A modified, minimally invasive technique for acute Achilles tendon repair using two transverse incisions

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Abstract

Background: Typical complications of the surgical treatment of acute Achilles tendon rupture are wound infection, seroma, skin tethering, sural nerve damage and hypertrophic scar. Some percutaneous or mini-open methods for acute Achilles tendon repair have been developed recently. Many of them have specific complications such as sural nerve damage, scar adhesion at the rupture site or maladaptation of the tendon.

Method: To minimize these complications, we describe a technique using 2 transverse incisions, leaving the rupture site under a bridge of intact peritendineum. The sural nerve is exposed and spared from damage using the cranial incision. The aim of this surgical technique is to minimize complications concerning wound healing, scar adhesions at the rupture site, maladaptation of the tendon ends, damage to the sural nerve and seroma due to large-diameter resorbable sutures.

Results: Between 2008 and 2010, we treated 47 patients with a mean age of 50 years who sustained a complete rupture of the Achilles tendon. Forty-one patients were re-evaluated after an average of 7 months. Thirty-seven Achilles tendons healed without complications. Complications were one delayed wound healing, two re-ruptures after trauma and one deep vein thrombosis.

Conclusion: Combined with a good clinical outcome, this minimally invasive technique may reduce the incidence of sural nerve entrapment. An early functional rehabilitation program is possible with full weight-bearing using a brace.

Keywords: Achilles tendon, acute rupture, minimally invasive.

1. Introduction

The Achilles tendon is the largest and strongest tendon of the human body. It normally withstands a force of 1000 pounds or more without tearing. Achilles tendon ruptures usually occur in middle-aged men between 30 and 40 years with an estimated incidence of approximately 18 per 100,000 (Leppilahti, Puranen, & Orava, 1996; Amlang, & Zwipp, 2006). The male to female ratio varies between 5:1 and 30:1 depending on the study (Strauss, Ishak, Jazrawi, Sherman, & Rosen, 2007). The tendon rupture frequently occurs 2 to 6 cm away from the insertion at the calcar. This region has a smaller cross sectional area than the rest of the tendon (Wren, Lindsey, Beaupré, & Carter, 2003). Kannus and Józsa (1991) described characteristic histopathological patterns in spontaneously ruptured tendons. Most of the described pathological changes were degenerative and included hypoxic degenerative tendinopathy, mucoid degeneration, tendolipomatosis, and calcifying tendinopathy, alone or in combination. Degenerative changes were more common in the tendons of people older than thirty-five years, and these changes were associated with spontaneous rupture. The other risk factors for spontaneous tendon rupture were steroid therapy and fluoroquinolone therapy (Maffulli, 1999).

Different methods have been described to treat Achilles tendon rupture. The treatment goal of a closed Achilles tendon rupture is to restore its original length and strength. Conservative treatment was recommended by some authors because the immobilization of the ankle in equinus angulation yields nearly similar results as surgical treatment (Lea & Smith, 1968). This treatment is an option for patients who have lower functional requirements or those with risk factors such as diabetes mellitus or immunosuppression. Problems associated with conservative treatment include a high rate (up to 20%) of tendon rerupture (Cetti, Christensen, Ejsted, Jensen, & Jorgensen, 1993) or increased ankle stiffness and calf atrophy, increased cutaneous adhesions, a higher risk of thrombophlebitis and possible tendon lengthening (Maquirriain, 2011; Soma & Mandelbaum, 1995).

Alternatively, operative treatment may be pursued. Surgery is performed to ensure tendon approximation and to improve healing. Open repair of Achilles tendon rupture is associated with a higher risk of infection and wound problems compared to non-operative treatment. Ma and Griffith first reported Achilles tendon repair using percutaneous sutures to reapproximate the ends. Complications of surgical treatment, including wound infection, skin tethering, sural nerve damage, and hypertrophic scar, were observed in approximately 4 to 19% of patients (Carden, Noble, Chalmers, Lunn, & Ellis, 1987; Cetti, Christensen, Ejsted, Jensen, & Jorgensen, 1993). To avoid sural nerve damage, some mini-open techniques have been described such as the three-incision technique described by Webb and Bannister and the single-incision techniques using the Achillon device (Assal et al., 2002) or Dresden instrument (Amlang, Christiani, Heinz, & Zwipp, 2006).

