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Original Article

Effects of evolutionary "ㄣ"-shaped incision on surgical treatment for achilles tendon rupture

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Abstract: This study aimed to compare efficacy of evolutionary "ㄣ"-shaped incision with conventional incision for treatment of Achilles tendon rupture. Nineteen Patients of Achilles tendon ruptures were recruited from Third Hospital of Hebei Medical University from Jun. 2011 to Aug. 2013. Group A (n=9 patients) was treated with evolutionary ㄣ-shaped incision and Group B (n=10 patients) with conventional incision. Patients in both groups received same postoperative techniques of fixation. Primary outcome measures were healing period and incidence of important surgical complications, including infections, adhesions, Achilles tendon re-ruptures, and sural nerve lesions. Arner-lindholm clinical outcome score was used. The observation period ranged from 6 to 32 months in Group A, and 13 to 30 months in Group B. There were no surgical complications taking place in Group A. There were 3 cases of infections, 1 case of Achilles tendon re-ruptures and 2 cases of wound necrosis in Group B. Mean healing period was 12 days in Group A and 16.2 days in Group B. No sural nerve lesions were reported in either group. Arner-lindholm clinical outcome score of Group A was excellent in 8 cases and good in 1 case. Score of Group B was excellent in 7 cases, good in 2 cases and poor in 1 case. In conclusion, evolutionary ㄣ-shaped incision can reduce damage to blood circulation around incision as well as tension of the incision. Evolutionary ㄣ-shaped incision can achieve excellent effects and avoid surgical complications.

Keywords: Achilles tendon, rupture, incision, open surgery, complication

Introduction

Achilles tendon rupture is a common orthopedic disease. However, open surgery for Achilles tendon rupture, especially old Achilles tendon rupture, can bring about high incidence of postoperative complications due to the involvement of surrounding soft tissues. The common complications include flap margin necrosis, delayed healing, infection, keloids and soft tissue adhesions. Flap margin necrosis is the hardest to tackle [1, 2].

We adopted evolutionary ㄣ-shaped incision for 9 patients of Achilles tendon rupture and conventional incision for another 10 patients from June 2011 to August 2013 at our hospital. The incidence of necrosis of flap margin was compared between the two incisions.

Materials and method

Subjects

Inclusion criteria: Admitted to our hospital from June 2011 to August 2013; closed Achilles tendon rupture; aged between 10 and 60 years old; injured during sports activities. Exclusion criteria: Having a previous history of injury or pain in the Achilles tendon on the affected side; non-compliance due to mental disorders. The patients totaling 19 were divided into ㄣ-shaped incision group (Group A, **Figure 1A**) and conventional incision group (Group B, **Figure 1B**). Group A had 9 patients, who were aged 14 to 51 years old (average 35.1), including 7 males and 2 females; 7 patients were injured in the left and 2 in the right; the time from injury to treatment was 1 d to 4 months; 4 patients had old Achilles tendon rupture more than 3 weeks ago, and the remaining 5 patients received surgical treatment within 3 weeks after injury. The follow-up period was 6 to 32 months. As to the underlying diseases, 1 patient had diabetes and 1 had hypertension. Group B had 10 patients, who were aged 27 to 50 years old (average 39.7), including 9 males and 1 females; 5 patients were injured in the left and 5 in the right. The time from injury to surgical treatment was 1 d to 2 weeks. The postopera-

