, a similar number of patients in each group returned to their original sport activity. Out of 31 patients that discontinued their sport, 16 (52 %) belonged to M-G/MISI, and 15 (48 %) to MST. All patients returned to their previous work, except the one patient that required a re-operation in the M-G/MISI group due to trauma due to a septic complication, whereas in the MST group, one patient had an infection and another had a deep venous thrombosis. All three patients were treated symptomatically and recovered well after the operation.

Discussion

The post-operative recovery of acute Achilles tendon rupture treated with M-G/MISI is better than that of MST; the M-G/MISI surgery incision is smaller. The new method (M-G/MISI) of repairing Achilles tendon rupture not only combines the advantages of open surgery, percutaneous surgery, and minimally invasive surgery but also saves cost, therefore it is worth promoting. Compared with minimally invasive surgery, traditional incision repair is more stable but more prone to infection. In a retrospective analysis of 4,477 patients, Popovic et al. [14] reported that the total incidence of complications was 12.5%, the most common of which was mild incision problems (6.5%), and the recurrence rate was 1.5%. In fact, the problem of incision complications was considered as early as 1977, when Ma-Griffith proposed the Ma-Griffith method [15]. Although this method can reduce the risk of infection and avoid long incisions, the strength of the percutaneous suture has been questioned. Some researchers have studied the method of operation and found the rate of re-rupture to be as high as 8%, and the rate of sural nerve injury as high as 19% [16].

In comparison with open surgery [17], there were significantly fewer main complications in the percutaneous repair group than in the incision repair group, especially necrosis, and the total number of complications was lower. Percutaneous minimally invasive surgery has the advantages of a small incision and a short operation time, but sural nerve injury is a complication that cannot be ignored. The incidence of sural nerve injury varies with different suture techniques. Lo et al. [18] found that the rate of common peroneal nerve injury in 701 patients was 6.0%. According to different reports, percutaneous repair techniques have different rates of sural nerve injury [19–21]. When using the percutaneous puncture technique to repair the Achilles tendon, sural nerve injury is inevitable because it cannot be sutured under direct vision. In 2002, Assal et al. [22] conducted a prospective multicentre study using a limited incision and a specially designed device, the Achillon stapler, to ensure that all sutures were placed into the peri-tendinous tissue, thereby minimising the risk of implanting suture material into the sural nerve; none of the patients in that study experienced nerve injury. However, this type of operation requires expensive instruments with limited open repair, which places a significant financial burden on patients.

Unfortunately, the underlying reasons for the different effects of the two surgical methods were not addressed in this study. Those reasons, however, are worthy of discussion and should be discussed in future. Considering that the participants of this study originate from only one province and are of limited numbers, this study may not be representative of the larger population. Finally, in this study the two treatment groups each had their own surgeon who carried out their respective patients' post-operative follow-up. Hence, subjective factors cannot be ruled out.

In conclusion, this study shows that the M-G/MISI treatment group has an advantage over the modified suture group in the treatment of acute Achilles tendon rupture. In the M-G/MISI group, the length of incision was smaller, the amount of bleeding during the operation was less, and the long-term prognosis was better than in the modified suture group. Therefore, M-G/MISI has a lower recurrence rate, less nerve injury, lower operation cost, and a better post-operative effect than the modified suture method in our hospital.

Abbreviations

AOFAS, American Orthopedic Foot and Ankle Society score

ARTS, Achilles tendon rupture score

M-G/MISI, Ma-Griffith method combined with a minimally invasive small incision

MST, modified suture technique

Declarations

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Ethical Approval

The authors certify that their institution has approved or waived approval for the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

Consent to Participate and Publish

The authors affirm that human research participants provided informed consent for publication of the images in Figures.

- The participant has consented to the submission of the case report to the journal.
- Patients signed informed consent regarding publishing their data and photographs.

Authors' Contributions

Jun Li designed the study. Juehua Jing, Yunfeng Yao and Junfeng Zhan participated in the design of the study. Hao Yu , Fangyuan Wang and Jia Xie enrolled patients. Hao Yu performed literature search. Hao Yu wrote the initial draft. Hao Yu made statistical analysis. Jun Li, Juehua Jing , Yunfeng Yao and Junfeng Zhan provided comments and prepare the final version of the manuscript for publication. All authors read and approved the final manuscript.

Availability of data and materials

All data generated or analyzed during this study are included in this published article.

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Conflicts of interest

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

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Tables

Due to technical limitations, tables.xlsx is only available as a download in the Supplemental Files section.

Figures

Figure 1

Modified Ma-Griffith method combined with a minimally invasive small incision schematic diagram (a1) A lumbar puncture needle, (a2) a lumbar puncture needle with a polydioxanone synthetic absorbable suture (PDS) thread inserted. (b1) The incision AB is on the inside of the broken Achilles tendon end. It has a length of approximately 3 cm and can be extended if the length is insufficient. (b2) After disinfecting and laying the towels, the AB is cut along the broken end, and the foreign body is removed.

The vertical Achilles tendon is drilled with a Kirschner wire at the C and D positions on the calcaneus, while the suture is pierced along the dotted line. The broken end of the Achilles tendon in the AB incision is fastened from both in- and outside the Achilles tendon. (c1) Along the dotted line drawn before the operation, under the guidance of the lumbar puncture needle, the PDS line passes through the Achilles tendon. (c2) With plantar flexion of ankle joint, the ruptured Achilles tendon is sutured. After suturing the incision, (d1) the ankle joint is fixed with plaster in metatarsal flexion of the affected limb after bandaging the surgical incision. (d2) Achilles tendon during a post-operative dressing change.

Figure 2

Modified suture treatments schematic diagram (a1) Surgical markings made before the operation. (a2) Broken end of Achilles tendon is ponytailed. (b1) Broken end of the Achilles tendon was combed and divided into 4–7 bundles. (b2) Suturing of the deep tissue and broken end of the Achilles tendon. (c1) Appearance of the skin after stitching. (c2) Appearance of the dressing on the first day after the operation.

Figure 3

The black dotted line indicates the suture track of the inside of the tendon.

Supplementary Files

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