

Comparison of the curative effect of modified medial arc incision of achilles tendon and traditional straight incision in the treatment of old achilles tendon rupture

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Abstract: Modified medial arc incision of Achilles tendon and traditional straight incision were applied to treat 50 cases of old rupture of Achilles tendon. Among them, there were 20 cases involved in the modified medial arc incision of Achilles tendon (group A). Furthermore, 30 cases accepted traditional straight incision treatment (group B). The same rehabilitation program was applied in both groups, combined with the evaluation using the clinical objective examination, subjective satisfaction of patients and the American Orthopaedic Foot and Ankle Society (AOFAS) scores. There was significant difference between group A and group B in the recovery time to normal motion ranges ($P < 0.05$). The average AOFAS score of group A was higher more than ($P < 0.05$). In addition, patients from the two groups did not suffer from cutaneous sensory disturbance of the dorsum of foot due to sural nerve injury, or no deep venous thrombosis. Except for 1 patient with deep infection, all patients recovered to normal motion ranges. The overall curative effect of modified medial arc incision of Achilles tendon is superior to traditional straight incision in the treatment of old Achilles tendon rupture, which is conducive to the early recovery to normal motion ranges before injury.

Keywords: Old achilles tendon, rupture, incision, skin, necrosis.

INTRODUCTION

Closed rupture of Achilles tendon is a common disease in trauma department of orthopedics. If the patient with acute Achilles tendon rupture is untreated or missed diagnosis (Inglis *et al.*, 1981; Carden *et al.*, 1987; Nestorson *et al.*, 2000) for over 4 weeks (Flint *et al.*, 2014), it will progress in an old Achilles tendon rupture. The filling of the fracture gaps can be achieved by exerting the bridging effect of the scar at the broken-end of old rupture of achilles tendon. However, the new tissue is no longer the normal tendon tissue, and the strength is different from the normal tissue. When there exist gastrocnemius muscle and soleus muscle fiber contraction, ankle weakness caused by disuse ankle weakness will be occurred to affect the normal walking of the patient (Myerson *et al.*, 1999; Arner *et al.*, 1959; Maffulli *et al.*, 2008). In this regard, surgery is needed frequently at this time (Maffulli *et al.*, 2008; Jiang *et al.*, 2012; Neufeld *et al.*, 2014).

Complications of surgical incision reduce the postoperative clinical efficacy. In recent years, there are reports focused on small incision and minimally invasive treatment of old Achilles tendon rupture (Gao *et al.*, 2015)). However, the formation of scar adhesion and limited operation space will have adverse effect on the operation and induce inexact suture of the broken-end, resulting in the complication of secondary rupture. Traditional incision slightly medial to the midline

posterior aspect of Achilles tendon has the advantages of fully exposing the broken-end of Achilles tendon and suturing the fractured tissues. However, complications of traditional straight incision infection and Achilles tendon exposure caused by skin necrosis (Zhang *et al.*, 2011; Movin *et al.*, 2005) are widely condemned by clinicians. From January 2011 to May 2017, 50 patients with old rupture of Achilles tendon were treated with surgical treatment in our department. Among them, there were 20 cases accepted modified medial arc incision of Achilles tendon, and 30 cases received traditional straight incision treatment. The clinical data of 50 patients were retrospectively analyzed and the curative effect was evaluated, which were reported below.

