



Percutaneous repair of acute Achilles tendon rupture: a functional evaluation study with a minimum 10-year follow-up

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Objective: The purpose of this study was to present the functional outcomes of percutaneous tenorrhaphy of the Achilles tendon with a minimum follow-up of 10 years.

Methods: The medical records of patients who underwent percutaneous surgery for acute unilateral Achilles tendon rupture between 2000 and 2004 were retrospectively reviewed.

Results: A total of 11 male patients met the inclusion criteria and were followed for a mean of 12.6 years (range: 10–13 years). The average age at the time of surgery was 39.3 years (range: 29–53 years). Patients returned to work at an average of 2.7 months (range: 1–4 months) after surgery and to normal daily activities (NDA) at an average of 4.1 months (range: 3–6 months) postoperatively. The mean strength ratio between the injured and normal sides was 90%. Compared with the contralateral normal side, the thickness of the operated tendon increased by a mean of 0.7 cm, while the circumference of the affected calf diminished by a mean of 1.1 cm. No difference in active and passive range of motion (ROM) was recorded between the affected and the contralateral normal ankle joints. Isometric plantar flexion was 87% of normal. Sensory impairment in the territory of the sural nerve was identified in 1 patient immediately after surgery. The sensory defect had completely resolved by 6 months postoperatively.

Conclusion: Long-term outcomes of our series support the effectiveness of percutaneous tenorrhaphy in Achilles function rehabilitation of patients with acute ruptures.

Keywords: Achilles tendon; long-term outcomes; percutaneous repair; rupture; sural nerve.

Level of Evidence: Level IV Therapeutic Study

Acute Achilles tendon rupture is a common injury, with an incidence of 5.5–9.9 ruptures per 100,000 people in North America.^[1] It is thought to be the most frequently ruptured tendon, accounting for 40% of all tendon ruptures requiring surgery.^[2] An increase in Achilles tendon

ruptures during the last decades has been recorded. The highest incidence of acute Achilles tendon rupture involves men aged 30–50 years.^[3] Most ruptures occur during athletic activities and are more frequent on the left side.^[3–5] The risk of contralateral Achilles tendon

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rupture is increased in patients who suffered a tendon rupture.^[6]

Multiple treatment modalities for acute Achilles tendon ruptures have been proposed, including conservative and surgical alternatives. Currently, although there is a tendency for operative treatment, there is still considerable controversy regarding the optimal management of acute Achilles tendon rupture.^[7-11] According to the literature, conservative management is associated with high rerupture rate, loss of strength, and stiff ankles, secondary to long periods of cast immobilization.^[12-16] Conversely, open surgery is associated with lower risk of rerupture, though it can be complicated by infection, wound breakdown, scar adhesions, and sural nerve damage.^[17,18] While they have not entirely eliminated the risk of postoperative complications, percutaneous and mini-open surgical repair techniques for Achilles tendon rupture have been developed to overcome the aforementioned complications. Opponents of percutaneous suturing believe that this method places the sural nerve at high risk for injury and has a higher rerupture rate compared to open surgery.^[4,19,20]

The long-term consequences of tendon injuries for today's athletes after the end of their sport participation are greater than previously anticipated.^[21] To our knowledge, there is no study evaluating the long-term outcomes of percutaneous repair of Achilles tendon ruptures. The purpose of this study was to present the long-term functional outcomes of percutaneous tenorrhaphy of the Achilles tendon with a minimum follow-up of 10 years.

Patients and methods

This study was performed at the University of Ioannina School of Medicine. After obtaining Institutional Review Board Approval, the medical records and ultrasonographic studies of patients who underwent surgery for Achilles tendon rupture between 2000 and 2004 were retrospectively reviewed. Inclusion criteria were 1) acute Achilles tendon rupture, 2) unilateral closed rupture, 3) rupture that occurred 2–8 cm proximal to the calcaneous tuberosity (tendinous portion), 4) no history of previous Achilles tendon rupture, 4) complete rupture, 5) absence of local or systematic predisposing factors such as corticosteroid use, therapy with quinolone antibiotics, rheumatoid arthritis, or tendinopathies, 6) patients who underwent percutaneous repair, 7) minimum follow-up of 10 years, and 8) patients treated by the same surgeon.