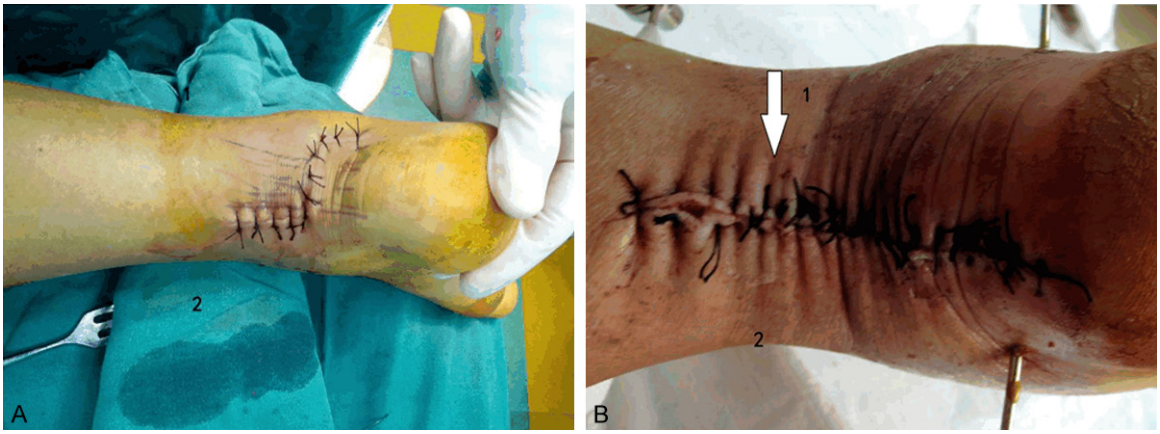

Figure 1. Demonstration for the evolutionary incision (A) and the conventional incision (B).

Figure 2. The wound necrosis and infection.

tive follow-up period was 13 to 30 months. One patient had diabetes before surgery.

Surgical method

The patient took prone position and received intraspinal anesthesia or combined spinal-epidural anesthesia. The blood flow of the thigh on the affected side was blocked with pneumatic tourniquet at the pressure of 260 mmHg for 1 hour. The skin to be operated was disinfected conventionally with iodine tincture and alcohol. The drape was laid down conventionally. A ㄣ-shaped incision was made from the medial-superior to the lateral-inferior of the Achilles tendon. The transverse segment of the incision was located on the level of the distal ruptured end of the Achilles tendon; the two longitudinal segments were located on two sides of the Achilles tendon, running for a length that fully exposed the ruptured end of the Achilles tendon and the surrounding normal tissues. The skin, subcutaneous tissues and deep fascia were cut open successively to expose the ruptured end of the Achilles tendon and the normal surrounding tissues. The necrotic and degenerative Achilles tendon was removed, the two ruptured ends were joined together and sutured by Kessler method. It was checked whether the suture was firm and tight and the suture was strengthened at the vulnerable places. If the Achilles tendon showed horsetail-shaped tear, the Achilles tendon was gathered together and properly aligned during the suture. The peritendon membrane was preserved and repaired if possible. If the defect of the ruptured end was too large to repair, autologous or allogeneic rotation flap was grafted. Then the deep fascia and skin were sutured, and the incisions were covered with sterile dressings.

Postoperative recovery

The plaster cast was applied to the dorsal surface of the affected ankle in plantar flexion for 8 weeks. The ankle was kept in inflexion of 20 to 30 degrees and bent naturally under gravity. The patients were encouraged to take inflexion and extension movements of the toes. If the incisions were properly healed at 12-14 days postoperatively, the sutures were removed. The plaster cast was removed at 8 weeks postoperatively, and the patients started walking with crutches. The affected limb began to bear load. The patients could walk without crutches at 3 months postoperatively and do unrestricted movement at 6 months.

Evaluation indicators

Both two groups were followed up regularly. The time of incision healing was recorded along with complications, such as necrosis of flap margin, wound infection, paraesthesia in the

Table 1. Comparison of the postoperative complications between two groups

	Group A (9 cases)	Group B (10 cases)	*P* value
Wound infection	0	2	0.211
Necrosis of flap margin	0	3	0.474
Total	0	5	0.033
Achilles tendon re-rupture	0	1	1.000

Table 2. Comparison of the incision healing time between two groups

	Group A (9 cases)	Group B (10 cases)	*P* value
Incision healing time (days, $\bar{x}\pm s$)	12.00±0	16.20±6.97	0.089

region enervated by the sural nerve and Achilles tendon re-ruptures. Arner-lindholm score was used for treatment effect evaluation [3]: 1. Excellent, dorsiflexion of 30 degrees and plantar flexion of 45 degrees of the ankle, normal squatting movement, normal strength in raising heels with one leg, fully capable of working, running and jumping; 2. Good: dorsiflexion of 25 degrees and plantar flexion of 30 degrees of the ankle, normal squatting movement, slightly weakened strength in raising heels with one leg, basically capable of working, running and jumping; 3. Moderate, mildly restricted ankle movement, squatting movement and raising heels with one leg with some exertions, incapable of intense physical activities or running and jumping; 4. Poor, obviously restricted ankle movement, restricted squatting movement, incapable of raising heels with one leg or doing intense physical activities.