MATERIAL AND METHODS

Patients

Inclusion criteria: Duration from rupture of Achilles tendon to operation ≥ 4 w; age distribution of 19~51 years old; the distance between the rupture plane and insertion point of Achilles tendon ranged between 2~8 cm; rupture of Achilles tendon was a closed injury; and involved patients were informed to the treatment regimen. Exclusion criteria: Surgical history of ipsilateral Achilles tendon rupture; previous history of chronic Achilles tendon pain; history of steroid injection in Achilles tendon; current administration of steroids and quinolone drugs; patients with mental disorders that could not cooperate or refuse surgical treatment; and patients with diabetes. There were a total of 50 patients incorporated in

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the present study. There were 20 cases involved in the modified medial arc incision of Achilles tendon (group A), including 14 males and 6 females, ranging from 20~51 years with an average age of 34 years old. The causes of injury were 17 cases of sports injury, 2 cases of sprain and 1 case of falls. The time from injury to operation was 4~8 weeks, with an average of 5 weeks. Meanwhile, the patients were followed up for 6~72 months, with an average duration of 33 months. Furthermore, 30 cases accepted traditional straight incision treatment (23 males and 7 females, group B), with an average age of 35 years ranging from 19~48 years. The causes of injury were 26 cases of sports injury, 3 cases of sprain and 1 case of falls. The duration from injury to operation was 4~9 weeks, with an average of 6 weeks. The patients were followed up for 8~76 months (average time of 39 months). There was no significant difference between the two groups in general data and follow-up time ($P>0.05$, table 1) indicating comparability.

Operative method

Patients were informed to keep their supine position. After successful lumbar epidural anesthesia, the pneumatic tourniquet of 70 kPa was applied at the proximal 1/3 of the affected limb and the ankle joint was in plantar flexion. In group A, the skinfold area of Achilles tendon should be avoided as far as possible, and an arc mark was made on the back to restore the functional position of the ankle joint. A "∩"-like arc incision was made at about 2~3 cm in the medial part of Achilles tendon around the mark (fig. 1). Meanwhile, the incision should be extended moderately according to the position of Achilles tendon. Furthermore, in group B, straight medial incision was made slightly medial to the midline posterior aspect of Achilles tendon. The skin, the subcutaneous and the fascia were cut in sequence, followed by sharp separation of subcutaneous tissues, protection of tissues of the tendon possibly, exposure of the broken-end, lysis of the broken-end of adhesion, removal of old scar, and exposure of the fresh wound at the broken-end. (1) Extraction of wire for fixation (Bunnell suture) + circular suture of plantar muscle tendon: Bunnell tendon anastomosis was used to pull the proximal end of the tendon to the distal end at about 5 cm at the proximal end of the broken-end. Then, a bone tunnel was constructed in the direction of Achilles tendon with the electric drill through posterolateral approach of the calcaneus. A lumbar puncture needle was used through the tunnel to reach the central point of Achilles tendon, and a steel wire was led to the electric drill in posterolateral approach of the calcaneus via the lumbar puncture needle. Following flexion and alignment of the ankle joint to the broken-end, a fine wire was inserted into the proximal end of the wire. And the distal steel wire was sheathed with the rubber pad, and a self-made syringe with two holes was provided to be pressed by the hand to avoid necrosis caused by skin pressure, subsequently, the

distal end and the wire were both tightened. X519 tendon suture was used to rupture Achilles tendon with modified Kessler suture, and the proximal flexor tendon was severed. After pulling through the tunnel at the proximal end of Achilles tendon, the plantar flexor tendon was pulled out and then turned back to the distal end. Afterwards, the plantar flexor tendon was pulled out at the distal end of Achilles tendon after crossing the tunnel. The free-end of the plantar flexor tendon and the proximal end of Achilles tendon were straightened and sutured, and the proximal steel wire was penetrated to the skin at the corresponding position. The firmness and reliability of the suture of the tendon was checked intraoperatively. This method was suitable for patients whose broken-ends were less than or equal to 2 cm. The approach was applied in 10 cases in group A and 12 cases in group B. (2) Inverted V-Y tendon plasty (Abraham): The proximal end of Achilles tendon was cut into "V" line, with the tip located at the center, and the length cut to both sides was at least 1.5 times as much as the defect (Elias *et al.*, 2007; Guclu *et al.*, 2016). If the defect of Achilles tendon was over 5 cm, the incision should be 2 times as long as the defect length to achieve the alignment of the "Y" line (Elias *et al.*, 2007). The tendon flap was pulled down slowly to align the broken-end of Achilles tendon. This method could be applied to those patients with broken-ends in 3~5 cm, including 10 cases in group A and 18 cases in group B. After washing, the peritendon tissues should be sutured as far as possible, and a 4-0 absorbable suture was used to suture the incision, following by dressing of the incision. The sutures used in the process were provided by Johnson (Shanghai) Medical Instrument Co., Ltd.