Achilles tendon rupture was diagnosed clinically by the presence of a palpable gap in the tendon, positive Thompson test, and inability of toe or heel walking. In

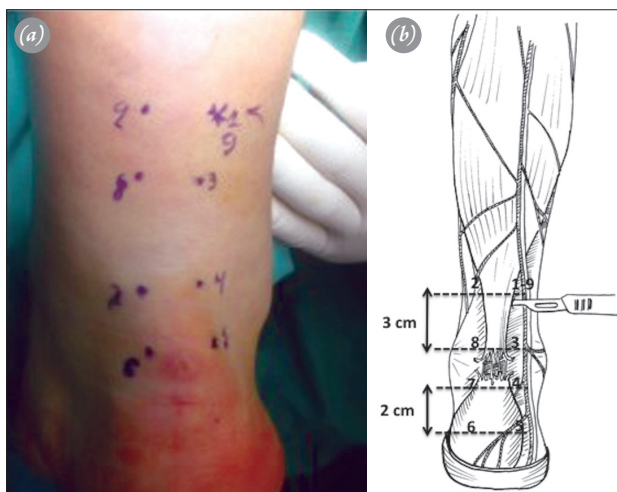


Fig. 1. (a) Eight marks corresponding to the 8 puncture holes were made just medial and lateral to the Achilles tendon. (b) The first and second marks were located at the proximal-lateral and proximal-medial borders of the Achilles tendon, respectively, 3 cm cephalad to the proximal tendon stump. The third mark was drawn on the lateral side of the tendon at the level of the proximal stump, while the fourth mark was drawn on the lateral side of the tendon at the level of the distal stump. The fifth and sixth marks were located at the distal-lateral and distal-medial borders of the Achilles tendon, respectively, 2 cm caudal to the distal tendon stump. The seventh mark was drawn on the medial side of the tendon at the level of the distal stump, while the eighth mark was located on the medial side of the tendon at the level of the proximal stump. The ninth and first mark correspond to the same hole. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

all cases, clinical diagnosis was confirmed by ultrasonographic examination.

The procedure was performed with the patient in the prone position without a tourniquet. The location of tendon diastasis was detected by palpation, and the sites of the 8 puncture holes just medial and lateral to the tendon were marked (Figure 1). The skin, subcutaneous tissue, and peritendon medial and lateral to the palpated gap from the most proximal to the most distal marks were infiltrated with 20 mL of 1% lidocaine. Using a No. 15 blade, 8 stab incisions of 0.5 cm each were made at the marked sites. A small hemostat was used to widen the holes. To prevent sural nerve iatrogenic injury, the proximal-lateral incision (No. 1) was further opened by 0.5 cm, and the sural nerve was identified lying superficially to the fascia with careful subcutaneous dissection (Figure 2a). Using a small vein retractor, the sural nerve was retracted laterally and protected.

The tendon was repaired using a looped No. 1 polydioxanone-suture (PDS II, Ethicon, Norderstedt, Germany) and a special semi-curved long rigid needle with an eyelet at its proximal end. The procedure was

