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Open versus percutaneous repair in the treatment of acute Achilles tendon rupture: a randomized prospective study

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Abstract There is no agreement on the ideal type of surgical management for Achilles tendon rupture. The present randomized prospective study was performed to compare outcome data of open and percutaneous repair in the treatment of Achilles tendon rupture. Forty consecutive patients with acute rupture of Achilles tendon were recruited. Patients were randomized to receive open (group A) or percutaneous repair with Tenolig® (group B). All patients followed the same rehabilitation protocol except for slight differences in the duration of immobilization. Follow-up included objective evaluation (at 4 and 12 months), subjective evaluation using the SF-12® questionnaire (at 24 months), and bilateral ultrasound scanning and isokinetic testing (at 12 months). The differences in the parameters evaluated clinically were not significant except for ankle circumference, which was significantly greater in group B. There were two minor complications in the open repair group and one case of failed repair in the percutaneous group. SF-12® questionnaire, ultrasound and isokinetic test data did not show significant differences between the groups. The present study demonstrates that the open and the percutaneous technique are both safe and effective in repairing the ruptured Achilles tendon and that both afford the same degree of restoration of clinical, ultrasound and isokinetic patterns. Medium-term results were substantially comparable. Percutaneous repair is performed on a day-surgery basis, it reduces cutaneous complications and operation times, and enables faster recovery, enhancing overall patient compliance. To us, these characteristics make it preferable to open repair in managing subcutaneous ruptures of Achilles tendon in non-professional sports practicing adults.

Keywords Achilles tendon · Tendon rupture · Tendon repair · Percutaneous repair · Percutaneous treatment

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Introduction

Subcutaneous rupture of Achilles tendon is a frequent lesion, accounting for approximately 35% of all tendon tears [18] and for about 1/3 of foot traumas [31]. Despite its high incidence and the copious literature, there is still controversy with regard to the optimal management of Achilles tendon rupture [27].

The several techniques proposed to treat acute ruptures can essentially be classified into: conservative management in a cast, open repair and percutaneous repair [21].

With conservative treatment, the ankle is immobilized in maximal plantarflexion so as to re-approximate the two stumps, and a cast is worn to enable the tendon tissue to undergo biological repair. Advantages include the avoidance of surgical complications [4, 10, 22–25, 31] and hospitalization, and cost minimization [32]. In a randomized prospective study, Nistor [25] did not observe outcome differences between surgical and non-surgical management.

His study contributed to the gradual resumption of non-operative treatment, especially in selected patients. However, conservative procedures carry some disadvantages related to high rates of re-rupture [5, 12, 17, 19, 20, 23, 25, 32] and healing with residual lengthening. Re-rupture is

the most common complication of non-operative procedures, with reported rates of 13–35%. In Nistor's patients treated with this technique, rupture recurred 1–7 weeks after cast removal [25]. In a randomized prospective study, Moller et al. [23] observed equally good long-term results for surgical and non-surgical treatment if complications were avoided. However, the rate of re-rupture after non-surgical treatment was unacceptably high.

Residual lengthening involves increased dorsiflexion at physical examination, possible weakness of the gastrocnemius muscle and calf fatigue, resulting in a high proportion of dissatisfied patients [12, 15, 17].

Open repair aims at restoring anatomical length of the triceps surae through stump re-approximation [8]. The techniques used range from simple end-to-end repair using Bunnel or Kessler sutures to more complex procedures using fascial flaps or tendon grafts [30]. Open repair can be performed under local, spinal or general anesthesia [23]. The main advantages over conservative management in randomized prospective studies are decreased rates of re-rupture, less residual tendon lengthening, less calf atrophy, better ankle range of movement (ROM) and consequently resumption of a higher level of sports activities [6]. Treatment carries surgical complications, such as skin-tendon adhesions, infection, delayed healing of the surgical wound, sural nerve iatrogenic lesion, and suture granulomas [27, 28]. Severe complications such as deep venous thrombosis, pulmonary embolism and death have been reported for both techniques [27].