To minimize complications using a minimally invasive technique, we assigned importance to the following considerations:

Wound healing may be improved by using small transverse incisions, which are expected to produce a lesser rate of complications compared to incisions parallel to the tendon. Scar adhesions at the rupture site should be minimized because the suture is located in a region of intact peritendineum between the two skin incisions.

Maladaptation of the tendon ends may be avoided because of good exposure through the two small incisions and the secure suturing method. Damage to the sural nerve may be avoided by exploration and prevention at the proximal transverse incision.

Seroma formation due to large-diameter resorbable sutures is avoided because this technique requires only a PDS 1.0 suture.

2. Methods

Between 2008 and 2010, we treated 47 patients (3 women and 44 men) with a mean age of 50 years (range, 21-79). Injuries occurred during participation in athletic activities in 36 cases (77%) and non-sports-related activities in 11 cases (23%). The time between rupture and surgery was on average 2.9 days. The diagnosis was made clinically with ultrasonographic confirmation. Exclusion criteria were tendon re-rupture, complex open rupture with soft-tissue defect and a rupture less than 2 cm from the tuberosity of the calcaneus.

Postoperatively, the foot was immobilized using a flexible VACOped® orthosis (OPED GmbH, 83626 Valley/Germany). We instituted an early functional rehabilitation program, carefully supervised by a physical therapist. Full weight-bearing was allowed during the 7 weeks of bracing. Sports were allowed 3 months after the rupture.

We re-examined 41 patients after an average of 7 months (5-11 months). Six patients were lost to follow up. Patients were assessed using a standardized protocol for calf muscle strength (measured by single heel raise, with ground-to-heel distance compared with the normal foot), calf atrophy (measured by comparing the circumference of the calf with the normal side), wound healing, and ability to return to pre-injury activity.

Pain, function and other complaints were measured. We decided to use the ankle-hindfoot scale developed by the American Orthopaedic Foot and Ankle Society (AOFAS Score). The mean AOFAS score was 83 points with a range of 76 to 100 points.

2.1. Operative Technique

The patient is placed in the prone position with free movement in both ankles. A single dose of a second-generation cephalosporin antibiotic is administered prophylactically.

The rupture zone is marked preoperatively (Fig. 1). Two 25-30-mm transverse incisions are made approximately 25 mm distal and proximal to the detected rupture zone (Fig. 2). The incision is deepened via blunt dissection down to the level of the paratenon of the Achilles tendon. In the area of the proximal incision, the sural nerve is identified and optionally tagged with a vessel loop (Fig. 3). After identification, the sural nerve is moved gently aside with a lateral hook. In part of the transverse proximal and distal incisions, the paratenon of the Achilles tendon is incised transversely. The distal and proximal tendon ends are mobilized from the distal and proximal incision, and the peritendinous adhesions are detached. After mobilization, the tendon ends are dislocated through the incisions (Fig. 4).

Both ends of the Achilles tendon are passed transversely and longitudinally with delayed absorbable sutures (PDS® 1). First, the transversal suture is passed from lateral to medial through the proximal end of the Achilles tendon. The needles are then reintroduced and passed along the axis of the tendon (modified Kirchmayr technique). This type of suture is placed through the proximal and distal ends of the Achilles tendon (Fig. 5). The distal suture is tunneled to the proximal incision, and the proximal suture to the distal incision (Fig. 6). The needles are then reintroduced in the opposed end of the tendon and passed along the axis of the tendon for approximately 3 cm. With the ankle in the equinus position, the tendon ends are approximated, and both pairs of sutures are pulled and tied (Fig. 7). In sum therefore, no tendon suture perforates the paratenon. The paratenon is closed with an absorbable suture (Vicryl® 3.0, Fig. 8), and the skin is closed using the surgeon's preferred method.