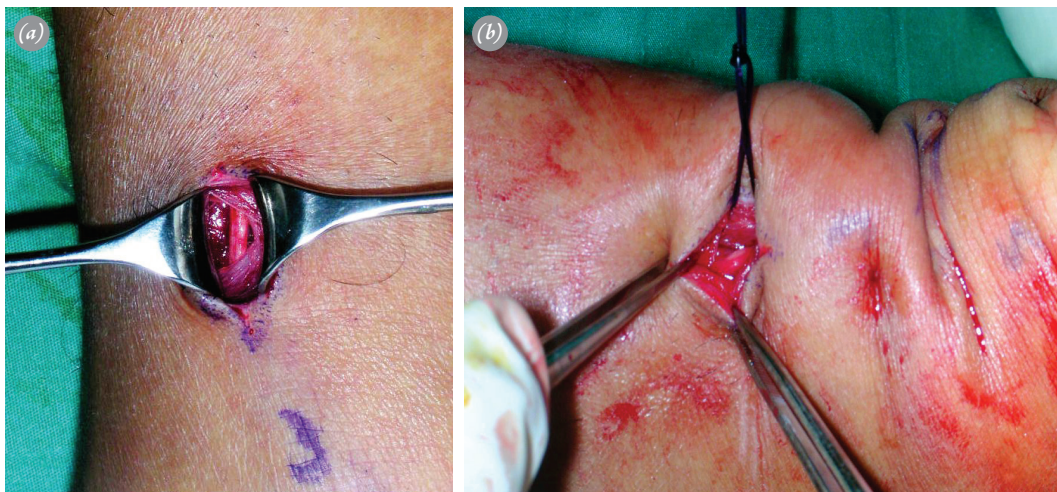


Fig. 2. (a) The first incision was further opened and dissected in order to allow direct visualization of the sural nerve while the later was lying superficially to the fascia. (b) The knot was made under direct visualization of the sural nerve. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

started and finished in the proximal-lateral incision (#1). The cutting needle was transversely passed through the tendon to the proximal-medial incision (#2) and then diagonally to incision #3. The suture was sequentially advanced from incision #3 to incision #8 and then diagonally back to incision #1. The ends of the suture were tied with the foot in plantar flexion of 20° to allow approximation of the tendon stumps. The knot was made under direct visualization of the sural nerve (Figure 2b).

Postoperatively, a sterile dressing and an anterior splint were applied with the foot in 20° of plantar flexion. At initial reevaluation 2 days postoperatively when the swelling had subsided, the splint was removed, and a walking boot (with a 3-cm heel lift) locked at 20° of plantar flexion was applied for 6 weeks. The patient was allowed weight-bearing as tolerated, using crutches for assistance. After 4 weeks, the boot was locked in 0° of plantar flexion. At 6 weeks postoperatively, the boot was removed, and the patient began rehabilitation with range of motion (ROM) exercises, stretching exercises, and swimming. Limited sports activities were allowed 12 weeks postoperatively.

Data was collected on age, weight, height, gender, length of follow-up, mechanism of injury, prodromal symptoms and symptoms in the contralateral leg (if present), level of rupture (distance from calcaneus tuberosity), restrictions in athletic activities or activities of daily living (ADL), time to return to maximum function, and strength ratio between injured and normal side.

Further evaluation included patients' ankle ROM, ability to raise 20 times on the toes of the injured side, difference in Achilles tendon thickness between the repaired and contralateral normal side at the level of the

medial malleolus, difference in the calf circumference between the repaired and the healthy side, patient satisfaction with the procedure, subjective complaints as recorded with the Visual Analog Scale (VAS), and complications such as tendon rerupture and sensory impairment in the territory of the sural nerve.

All patients were evaluated with isokinetic dynamometry (Cybex II, Lumex, Inc., Rokonkoma, NY, USA) of both limbs after correction for gravity. After a 10-min warm up on a bicycle ergometer and 5–10 trial runs at submaximal speed, tests were made with 3 cycles at an angular velocity of 30°/sec and 15 cycles at 120°/sec. Endurance strength was evaluated in quantitative terms. It was defined as the work done during the test at a predefined constant angular velocity and expressed in Joules. Power and strength measurements were performed at 30°/sec, with power determined as the work done over 5 cycles and strength as the peak torque. The angle at which the peak torque occurred was recorded. Endurance was measured as the work done for 15 cycles at 180°/sec. Testing was performed isokinetically at speeds of 30°, 90°, and 180°/sec. Each evaluation was preceded by a 4-repetition warm up at the preset speed (i.e., 60°, 120°, and 180°/sec). Five repetitions were performed at each speed to attain a peak torque in foot-pounds. The percent differences were calculated using the contralateral normal side as a reference. All measurements were made by 2 of the authors who were not involved in the surgical treatment and were blinded to the results.

Statistical comparison of the different sides was performed using the Mann-Whitney U test for non-parametric data. All tests were calculated with use of SPSS

version 19.0 (SPSS Inc., Chicago, IL, USA). In all instances, $p < 0.05$ was regarded as statistically significant.