Percutaneous repair is a closed procedure originally described by Ma and Griffith [20]; it is performed under local anesthesia using various surgical techniques and instruments. It is based on stump juxtaposition without exposure of the rupture site, thus sparing the peritendinous sheaths and cutis and reducing surgical morbidity. Its advantages lie precisely in this reduced rate of complications, and indeed several researchers have reported an absence of infection, nerve lesions and re-ruptures [7, 16, 20]. In other studies, rates of re-rupture of 12% [3] or 33% have been described [1], as well as sural nerve incarceration with paresthesia, requiring surgical re-exploration to remove sutures and release the nerve [11, 21].

The above considerations seem to point to the superiority of operative over non-operative treatment in terms of final ROM, time to recovery, muscle trophism and functional outcome, despite higher rates of surgical complications; however, there is no agreement on the ideal type of surgical management.

The present randomized prospective study was performed to compare the clinical and imaging outcome data of open repair and a type of percutaneous repair.

Patients and methods

Forty consecutive patients with acute rupture of Achilles tendon, 36 men and 4 women (ratio 9:1) were recruited. Average age was 40.7 years (range 20–60), the highest incidence of rupture being found in 31–40 year old patients (55%), followed by patients aged 41–50 years (17.5%). All lesions were caused by indirect trauma. Five a side soccer (35%), soccer (12.5%), volleyball and tennis (5%), skiing (2.5%), and other activities (15%) were the main sports-related causes compared with walking and climbing/descending the stairs (25%). The right tendon was affected in 57.5% of cases and the left in 42.5%. Exclusion criteria were diabetes mellitus, rheumatoid arthritis, systemic lupus erythematosus and other autoimmune disorders, and previous local corticosteroid treatment. Inclusion criteria were age from 20 to 60 years and first-time rupture.

Rupture was diagnosed by physical examination (palpable gap in the tendon substance and Thompson's test) and bilateral ultrasound (US).

All subjects gave their written informed consent to participate in the study.

Patients were randomized to receive open (group A) or percutaneous repair (group B) using the Casio Scientific Calculator fix-88 (Casio Computer Co., Ltd. Tokyo, Japan).

Group A

Open repair was performed with the patient lying prone under spinal or general anesthesia using a 6–8 cm cutaneous midline incision above the rupture. An end-to-end Kessler suture was applied using slowly absorbable 1-0; the paratenon was sutured with absorbable Vicryl® 3-0 and the cutis with a 2-0 silk interrupted suture. Finally, a full above-knee cast with the knee in 30° flexion and the ankle in gravity equinus was applied for 30 days. Sutures were removed about 15 days postoperatively; at 30 days the cast was replaced with a below-knee walking boot with the foot in neutral position, for 20 days. When this was removed, US scanning and clinical examination were performed. Rehabilitation was begun to restore ankle ROM in flexion and extension, normal ankle proprioception, trophism, and strength of the triceps surae.

Group B

Percutaneous repair with implantation of Tenolig® (Group Fournitures Hospitalier, France) was performed on a day-surgery basis. The Tenolig® kit is composed of two

long needles threaded with non-absorbable wire, each ending with a metal anchor (for a detailed description see also 7, 9). The patient lay face down with the foot on a gel cushion. Local anesthesia was performed at medial and lateral sites both proximal (5 cm from the lesion) and distal (at the tendon insertion) to the lesion. The proposed incisions were drawn with a marking pen. Medial and lateral stab wounds measuring ca. 5 mm were made about 5 cm proximal and distal to the rupture site and enlarged with a Kelly retractor. The needle was modeled according to the morphology of the areas medial and lateral to the rupture. Holding the tendon in the left hand, the surgeon introduced the first needle through the lateral or the medial proximal stab wound, passed it through the two stumps and recovered it from the distal wound on the same (lateral or medial) side; the procedure was then performed on the other side. The two metal anchors were introduced proximally and their stable hold was tested by pulling on each needle distally. Holding the two wires ending with the needles, the surgeon flexed the ankle to maximal equinus, then the two plastic washers were inserted with the convex side against the skin, the two lead stoppers were slid into place against the respective washer and finally crimped with pliers. The incisions were medicated, where required using steri-strips, and a dorsal cast splint with the ankle in gravity equinus was applied. Patients were discharged after US scanning. At 15 days the splint was removed and a loose elastic dressing applied with the ankle in a more neutral position. Careful weight-bearing with crutches and active flexion-extension exercises of the ankle were recommended. At 30–35 days US scanning was performed to assess the scope for implant removal, progressive weight-bearing with crutches as tolerated, and initiation of Achilles tendon rehabilitation with a therapist. Weight-bearing restrictions were lifted on day 45–50; rehabilitation was continued.