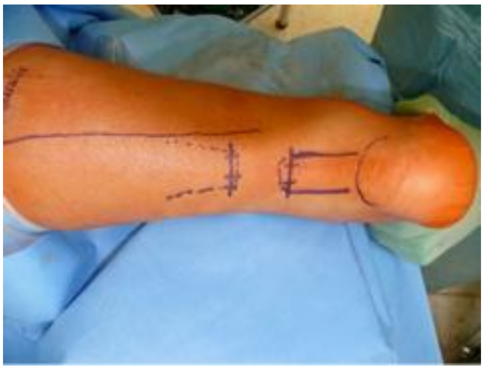

Figure 1. Pre-operative skin markings

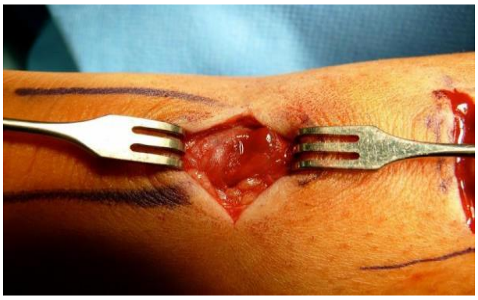

Figure 2. Skin incision: Two 30-mm transverse incisions are made 25 mm distal and proximal to the detected rupture zone.

Figure 3. Identification of the sural nerve, retraction of the nerve using soft-rubber vessel loop.

Figure 4. Mobilization of the Achilles tendon.

Figure 5. Sutures in the proximal and distal ends of the proximal ruptured tendon.

Figure 6. The sutures are then passed under the skin to the proximal and distal incisions.

Figure 7. In maximal plantar flexion, the tendon ends are apposed and tied.

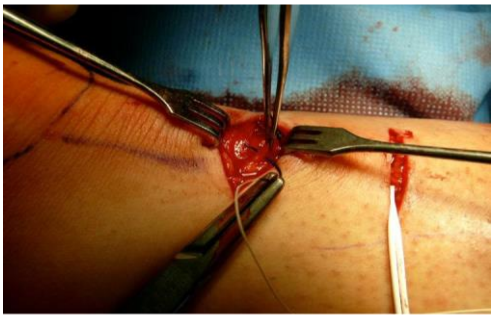

Figure 8. Paratenon is closed with an absorbable suture.

2.2. Postoperative Treatment

Postoperatively, the foot is immobilized in 30 degrees plantar flexion using a flexible VACOped® orthosis cast for two weeks. The orthosis must be worn 24 hours a day. Postoperatively, full weight-bearing with the orthosis is allowed.

During the period of immobilization, patients with the orthosis are instructed to perform gentle contractions of the gastrocnemius-soleus complex. The flexible VACOped® orthosis is converted to 15 degrees plantar flexion at the end of the second week for an additional 3 weeks of 24-h daily wear. During weeks 5-7, the VACOped® orthosis is converted to a neutral position and is only worn during the day. The VACOped® orthosis is removed 7 weeks after surgery, and physiotherapy is begun with range-of-motion and muscle-strengthening exercises. Two weeks after removal of the cast, swimming is initiated. Light jogging is permitted after 3 months, and a full return to running and jumping sports is permitted 4-5 months after surgery.

3. Results

Between 2008 and 2010, 47 patients with an acute Achilles tendon rupture were included (3 women and 44 men). The mean age was 50 years (range, 21-79). The mean duration of follow-up was 7 months (range, 5-9). Six patients were lost to follow up. Two patients (6%) presented with re-ruptures of the Achilles tendon 3 and 5 weeks after surgery; one described falling after missing a step on the stairs, and one stepped into a hole. One patient had a revision repair through the same incisions, whereas the other was treated non-operatively. One patient (3%) had a major wound complication; therefore, we removed the sutures and observed a complete healing of the tendon. We re-examined this patient after 8 months and ultrasound revealed a complete healing of the tendon with a 10° limitation of ankle dorsiflexion and 10° limitation of ankle flexion.

One patient had virtually permanent tendon pain and twelve had mild occasional pain. One of these patients had previous localized achillodynia. Other complications included one deep vein thrombosis (3%). Most patients were satisfied with the subjective result: 18 rated the outcome as excellent or very good, 18 as good, 4 as satisfactory, and 1 as poor.

A 5° limitation of ankle dorsiflexion was observed in 12 patients, and a limitation of 10° ankle dorsiflexion was observed in 6 patients (Fig. 9). Compared to the non-operated side, no increased movement of the joint such as hyperdorsiflexion was detected. Monopedal weight-bearing was possible for all re-evaluated patients. Hopping was not possible in four cases. An overall 1.4-mm (range 0-4) decrease in calf circumference was observed.