Statistical analysis

Statistical analysis was carried out using SPSS 16.0 software. The incision healing time was expressed as $\bar{x}\pm s$ and compared using independent two-samples t-test. The incidence of postoperative complications including necrosis of the flap margin, infection, sural nerve lesion and Achilles tendon re-rupture was compared between the two groups using Fisher's exact test for four-fold table. $P<0.05$ indicated significant difference.

Results

The follow-up period was 6 to 32 months in Group A and 13 to 30 months in Group B. All incisions, new or old, were properly healed. No necrosis of flap margin, delayed healing, wound infection or re-ruptures were reported. In Group B, 3 cases had necrosis of flap margin and 2 had wound infection (**Figure 2**). Four of them finally achieved incision healing after regular dressing changes, debriding and antibiotics therapy; the remaining case received regular dressing changes, debriding and antibiotics therapy as well as surgical debridement and bridge flap transplantation at 14 days postoperatively, and finally achieved incision healing. One case had Achilles tendon re-rupture caused by accidental fall at 6 weeks postoperatively. This case received secondary surgery (**Table 1**). The sutures were removed in all cases of Group A at 12 days postoperatively, and all wounds were healed properly without swelling or exudation. The incision healing time was 12 days to 1 month in Group B, with an average of 16.2 days (**Table 2**). No cases had sural nerve lesion in either group. Arner-lindholm score was used to evaluate the treatment effect. In Group A, 8 cases (88.9%) achieved excellent effect and 1 case (11.1%) good effect, the excellent and good rate being 100%. In Group B, 7 cases (70%) achieved excellent effect, 2 cases (20%) good effect, and 1 case (10%) moderate effect, the excellent and good rate being 90%.

Discussion

Achilles tendon starts near the middle of the calf and ends at calcaneal tuberosity. The blood vessels of the Achilles tendon are concentrated near the endpoint of the tendon and where the muscles bind to the tendons. There are no vessels within the tendon, so the blood supply of the middle segment of the tendon is very scarce. Achilles tendon is mainly supplied by the peritendon tissues [4]. The 2 to 6 cm proximal end of the tendon is the most common site of rupture due to poor blood supply. The blood supply from the peritendon membrane will decrease with age [5], leading to calcifications and other degenerations. This further increases the risk of tendon rupture [6]. The superficial fascia on the two sides of tendon contains much fat. Bursa is found between the endpoint of the tendon and the bone surface of the calcaneus, and bursa subcutanea calcanea exists between the tendon and the skin.

Communicating branch emanates from the lateral sural cutaneous nerve lateral to the Achilles tendon in the posterior-inferior part of the calf. It forms the sural nerve with the lateral sural cutaneous nerve via anastomosis. The sural nerve runs down the superficial fascia along with the small saphenous vein. The sural nerve passes through the posterior-inferior part of the external malleolus and runs towards the lateral margin of the dorsum of the foot. The main branches of the sural nerve are found in the skin of posterior-inferior part of the calf.

Due to special anatomical relationship between the Achilles tendon and the soft tissues, no standard surgical treatment for Achilles tendon rupture has been established yet [7]. Nevertheless, some basic understanding of the advantages and defects of different treatment methods has been gained [8]. Conservative therapy usually has high incidence of Achilles tendon re-rupture [9], and the patients are barely capable of raising the heels or doing physical activities. Long duration of plaster cast may lead to rigidity of the affected ankle, muscle atrophy and weakened strength of calf [10]. Minimally invasive surgery or percutaneous repair of the ruptured Achilles tendon are gaining popularity in recent years due to reduction of surgical trauma, injury to blood supply near the tendon and postoperative complications. They are ideal for reconstruction of Achilles tendon with reliable effect [11]. But these procedures have less satisfactory anastomotic effect compared with the open surgery and the fixation effect is uncertain. Achilles tendon re-rupture may still occur, though at less frequency than the conservative therapy. Minimally invasive surgery cannot fully expose the sural nerve, so it is easy to injury or even suture the sural nerve, which makes loosening by secondary surgery necessary [12]. Open surgery has more reliable treatment effect and higher patient satisfaction. However, the incidence of postoperative complications remains high, including necrosis of flap margin, delayed or poor incision healing, wound infection, keloids, soft tissue adhesions and sural nerve lesion [13].