The final clinical and US checks were performed at 60–65 days.

All patients received antibiotic prophylaxis perioperatively and for 4–5 days; anti-thrombotic treatment with low molecular weight heparin was administered until resumption of normal ambulation.

The time of occupation of the operating room was calculated using the Ormawin 2000 database (Avelco, Genoa, Italy) available at our institution.

Follow-up envisaged checks at 4, 12 and 24 months that included objective clinical evaluation (at 4 and 12 months), subjective evaluation (at 24 months) using the SF-12® questionnaire (official site: http://www.SF-36.org), and bilateral US scanning and isokinetic testing (at 12 months).

Postoperative clinical evaluation

This assessment included bilateral measurements of ankle circumference and diameter of the triceps surae 25 cm proximal to the medial malleolus, and bilateral ankle ROM with a goniometer. The SF-12® questionnaire assesses physical (PCS) and mental (MCS) health state components in the general population. Scores exceeding 50 indicate optimal psycho-physical health; scores of 40–49 mild disability; scores of 30–39 moderate disability, and scores less than 30 severe disability. Scores were calculated using the Health Survey Scoring Demonstration on-line program (http://www.SF-36.org).

Ultrasound examination

Ultrasound scanning was used to measure the anteroposterior and cross-sectional diameter of Achilles tendon 5 cm from its calcaneal insertion.

Isokinetic assessment

At 12 months patients underwent isokinetic testing of the ankle by evaluation of peak torque (strength) and total work at 60° and 120°/s with a Biodex System 3 dynamometer (Biodex Medical System, Brookhaven R&D, Shirley, NY).

Statistical analysis was performed with Student's t test for paired and unpaired data.

Results

Calculation of the time of occupation of the operating room showed average times of 47 min (range 28–63) for open and of 24 min (17–32) for percutaneous repair. The difference was significant ($P < 0.01$).

Clinical evaluation

Follow-up data are available for 39 patients, because at 4 months a 60-year-old patient of group B required an open procedure due to tendon elongation with insufficiency of the triceps surae.

Postoperative complications, i.e., thrombophlebitis, infection, sural nerve lesion and re-rupture did not arise in either group. However, two patients of group A experienced delayed wound healing, which resolved in about 45 days.

The results of the clinical evaluations at 4 and 12 months are summarized in Fig. 1. The differences in the three parameters evaluated clinically were not significant except for ankle circumference, which was significantly greater in group B (Table 1).

The data of the SF-12® questionnaire are summarized in Fig. 1. The mean PCS score was 50.7 (± 2.57 SD) and the MCS score was 50.4 (± 2.75 SD) in group A compared with 52.6 (± 2.31 SD) and 52.2 (± 1.91 SD) in group B, without significant differences (Fig. 1).

Ultrasound examination

The results of US scanning at 4 and 12 months are reported in Table 2. Differences in the major tendon diameters between the groups were not significant (Table 2).

Isokinetic test

Isokinetic test results at 12 months are reported in Fig. 2. The differences between the groups were not significant (Fig. 2).

Discussion

In the present study subcutaneous rupture of Achilles tendon demonstrated an incidence peak between the third and fifth decade and a marked predominance of male patients, in line with the literature [7, 21].

All ruptures were due to indirect causes, also in agreement with the literature, which attributes them to a combination of mechanical stress and intratendinous degeneration [13]. Sports such as five a side soccer, tennis and jogging performed by non-professional athletes accounted for nearly all ruptures, in line with reports describing typical patients as subjects with sedentary jobs who sporadically engage in forceful sports activities [11]. These researchers believe that muscle fatigue in poor fitness conditions may predispose to tendon to rupture.

