



Isokinetic functional outcomes of open versus percutaneous repair following Achilles tendon tears



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ABSTRACT

Background: Rupture of the Achilles tendon (AT) is frequent in young recreational athletes. Conservative management, open surgery and percutaneous/minimally invasive approaches are all advocated, and conflicting data are available. This study compared functional and anthropometric outcomes of patients who underwent open or percutaneous repair.

Methods: A retrospective comparative study, in which 38 patients underwent open and percutaneous techniques to manage AT ruptures. For functional assessment, the calf circumference of both injured and uninjured legs was evaluated. Isokinetic testing included total plantar flexion work, peak plantar flexion torque, total dorsiflexion work peak and dorsiflexion torque. The Achilles Tendon Rupture Score (ATRS) and the American Orthopedic Foot and Ankle Score (AOFAS) were evaluated at a final minimum follow-up of 12 months.

Results: No major complications were observed. The average time to return to sport was 9 months. AOFAS and ATRS values did not differ statistically between groups. Isokinetic variables and circumference were similar in the operated and non-operated limb in both groups, and did not differ either when comparing open and percutaneous repair.

Conclusions: Open and percutaneous repair of a torn Achilles tendon produced similar functional outcomes.

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1. Introduction

Rupture of the Achilles tendon (AT) is frequent in young recreational athletes, with an incidence ranging from 6 to 18 per 100,000 per year [1,2]. The rupture does not occur in healthy tendons, and profound clinically asymptomatic tendinopathy changes are present [3].

The management of torn Achilles tendon has evolved, and there is an ongoing debate on the optimal option. Conservative management, open surgery and percutaneous/minimally invasive approaches are all advocated. A recent meta-analysis showed that

non-operative management coupled with functional rehabilitation and early mobilization produces similar re-rupture rates and less complications than operative treatment [4].

Open surgery, classically regarded as the gold standard for many years [5], provides good repair strength and low re-rupture rates, at the cost of major complications such as wound necrosis and infection [6,7]. To avoid these complications, percutaneous and minimally invasive techniques have been described [8–19]. The comparison of percutaneous/minimally invasive versus open repair resulted in similar functional outcomes, with a better cosmetic appearance, a lower rate of wound complications, and no increase in the risk of re-rupture [20].

The present study compares anthropometric, functional and isokinetic outcomes in patients who underwent open or percutaneous repair following an Achilles tendon tear.

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Table 1
ATRS and AOFAS results.

Variables	Surgical technique	n	Average	p-value
ATRS	Open	20	95.1	0.588
	Percutaneous	18	96.1	
AOFAS	Open	20	98.2	0.171
	Percutaneous	18	95.3	

2. Methods

This is a retrospective comparative study of 38 individuals, 35 females and 3 males (average age 47 years) operated between January of 2014 and July 2015 following an acute AT rupture 2–6 cm from the insertion of the AT on the calcaneus. Eighteen patients received a percutaneous repair [12], and 20 a traditional open repair performed through a postero-medial incision and a modified Bunnell suture configuration. One surgeon performed the open repair, and another the percutaneous repair. After surgery, the patients followed the same post-operative protocol, which consisted of functional rehabilitation with early weight bearing and early mobilization, started at two weeks with a boot with the foot held in equinus, progressing to neutral at 6 weeks. After 6 weeks, patients were allowed to full weight bear without any orthosis. The average follow-up was 33 months (12 months minimum).

In all patients, demographic data were collected. The Achilles Tendon Rupture Score (ATRS) and the America Orthopedic Foot and Ankle Score (AOFAS) were administered at the final follow-up (Table 1). Isokinetic evaluation was performed at the final follow-up using a commercially available isokinetic dynamometer (Biodex System 3 Pro Biodex Medical Systems Inc., Shirley, USA) [13], evaluating total plantar flexion work, peak plantar flexion torque, total dorsiflexion work and peak dorsiflexion torque. All patients were asked about personal satisfaction, data were collected about return to sport (Table 2).

For the purposes of isokinetic evaluation (Table 3), all patients warmed up by walking on the flat for five minutes. Next, they were seated in the testing chair of the isokinetic dynamometer, with belts over the trunk, pelvis, and thigh to ensure appropriate stabilization. The seat back tilt was set at 70° and the distal portion of the thigh of each participant was positioned over the device limb support pad so that the knee remained flexed between 30° and 40°, as assessed using a goniometer. The axis of rotation of the dynamometer was aligned with the lateral malleolus, and the barefoot of the leg to be tested was strapped to the footplate of the ankle attachment of the isokinetic dynamometer so that the plantar surface of the foot was fully supported. The testing protocol consisted of concentric and eccentric evaluations of the plantar flexors muscles, within a range of 10° of dorsiflexion and 20° of plantar flexion, repeated five times at an angular velocity of 30°/s. Initially, the participants were familiarized with the system performing five submaximal contractions. During the test,

Table 3
Isokinetic analysis.