Postoperative treatment

After the operation, long-leg plaster was used for knee fixation and ankle flexion of the affected limb by 30°. Patients had their stitches removed after 2 weeks and replaced with short-leg plaster 6 weeks later combined with initiative activity of knee joint. After 2 weeks of plaster fixation, the plaster of the affected limb was removed, and changed into Achilles tendon boots. At this time, the steel wire was pulled out in patients adopted the first operative strategy. During the immobilization period, the muscles of the affected limb received isometric exercise, and the exercise strength was increased gradually. During the wearing of Achilles tendon boots, functional exercises were carried out according to the guidance of the rehabilitation physician. No strenuous activity was permitted within half a year after the operation.

Evaluation indexes

Postoperatively, emphasis was placed on the recording of healing time of incision, the presence of incision infection, necrosis of skin and injury of sural nerve. The duration of recovery to the normal motion ranges was recorded in the follow-up period of 1 year after operation.

The traction and movement of scar was observed by the movement of ankle joint to determine the adhesion of Achilles tendon. The angle range of dorsiflexion and plantar flexion of ankle joint was measured with goniometer, and the difference with the contralateral side was recorded simultaneously, with the difference $\geq 11^\circ$ as limited motion of the ankle joint. American Orthopaedic Foot & Ankle Society (AOFAS) Ankle-Hindfoot score was used for function evaluation. The patients were invited to make a subjective evaluation of the overall treatment outcome. The results were divided into four levels of very satisfactory, satisfactory, acceptable and unsatisfactory, with very satisfactory and satisfactory as "Satisfactory". Furthermore, evaluation indexes also included the measurement of the maximum circumferential diameter of bilateral leg and the difference of circumferential diameter between the two sides of Achilles tendon rupture plane. All patients were followed up in the outpatient department or by telephone per year to enquire whether the patient had Achilles tendon rupture. Positive incision secretion for bacterial culture or purulent secretion in the incision was considered to have incision infection. Superficial infection was defined as an infection involved superficial layer of deep fascia and those over the deep fascia was deep infection.

Ethical approval

The study was approved by the Ethics Committee of the Affiliated Hospital of Jiangnan University.

STATISTICAL ANALYSIS

All data were processed by SPSS16.0 statistical software. Measurement data were expressed as $(x \pm s)$, and two independent samples t test was used to compare measurement data between groups. Baseline data of gender was tested by using Pearson χ^2 . Continuity

Correction test was used to compare the infection rate of incision, the incidence of adhesion, the rate of limitation of ankle joint movement, the rate of adhesion and the satisfaction rate. $P < 0.05$ was considered to have statistical difference.

RESULTS

Patients in group A and group B were followed up for 6~72 months (average of 33 months) and 8~77 months (average of 39 months), respectively. There was significant difference between the A group and the B group in the recovery time to the normal motion ranges ($P < 0.05$). The average AOFAS score of group A was 93.8 and that of group B was 88.5, the difference between groups was statistically significant ($P < 0.05$). Furthermore, no incision infection and other complications were found in group A, meanwhile, there were 4 cases with superficial infection and 2 cases with deep infection in group B, and infection rate was 16.7%; besides, the difference between the two groups was not statistically significant ($P > 0.05$). In group B, 4 cases of superficial infection were treated with oral antibiotics and healed under an average of 31 d (24~42 d) dressing time. In the patient with deep infection, staphylococcus epidermidis was cultured in wound secretion, subsequently, antibiotics were used intravenously, followed by opening the wound and repeated dressing change. Most of Achilles tendon showed defects, the wound was healed by the transfer of island skin flap with vascular pedicle, and then reconstructed with autologous fascia lata transplantation. Finally, the ankle joint was stiff, the range of flexion-extension was limited by 28° , and the patient was recovered with claudication. Furthermore, there were no significant statistical differences in the length of incision, incidence of adhesion between Achilles tendon and skin incision, rate of re-rupture, incidence of limited motion of ankle joint, patient satisfaction rate, difference of the