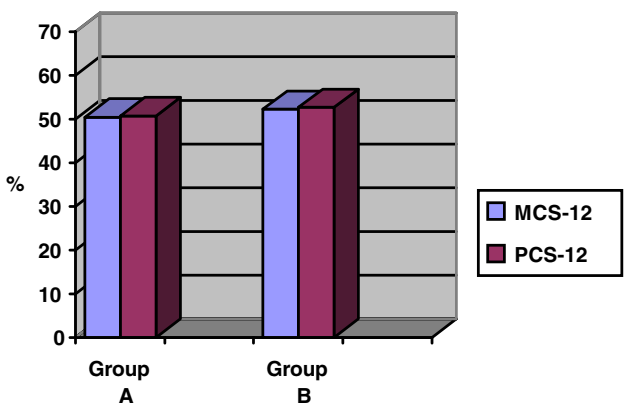

Fig. 1 SF-12® questionnaire

Open repair for Achilles tendon rupture is among the most effective methods to restore anatomy and function [6]. The most frequent complications are adhesive scars, infection, problems with wound healing, new rupture, sural nerve lesions, suture granuloma, deep venous thrombosis, pulmonary embolism and death [27]. In 1959, Arner and Lindholm [2] reported a rate of 24% in 82 operations, including two cases of deep venous thrombosis (one of which led to death from pulmonary embolism), three infections of the surgical wound, 11 cases of wound necrosis and four re-ruptures. More recent studies have described lower rates and better results compared with non-operative treatment. Moller et al. [23] observed that surgical and non-surgical treatment produced equally good functional results, with higher re-rupture rates after non-surgical treatment. Soldatis and coworkers [29] described two complications due to wound healing in 23 patients. The most frequent complication in open repair is surgical wound healing, because the longitudinal incision, the one most widely used, is made on poorly vascularized skin [14]. Our group A patients developed none of the complications mentioned in the literature apart from delayed wound healing in two cases. The data obtained in this study suggest that open repair is safe and effective both anatomically and functionally, even though complications cannot be totally excluded. For these reasons, we feel that this technique is currently the golden standard against which any new treatment for Achilles tendon rupture is be measured.

Percutaneous repair techniques have become increasingly popular over the last few years [7, 20] and have been proposed as alternatives to open repair based on the theoretical advantage of a reduction in skin complications due to their mini-invasiveness [21]. The present study demonstrates that percutaneous repair did not induce any of the complications reported in the literature, such as re-rupture and sural nerve lesion, which are among those most frequently described in this type of operation [7]. Insufficiency of the gastrocnemius-Achilles tendon complex was observed at 6 months in a single patient, due to imperfect stump juxtaposition that did not enable restoration of original tendon length.

The two patient groups were compared for clinical, US and functional (isokinetic) subjective and objective results. In both groups, subjective assessment using the SF-12® questionnaire gave comparable results that were similar to those of the healthy general population. Average scores were greater than 50, with slightly absolute higher values in the percutaneous group, showing that at 2 years the

Table 1 Clinical follow-up data at 4 and 12 months

	Ankle circumference		Calf circumference		ROM	
	4 months (cm)	12 months (cm)	4 months (cm)	12 months (cm)	4 months	12 months
Group A (open repair)	25.5 (±1.5 SD)	24.5* (±1.4 SD)	33.5 (±2.4 SD)	34.8 (±2.4 SD)	50° (±6.5 SD)	57.3° (±4.8 SD)
Group B (Tenolig®)	25.8 (±1.1 SD)	25.7* (±1.3 SD)	34.4 (±1.9 SD)	34.8 (±1.7 SD)	51.4° (±10.9 SD)	55.3° (±6.9 SD)

* Significant $P < 0.01$

Table 2 US follow-up data at 4 and 12 months

	Cross-sectional diameter		Anteroposterior diameter	
	4 months (mm)	12 months (mm)	4 months (mm)	12 months (mm)
Group A (open repair)	20.7 (± 1.8 SD)	17.6 (± 2 SD)	12.2 (± 1.7 SD)	9 (± 2.4 SD)
Contralateral tendon (group A)	13.4 (± 2 SD)		5 (± 0.8 SD)	
Group B (Tenolig®)	21.3 (± 0.3 SD)	18.6 (± 2.3 SD)	13.6 (± 1.8 SD)	10.9 (± 1.6 SD)
Contralateral tendon (group B)	14.3 (± 2.3 SD)		5.8 (± 1.6 SD)	