Achilles tendon lies at shallow position. It is covered by a thin layer of soft tissues and has poor blood supply. This is one major reason for high incidence of complications with conventional incision, including necrosis of flap margin, delayed or poor incision healing, and wound infection [14]. The blood supply of the soft tissues around the tendon mainly comes from the vessels and branches emanating from the posterior tibial artery and fibular artery. The posterior tibial artery supplies the soft tissues medial to the tendon and the skin covering it. The fibular artery supplies the soft tissues lateral to the tendon and the skin covering it. Thus, the two sides of the tendon have more abundant blood supply. The closer the position to the middle and the dorsal surface of the tendon, the fewer the vessels and the scarcer the blood supply is [15, 16]. The ㄴ-shaped incision is located on the two sides of the tendon, where the blood supply is more abundant. Another reason for frequency postoperative complications in closed Achilles tendon rupture is the large transverse tension of the longitudinal segments of the incision and hence high difficulty of flap margin alignment (**Figure 1B**) [17, 18]. The ㄴ-shaped incision is made at the position away from the dorsal surface of the tendon, the skin with poor blood supply and the most folded skin. Moreover, making two turns and one transverse incision in the middle, the ㄴ-shaped incision converts part of the transverse tension into longitudinal tension. Therefore, the tension of the incision is reduced, and the incision has less skin folds and better alignment (**Figure 1A**). This further improves the blood supply at the flap margin. To accommodate the movement of the ankle, the skin right behind the Achilles tendon is relaxed and has higher extension and shrinkage ability. Comparatively, in conventional incision, the scars formed after incision healing will impede the extension and shrinkage of the skin. In ㄴ-shaped incision, the longitudinal segment is away from this part of the skin, and the transverse segment produces no restriction to the longitudinal movement of local skin. The middle segment of the tendon has poor blood supply and is mainly supplied by peritendon tissues [14]. The longitudinal segments of the ㄴ-shaped incision are located on two sides of the transverse segment, and they run in the medial, upward direction and in the lateral, downward direction, respectively. Minimally invasive surgery is likely to cause paresthesia of local skin due to surgical injury of the sural nerve [12]. By placing the longitudinal segment of the ㄴ-shaped incision running upwards to the medial side of the tendon and the segment running downwards to the lateral

side of the tendon, the incision was kept away from the portion of the sural nerve that is closest to the tendon. Therefore, the sural nerve is protected from injury and the postoperative complications are reduced.

The incision healing time of the evolutionary ㄣ-shaped incision group (Group A) was longer than that of the conventional incision group (Group B), though not significantly. No sural nerve lesion was reported in either group. The ㄣ-shaped incision can better protect the sural nerve and avoid damage. The conventional incision used in Group B is located in the posterior or the medial margin of the tendon without covering the region enervated by the sural nerve. The cases in Group A had good incision healing, without necrosis of the flap margin or wound infection. However, in Group B, 3 cases had necrosis of flap margin and 2 had wound infection (**Figure 2**). According to statistical analysis, the two groups did not show obvious difference in incidence of any single complication. But the total incidence of complications in Group B was significantly higher than that in Group A.

The sample size of the present study was not large enough. More randomized large-sample trials will be performed in the future to further confirm the advantages of ㄣ-shaped incision in treating closed Achilles tendon rupture. We will improve the surgical procedures by placing the transverse incision above the proximal fractured end of the tendon where the soft tissues and blood supply are more abundant.

In conclusion, we used evolutionary ㄣ-shaped incision to address the defects of large tension, scarce local blood supply and skin folding with conventional incision in closed Achilles tendon rupture. The ㄣ-shaped incision reduces the postoperative complications such as necrosis of flap margin and wound infection.

Disclosure of conflict of interest

None.

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