Table 1: Comparison of preoperative general data and follow-up time between the two groups

Groups	n	Gender (n)		Age	Duration from injury to operation	Follow-up time
		Male	Female	(y, $\bar{x} \pm s$)	(Week, $\bar{x} \pm s$)	(Month)
Group A	20	14	6	33.6 \pm 8.2	5.1 \pm 1.3	33.3 \pm 22.2
Group B	30	23	7	34.5 \pm 8.5	5.5 \pm 1.4	39.1 \pm 19.5
Test statistic	-	0.277		0.520	0.520	0.866
P	-	0.599		0.950	0.950	0.441

Table 2: Curative effect comparison between groups

Groups	Case	Incision infection rate	Re-rupture rate	Incidence of adhesion	Limitation of ankle joint movement	Satisfaction rate
		(%, n)	(%, n)	(%, n)	(%, n)	(%, n)
Group A	20	0 (0/20)	0 (0/20)	5.0 (1/20)	5.0 (1/20)	100.0 (20/20)
Group B	30	16.7 (5/30)	0 (0/30)	23.3 (7/30)	23.3 (7/30)	76.7 (23/30)
Test statistic	-	2.083	-	1.792	1.792	3.661
P	-	0.149	-	0.181	0.181	0.056

Table 3: Curative effect comparison between groups (Continued table 2)

Groups	Bilateral difference of maximum circumference of legs	Bilateral difference of the circumferential diameter of Achilles tendon	Incision length	AOFAS score	Duration of recovery to the normal motion ranges
	(cm, $\bar{x} \pm s$)	(cm, $\bar{x} \pm s$)	(cm, $\bar{x} \pm s$)	(Point, $\bar{x} \pm s$)	(Week, $\bar{x} \pm s$)
Group A	0.5±0.2	0.2±0.1	12.1±1.5	93.8±1.8	16.7±2.3
Group B	0.7±0.3	0.3±0.1	13.3±1.1	88.5±4.5	20.3±2.2
Test statistic	0.924	0.693	1.039	2.540	1.848
P	0.361	0.723	0.230	0.000	0.002



Fig. 1: Medial incision of “J” in modified medial arc incision of Achilles tendon. fig. 2: The incision 6 days after operation. The distance between anteromedial arc and posterior median was about 2.5 cm. fig. 3. Observation of the scar and the skin healing following the removal of wire for Achilles tendon fixation 4 months after the operation. figs. 4-5. Distribution of vascular network around Achilles tendon. PTA: posterior tibial artery; PA: peroneal artery; RPA: recurrent branch of peroneal artery. M, P and L represented the medial, posterior and lateral regions, respectively. The distribution of blood supply could be clearly seen.

maximum circumference of the injured side and the opposite side of the leg, the difference of the injured side of lateral circumference of the plane and the opposite side of Achilles tendon rupture, and the duration of recovery to normal motion ranges ($P>0.05$, table 2 and table 3). By the end of the follow-up, there was no cutaneous sensory disturbance of the dorsum of foot due to sural nerve injury and deep venous thrombosis of leg in the two groups. All patients recovered to normal motion ranges except for 1 patient with deep infection.