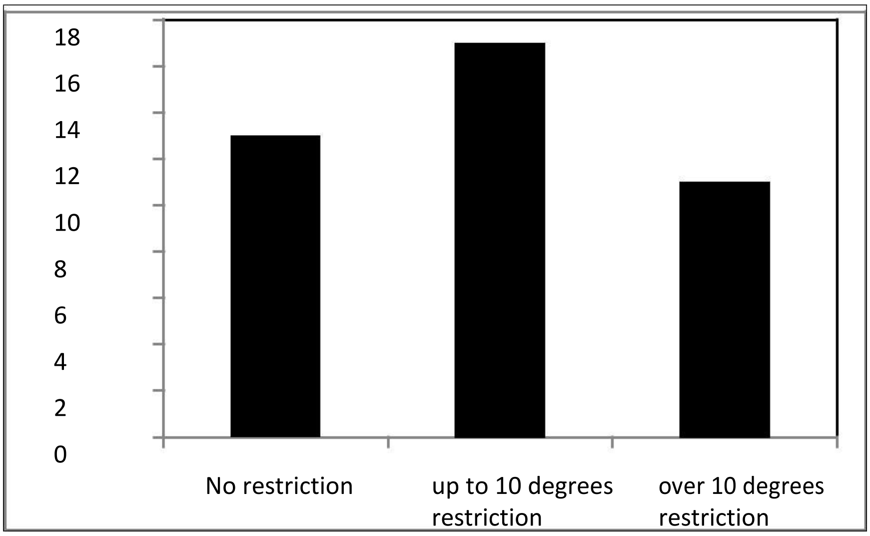

Figure 9: Restriction of the ankle joint compared with the native ankle joint.

No footwear restrictions were reported in thirty-six patients (88%), whereas five patients were unable to tolerate all fashionable shoes. No patient required modified shoes.

One non-compliant patient removed the orthosis one week after surgery and began walking and working without re-rupture of the tendon. In this case, we found no calf atrophy and no decrease in the range of motion. Most patients returned to work between 6 and 8 weeks after the initiation of treatment. At the end of the study period, all patients had returned to work, 86% had returned to participating in sports and 72% had returned to participating in the same sports as they had pre-injury.

4. Discussion

Although percutaneous suture repair offers advantages over open surgical and nonsurgical treatment, the former method introduces new problems. The rationale behind this surgical technique is to minimize complications concerning damage to the sural nerve, wound healing problems, scar adhesions at the rupture site, maladaptation of the tendon ends and seroma due to large-diameter resorbable sutures.

To avoid sural nerve damage, we recommend identifying the nerve at the proximal incision. After identification, the nerve must be held aside using a lateral hook. In this group, no sural nerve complications occurred. Ma and Griffith (1977) first developed a method for percutaneous repair. Although they reported no sural nerve complications in their study, other authors reported an unacceptably high incidence of sural nerve injury and re-rupture when applying the same technique (Haji, Sahai, Symes, & Vyas, 2004; Riedl, Sandberger, Nitschmann, & Meeder, 2002). Many percutaneous or less invasive Achilles tendon reconstruction methods have been described (Amlang, Christiani, Heinz, & Zwipp, 2006; Assal et al., 2002; Paessler, 1998). The possibility of damaging the sural nerve is one of the main disadvantages of percutaneous techniques. Sural nerve injuries or disturbed sensibility (e.g., numbness, hypersensitivity or tingling) occurred in 0 to 19% of cases (Haji, Sahai, Symes, & Vyas, 2004; Riedl, Sandberger, Nitschmann, & Meeder, 2002). Performing tenotomies with artificial tendons, Hockenbury and Johns (1990) found a sural nerve transfixation in 3 of 5 cadavers with a percutaneous repair. They described the sural nerve entrapment location as 2.5 cm proximal to the tenotomy. To avoid this complication, Klein, Lang, and Saleh (1991) modified the technique by extending the lateral skin incision to expose the sural nerve. The other techniques used to preserve the sural nerve are dorsal incisions (Webb & Bannister, 1999) or placement of the knots at the medial aspect of the Achilles tendon. As a modification of the Webb and Banister technique, we extend the proximal incision without an incision at the site of the rupture. In the area of the proximal incision, we locate the nerve and position it aside while placing the suture. This procedure allows us to avoid damage to the nerve during suture placement.