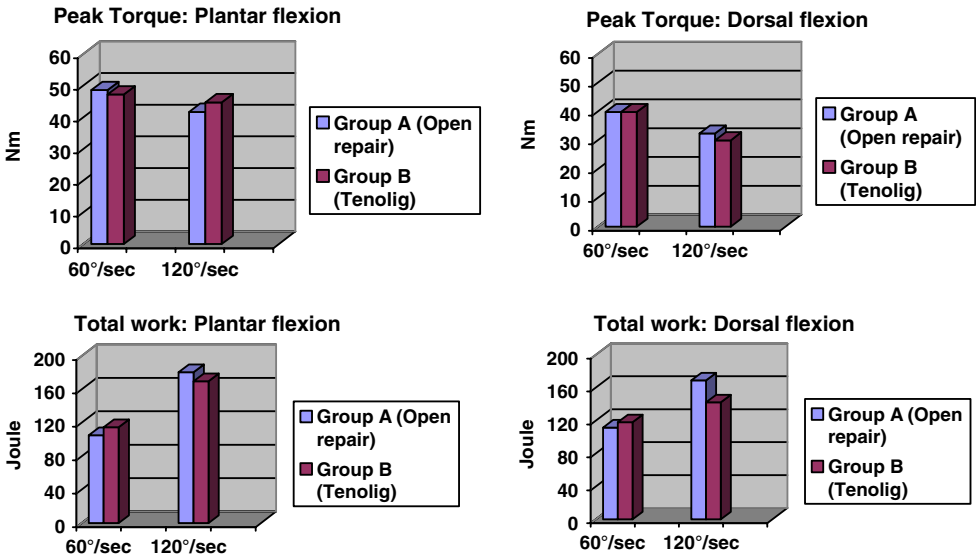

Fig. 2 Isokinetic evaluation of peak torque and total work in plantar and dorsal flexion at 60° and 120°/s

tendon rupture and the operation had not affected physical or mental health.

Clinical evaluation of ankle circumference, sural triceps trophism and tibio-tarsal joint ROM at 4 and 12 months demonstrated that there were no significant differences between the groups except for a greater ankle circumference at 1 year ($P < 0.01$) in patients treated with percutaneous repair. This indicates that the thickness of tendons treated with this technique was greater than that of tendons treated with the open method. This finding contrasts with some reports of a lesser thickness of tendons repaired percutaneously [3].

Ultrasound measurements of cross-sectional and anteroposterior tendon diameter at 4 and 12 months also showed slightly, albeit not significantly greater values in the tendons treated percutaneously, confirming clinical evaluation. Short-term (4 months) ankle ROM was also greater in these patients, though again not significantly so. This finding suggests that earlier active ankle mobilization may result in swifter ROM restoration in patients treated with percutaneously. An important test in terms of objective functional recovery was isokinetic evaluation at 12 months. The test assessed the plantar and dorsal flexion of the ankle joint through peak torque and total work of the repaired vs. the contralateral tendon. Peak torque (Nm) is the maximum muscle strength produced at any time during the repetitions, and thus reflects muscle strength. Total work (*J*) is a measure of the muscle's ability to produce force over the whole ROM. Functional recovery was good in either group for both measures, without significant differences. Early postoperative treatment envisaged immobilization for 50 days in group A and for 35 days in group B, in line with the

literature [3, 21, 26]. All patients received the same rehabilitation protocol after cast removal.

In conclusion, the present study showed that both the open and the percutaneous technique are safe and effective in repairing the ruptured Achilles tendon, and that both afford nearly total restoration of clinical, US and isokinetic patterns with the same rehabilitation protocol, despite slight differences in the duration of immobilization. Two minor complications arose with open repair, and the implant failed in one patient of the percutaneous group. Medium-term results were substantially comparable. Percutaneous repair is performed on a day-surgery basis, it reduces cutaneous complications and surgery times, and enables faster recovery, enhancing overall patient compliance. To us, these characteristics make percutaneous treatment preferable when managing subcutaneous ruptures of Achilles tendon in non-professional sport practicing adults. Further study is required to test its effectiveness in professional athletes and chronic ruptures.

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