DISCUSSION

Theoretical basis for the modified medial arc incision of Achilles tendon

The ideal surgical approach for the repair of ruptured Achilles tendon is a small incision to avoid excessive damage to the tendon tissue and reduce the interference of the blood supply around the tendon. However, this procedure requires special equipment. Although relatively stable fixation has been reported to reduce complications associated with the incision, the reduction of the incision

increases the risk of potential sural nerve injury or rupture of Achilles tendon (Lui *et al.*, 2007; Lui *et al.*, 2010). Meanwhile, the use of special equipment is expensive at times (LIN *et al.*, 2011; YANG *et al.*, 2014); besides, the curative effect of small incision of old Achilles tendon rupture is similar to that of traditional surgery, but the operation is significantly difficult than that of the traditional approach, all of the above issues require us to study and solve. Simultaneously, these problems also limit the popularization of minimally invasive or small incision technique. Due to advantages of simple operation under direct vision, and definite suture strength of the broken-end of Achilles tendon, etc., the traditional straight incision slightly medial to the midline posterior aspect of Achilles tendon is still the first choice in many primary hospitals. Nevertheless, skin complications of traditional incision are relatively numerous. For example, traditional vertical incision will induce greater tension to the skin when closing, afterwards, the skin of the incision and Achilles tendon will be mutually squeezed after the suture to cause the occurrence of blood transport disorders, eventually leading to skin necrosis (Yang *et al.*,

2014). This virtually increases psychological and economic burdens for patients in the subsequent treatment. Yepes *et al.* (2010) supported in their study that the blood supply intensity around the tendon was the largest, followed by the lateral region (Tian *et al.*, 2014), and the median posterior blood supply was the least. Both sides of the small artery supply area formed a rich vascular network, while the blood supply was scarce in the median posterior region of Achilles tendon (fig. 4-5), and the medial incision of Achilles tendon was thus recommended. Furthermore, Sun Shuhong *et al.* also presented a similar result, but failed to further explain the advantages and disadvantages of the internal and external incisions. In our study, it was believed that the medial incision could effectively prevent incision related complications and protect the sural nerve.

Significance of peritendon tissues

The peritendon tissue or the paratenon refers to the loose reticular tissue around Achilles tendon, which contains blood vessels to provide nutrition. The degree of injury of the peritendon tissue determines the healing process after the rupture of Achilles tendon (Gao *et al.*, 2015). Therefore, the protection of tendon tissue is particularly important for physicians in the department of orthopedics (Yang *et al.*, 2011; Yepes *et al.*, 2010; Sun *et al.*, 2007; YU *et al.*, 1994). In this study, the broken-end of Achilles tendon at 2~3 cm of the medial part with the most abundant blood supply was used to make an arc incision to separate Achilles tendon sharply layer by layer, and the dorsal part of Achilles tendon was intact. The operation in turn preserved the integrity of the posterior skin of Achilles tendon, reduced postoperative Achilles tendon adhesion and complications related to incision skin. Furthermore, subjects involved in the study were diagnosed with old rupture of Achilles tendon and there were certain changes and scarring of the peritendon tissue. However, postoperative follow-up showed that the problem of adhesion around Achilles tendon was relatively mild, and all incisions healed by grade I at first stage.

Advantages of the modified medial arc incision of Achilles tendon

In the study, we adopted modified medial arc incision of Achilles tendon. In the anteromedial region with multiple skinfold in the extreme plantar flexion position of the ankle joint, a scoop-shaped arc incision was made in the broken-end of Achilles tendon at 2 ~3 cm of the medial part, subsequently, the incision was extended appropriately according to the position of Achilles tendon rupture. The operation indicated the following advantages: (1) The medial skin of Achilles tendon was loose, and the incision in the medial side would weaken the tension of incision, reduce the difficulty of operation, facilitate the suture of incision after operation, reduce the blood pressure of incision skin, and decrease the risk of