Aldam first described a new method of repair of the ruptured calcaneal tendon that used a small transverse skin incision (Aldam, 1989). The reason for using a transverse skin incision was to minimize damage to the blood vessels. The blood supply of the Achilles tendon is poorest 2 to 6 cm above its insertion at the calcaneus (Lagergren & Lindholm, 1959). In Aldam's procedure, a 3 to 4 cm transverse incision was made distal to the palpable gap in the tendon and outside the area of poorest blood supply. After the incision of the paratenon, he grasped the proximal and distal ends of the tendon and brought them into the wound. The tendon was sutured, and the paratenon and skin were closed. He described one re-rupture and one wound problem (due to a technical error). Incision of the paratenon might be critical because it may damage nutritive blood vessels. Detailed studies of the blood supply of the leg performed by Haertsch (1981) demonstrated that classic longitudinal incisions for calcaneal tendon repair occurs in poorly perfused skin. To reach the lateral end of the tendon and the sural nerve, long longitudinal incisions are typically required. To minimize the risk of injuring these vessels by long incisions, we prefer transverse proximal incisions. Tendons may receive their blood supply from vessels originating from three sources: the musculotendinous junction, the bone-tendon junction and the surrounding connective tissue (Mayer, 1916). The majority of the blood supply approaches the tendon via the paratenon. The anterior tibial artery gives off 5 vessels, and the posterior tibial artery gives off 7 vessels entering the paratenon (Wolff et al., 2012). Microradiological and histological studies showed that the middle part of the tendon, which is most frequently ruptured, benefits the most from the blood supply of the paratenon (Ker, 1981; Paar, Klever, & Erli, 2001). Using the technique of two transverse incisions, we avoid incisions of the paratenon in the ruptured part of the Achilles tendon, thereby avoiding any further disturbance of blood vessels in this critical area. A further benefit of using incisions outside the `critical zone´ is to avoid scar adhesions in this area. Without a control group, it is difficult to draw conclusions about scar adhesion; however, a correlation exists between immobilization, for example in a cast, and outcome. In 1999, Mortensen described the effect of early ankle motion after operative ruptured Achilles tendon treatment. The patients managed with early motion had a smaller initial loss in range of motion, and they returned to work and sports activities sooner than those managed with a cast. Furthermore, fewer visible adhesions occurred between the repaired tendon and the skin in the patients managed with early motion, and these patients were subjectively more satisfied with the overall result (Mortensen, Skov, & Jensen, 1999).

A concern with minimal percutaneous repair is the failure to appose the tendon ends and a lack of proper tension at the time of surgery with progressive tendon lengthening occurring postoperatively. Lengthening of the Achilles tendon is difficult to measure directly. A surrogate measure for the length of the musculotendinous unit is an increase in ankle dorsiflexion (Maquirriain, 2011). The mean increase in dorsiflexion for each centimeter increase in tendon length is 12 degrees (Costa, Logan, Heylings, Donell, & Tucker, 2006). Although range of movement is only a surrogate measurement of tendon lengthening, our results did not indicate that our minimally invasive incision technique produced stretching of the tendon during the operation or healing process.

We found no increased movement of the joint such as hyperdorsiflexion compared with the non-operated side, although range of motion was reduced overall. This reduced range of motion might be a result of immobilization in the orthosis and might be viewed as an indicator of good contact of the stumps by the operative repair.

Although immediate weight-bearing mobilization and early motion carefully supervised by a physical therapist was allowed, we often found calf muscle atrophy after the operative treatment, which may have been influenced by many factors. First, after limb immobilization, a significant decrease in the rate of protein synthesis occurs, which most likely initiates the net loss of muscle protein (Booth, 1987). Second, the greater the degree of plantar flexion and relaxation of the calf muscles, the greater will be the subsequently atrophy. Early movement can shorten the rehabilitation time; however, unloaded exercise did not prevent muscle atrophy (Myerson, 1999).

It is difficult to resolve the conflict between immediate weight-bearing and limb immobilization. Limb immobilization is necessary in the described method because we only use two 1.0 polydioxanone sutures. Alternatively, the advantage of this method is that it requires less specific equipment, and this suture technique is inexpensive. The only specific equipment requirements are the polydioxanone sutures (PDS, Ethicon).

5. Conclusion

We describe a safe minimally invasive technique with good clinical results that allows for a reduction in the incidence of sural nerve entrapment. This technique permits a minimally invasive reconstruction of the Achilles tendon and decreases wound infections, skin tethering and hypertrophic scar formation while also allowing for faster rehabilitation and early weight-bearing.

Competing interests

The author(s) declare that they have no competing interests.

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