Results

A total of 11 male patients met the inclusion criteria and were followed for a mean of 12.6 years (range: 10–13 years). Average age at time of surgery was 39.3 years (range: 29–53 years). The right leg was affected in 4 cases and the left in 7. Mean patients' height at the time of the surgery was 179.5 cm (range: 172–191 cm), and mean weight was 87.9 kg (range: 74–115 kg). All patients were amateur athletes whose injury occurred during athletic activities: in 10 patients rupture occurred during soccer, while in 1 patient rupture occurred during basketball. One patient experienced constant pain in the insertion of the affected Achilles tendon beginning 3 days before rupture, and all others reported a suddenly initiated forceful plantar flexion from a dorsiflexed position that resulted in acute pain in the Achilles tendon and inability to continue the athletic activity. Mean time interval between rupture and percutaneous repair was 1.7 days (range: 0–6 days); 5 patients underwent surgery a few hours after the injury occurred. Mean distance of the rupture from the calcaneus tuberosity was 3.8 cm (range: 2–6 cm).

Patients returned to work at an average of 2.7 months (range: 1–4 months) postoperatively and to normal daily activities at an average of 4.1 months (range: 3–6 months) postoperatively. At 6 months postoperatively, all patients had returned to previous athletic activities at pre-injury levels of performance.

At final follow-up, no patients experienced pain or discomfort such as morning stiffness or painful push off in the surgically treated limb (mean VAS score: 0). Mean strength ratio between injured and normal side was 90% (range: 75–100%). Compared with the contralateral normal side, the thickness of the operated tendon was increased by a mean of 0.7 cm (range: 0–1.3 cm), while the circumference of the affected calf was diminished by a mean of 1.1 cm (range: 0–4.5 cm). All patients except 1 were capable of rising 20 times on the toes of the injured side. Motion of the involved ankle averaged 24°. No difference in active and passive ROM between the affected and the contralateral normal ankle joint was recorded. Isometric plantar flexion was 87% of normal ($p > 0.05$). Differences in Cybex II testing between the operated and the contralateral normal leg are shown in Table 1. All patients were satisfied, rated the outcome as excellent, and stated that they would undergo the procedure again.

Sensory impairment in the territory of the sural

Table 1. Differences in Cybex II testing between the operated and the contralateral normal leg (°/sec).

	Mean	Lower	Higher
Involved-uninvolved side torque deficit			
Low speed			
Plantar flexion	13.67*	-20	37
Dorsiflexion	1.33	-26	19
Medium speed			
Plantar flexion	10.08*	-32	32
Dorsiflexion	-3.67	-34	21
High speed			
Plantar flexion	6.25	-28	34
Dorsiflexion	-0.67	-38	31
Involved-uninvolved side work deficit			
Low speed			
Plantar flexion	17.92*	-20	48
Dorsiflexion	9.33*	-19	38
Medium speed			
Plantar flexion	12.67*	-28	42
Dorsiflexion	0.75	-29	33
High speed			
Plantar flexion	10.58*	-28	58
Dorsiflexion	10*	-16	36
Involved-uninvolved side power deficit			
Low speed			
Plantar flexion	10.42*	-31	33
Dorsiflexion	0.92	-36	42
Medium speed			
Plantar flexion	6.91*	-34	31
Dorsiflexion	1.5	-31	51
High speed			
Plantar flexion	8*	-47	44
Dorsiflexion	1.25	-40	37

* $p < 0.05$ indicates statistical significance.

nerve was identified in 1 patient immediately after surgery. The sensory defect had completely resolved by 6 months postoperatively. At final follow-up, no patients complained of sensory deficits in the surgically treated limb. Complications such as wound infection, swelling, deep vein thrombosis, rerupture, symphyses, or Achilles tendon lengthening were not observed.

Discussion

The management of Achilles tendon rupture has been debated for several decades. Although there have been many randomized controlled trials on surgical versus conservative management of Achilles tendon rupture,

systematic reviews of these trials have not been consistent because of the differences in inclusion criteria.^[22–24] It has been suggested that treatment should be adjusted to the patient's needs, while considering that conservative management is associated with higher rerupture rates and open surgery with higher complication rates besides rerupture. In the present study, patients returned to work at an average of 2.7 months after percutaneous surgery and to normal daily activities at an average of 4.1 months postoperatively. After a mean follow-up of 12.6 years, none of our patients complained of pain or discomfort. ROM of the operated side did not differ from that of the contralateral normal side. Although this was not a comparative study, it indicates that percutaneous Achilles tendon repair may provide longstanding functional outcomes, while minimizing the potential risks of open surgery.