skin necrosis due to the large suture tension. (2) The medial skin had relaxation, good ductility and other advantages, which contributed to the reduction of the number of stitches, thereby alleviating blood supply of incision skin, and reducing the probability of skin necrosis. (3) The broken-end of Achilles tendon and the incision was in the different level. The application of staggered suture reduced the risk of adhesion after operation and was convenient for patients to perform ankle functional exercises in the later stage. (4) The operative approach was safe, without important blood vessels and nerves along the way, which was far from the structure of the anterior malleolar canal and avoided the injury of the sural nerve. (5) The effect appeared after Achilles tendon suture resulted in the close attachment of the skin and Achilles tendon and avoided direct connection of the incision with Achilles tendon, which in turn avoided skin ischemia, necrosis caused by long-term pushing of the incision by Achilles tendon, and even Achilles tendon exposure.

In this study, two surgical approaches of modified medial arc incision of Achilles tendon and traditional straight incision were used for the treatment of old Achilles tendon rupture. In the process, open incision was adopted with clear operating area, and injury of sural nerve was avoided at the same time. The incision was sutured firmly to prevent from re-rupture postoperatively. No sural nerve injury and re-rupture of Achilles tendon occurred in the experiment. Open incision was accompanied by the risk of infection, however, there was no incision infection in modified medial arc incision of Achilles tendon. Incision infection occurred in 5 cases when applying traditional straight incision, including superficial infection in 4 cases and deep infection in 1 case. There was no statistical difference in the comparison of incision infection between modified medial arc incision of Achilles tendon and traditional straight incision ($P=0.149$), which might be correlated with the smaller sample size. In the modified medial arc incision of Achilles tendon, the skin suture avoided the suture at the broken-end of Achilles tendon, and reduced the interference of incision suture on the sliding channel of Achilles tendon. Besides, the location of the skin incision was located in the posteromedial part of the skin around the tendon with the most abundant blood supply, corresponding influence in the blood loss of Achilles tendon was significantly smaller than that of the traditional median straight incision. But no obvious difference was found in the incidence of Achilles tendon adhesion between the two groups ($P= 0.181$), the smaller sample size might be responsible for the above result. In addition, there was no significant difference between the two groups in the muscle atrophy of the leg, the thickening of Achilles tendon rupture, the rate of limitation of ankle joint movement and the satisfaction rate of the patients. Among them, the satisfaction rate of modified medial arc incision and traditional straight

incision were 100% and 76.7%, respectively, which might be affected by the sample size and the subjective feeling of patients. Nevertheless, AOFAS score was better in the group with modified medial arc incision of Achilles tendon than the traditional straight incision group ($P=0.000$), and could recover to normal motion ranges earlier ($P=0.002$). Only one patient underwent straight incision obeyed the doctor's advice, and occurred skin incision infection caused by bathing after discharge without prompt treatment. Then, the patient suffered from deep infection, the wound was opened and dressing was changed frequently. Most of Achilles tendon showed defects, the wound was healed by the transfer of island skin flap with vascular pedicle and then reconstructed with autologous fascia lata transplantation. Finally, the ankle joint was stiff, the range of flexion-extension was limited by 30° and the patient was recovered with claudication. In the current stressful life environment, early return to daily life could reduce the burden of family and the psychological burden of patients. AOFAS score was a comprehensive evaluation of ankle and foot pain, ankle mobility, walking ability and activities of daily living, which might be less affected by sample size, suggesting that modified medial arc incision of Achilles tendon was superior to traditional straight incision.

It should be noted that the study was designed as a retrospective analysis, without randomization in the two groups. Secondly, operations were conducted by two operators in modified medial arc incision of Achilles tendon and traditional straight incision, respectively, which might lead to unstable quality of operation. Thirdly, the sample size of the present study was relatively smaller, associated with relatively shorter period of follow-up. Additionally, gait analysis of lower limbs and muscle strength of triceps surae were not performed by gait analyzer. In view of the above shortcomings, the curative effect of the two surgical approaches need to be studied in the future.

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