Percutaneous repair for acute Achilles rupture was first described by Ma and Griffiths in 1977.^[24] Their technique incorporated a Bunnell suture through the proximal tendon stump and a box suture through the distal stump. Subsequently, several modifications have been described in order to increase the number of suture passes through the tendon stumps and improve gapping resistance.^[25,26] Mini-open techniques with a limited incision at the rupture site have been developed for Achilles tendon repair. Advocates of mini-open surgery favor this approach, as it allows direct visualization of the rupture site and removal of interposed tissue, while ensuring good tendon apposition.^[3,27,28] The Achillon[®] device (Integra LifeSciences Corporation, Plainsboro, NJ, USA) is an example of a mini-open approach. When the Achillon[®] device was compared with the modified Ma and Griffith technique in a prospective 2 cohort study, no difference was noted in terms of American Orthopaedic Foot and Ankle Score (AOFAS) scores, return to previous sports activity, and postoperative complications.^[29] However, mini-open methods have the disadvantages of open tenorrhaphy, including incision of the paratenon and decreased intrinsic healing potential of the Achilles tendon.

Although percutaneous repair of the Achilles tendon offers many advantages over open surgery, some authors report complications regarding sural nerve function after percutaneous surgery.^[27,30] Techniques in which the sural nerve is not identified or protected from laceration or entrapment during percutaneous tenorrhaphy are those usually associated with sural nerve iatrogenic injury. Several methods have been described to avoid sural nerve injury, such as using more medial and posterior incisions, and medial placement of the surgical knots.^[20,31] Consid-

ering the significant degree in variability in the location of the sural nerve in relation to the Achilles tendon,^[20,32] identification of the sural nerve with a small retractor as it crosses the lateral border of the Achilles tendon, about 8–10 cm from its insertion, to the calcaneus and nerve protection is highly recommended. Numbness and hypoesthesia in the territory of the sural nerve was identified in 1 of our patients immediately after surgery. In that case, although the nerve was identified during the first incision, no retractor was used, which may have resulted in sural nerve injury during suture passage. The sensory defect had completely resolved by 6 months postoperatively.

Percutaneous repair is associated with improved cosmesis, compared to open surgery, since there is no large skin incision and the repaired tendons are thinner than those repaired with open surgery. However, it has been suggested that percutaneous tenorrhaphy is associated with higher rerupture rate, with rates ranging from 3% to 10%.^[23,24,31] According to Maes and Copin,^[33] possible causes of rerupture following percutaneous repair include delayed repair, inadequate approximation of the tendon stumps, and early weight-bearing without protection. In a more recent comparative study of 17 patients treated with percutaneous repair and 15 patients managed with open tenorrhaphy, Henriquez et al.^[34] showed no reruptures in the percutaneous group and 1 rerupture in the open repair group. In accordance with these findings, we observed no reruptures after percutaneous Achilles tendon repair. All our patients were treated soon after injury, with 5 patients having surgery less than 12 hours post-injury. A strict orthosis protocol was followed in our institution, with the walking boot being removed at 6 weeks postoperatively. Limited sports activities were allowed 12 weeks postoperatively, while return to full athletic activities was allowed after at least 6 months postoperatively.

Limitations of the study include its retrospective nature and the absence of a comparison group consisting of patients treated with open Achilles tendon repair. Another limitation of our study is the small number of patients treated with percutaneous tenorrhaphy who were followed for more than 10 years.

Percutaneous Achilles tendon repair with identification and protection of the sural nerve is a valuable method for the treatment of acute ruptures. Long-term outcomes of our series support the effectiveness of percutaneous tenorrhaphy in Achilles function rehabilitation of patients with acute ruptures. Patient selection, careful preoperative planning, and meticulous operative technique, with special care in sural nerve protection

and sufficient postoperative immobilization, will minimize complication rates and ensure lasting beneficial outcomes.

Conflicts of Interest: No conflicts declared.

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