Isokinetic variables	Surgical technique				p-value
	Open		Percutaneous		
	Operated leg	Non-operated leg	Operated leg	Non-operated leg	
<i>Peak torque</i>					
Concentric	179.4 (48.4)	188.9 (46.1)	126.4 (21.0)	127.9 (26.3)	0.654
Eccentric	202.0 (53.8)	211.8 (48.4)	135.9 (19.4)	138.8 (23.4)	0.365
<i>Work</i>					
Concentric	45.1 (16.6)	47.8 (12.0)	146.4 (31.7)	165.8 (43.6)	0.789
Eccentric	58.0 (19.1)	60.9 (13.9)	171.9 (42.7)	176.3 (57.9)	0.323

Isokinetic results. The isokinetic variables did not differ statistically between the operated and non-operated leg, and for both open and percutaneous approach.

Table 2
Personal satisfaction.

Surgical technique	Satisfaction				p-value
	Very satisfied		Satisfied		
	n	%	n	%	
Open	19	95	1	5	0.730
Percutaneous	17	94.44	1	5.55	

Personal satisfaction results. Only one patient in each group was not highly satisfied with the results. There were no statistically significant inter-group differences.

participants were instructed to perform with maximal force. All the isokinetic tests were performed by the same experienced evaluator, who provided standardized verbal encouragement to ensure that the subjects performed at their maximum. The various isokinetic variables tested were normalized by body weight, except when indicated [14,15]. Calf circumference of both injured and uninjured limb was measured 10 cm distal do the anterior tibial tuberosity (Table 4).

Statistical analysis was performed with the Fisher's exact test for categorical variables and the Student's *t* test for comparisons between the groups. The data were recorded in a Microsoft Excel sheet (Microsoft Corporation, USA), and analyzed using SPSS_23.0 statistical software (SPSS Inc., Chicago, IL, USA). A *p* value <0.05 was considered significant.

3. Results

A total of 10 (26.3%) patients reported previous AT symptoms before the rupture. Eleven (29%) patients reported at least one risk factor for AT rupture, with obesity and smoking being the most common. The average time between the index injury and surgery was 7.8 days. A total of 33 (86%) patients were recreational athletes, with soccer being the most common sport played. The average return to sport was 9 months, with only two patients feeling incapable of returning to athletic activities. No major complications were observed.

Table 1 reports the average values for the ATRS and AOFAS questionnaires. Both groups reached high scores (>95) in both, with no statistical difference between open and percutaneous repair.

4. Discussion

The management of AT ruptures aims to restore function, minimize morbidity, optimize return to activities, prevent complications, and produce a good cosmetic appearance. The scientific quality of papers comparing open to minimally invasive/percutaneous repair is heterogeneous, with most articles reporting subjective outcomes, without structured methods to evaluate the effectiveness of the technique [21]. The present study reports some isokinetic outcomes and functional variables: open and

Table 4

Calf circumference measured 10 cm distal to the anterior tibial tuberosity. Did not differ statistically between the operated and non-operated leg, and for both open and percutaneous approach.

Variables	Surgical technique	n	Average	p-value
Calf circumference of the Operated leg	Open	20	37.9	0.588
	Percutaneous	18	37.8	
Calf circumference of non-Operated leg	Open	20	38.7	0.171
	Percutaneous	18	39.1	

percutaneous repair followed by functional rehabilitation produce similar functional outcomes.

The biomechanical evidence of superiority of one given repair over others is conflicting. Some authors have reported percutaneous repairs to be stronger than open repairs, while others have demonstrated that percutaneous repairs are weaker and more susceptible to gapping [22,23]. Clanton et al. [24] compared the open approach to minimally invasive techniques (Achillon, PARS, and SpeedBridge), and showed the susceptibility of the latter to significant early repair elongation, but comparable ultimate strengths. Consequently, these authors suggested that minimally invasive repairs might need to be protected longer postoperatively to avoid potential gapping [24].

Chan et al. [25] compared open sutures with minimally invasive surgery using the Achillon system: gait analysis and the loss of peak torque and total work observed at the injured side were similar between the minimally invasive and the open approach. Similar to the present study, Gigante et al. [26] found similar isokinetic results between open and percutaneous approaches in a retrospective study of 40 patients.

Other retrospective studies also report similar functional outcomes, and remark on the benefits of the minimally invasive approaches, such as reduction in surgical time, lesser incidence of complications, and less time required to return to sport activities and return to work [27]. The largest single-center series, with 270 patients, reports on similar outcomes between PARS and open repairs, with no significant differences in the rate of post-operative complications [28].

Systematic reviews and meta-analyses show the benefits of minimally invasive approaches. A meta-analysis of randomized controlled trials reported no significant difference in respect to the incidence of re-rupture, tissue adhesion, sural nerve injury, deep infection and deep vein thrombosis. However, minimally invasive techniques significantly reduced the risk of superficial wound infection, with three times greater patient satisfaction [29]. A more recent meta-analysis [30], with 815 individuals, reported similar functional outcomes between the percutaneous and open approach. There was a higher incidence of sural nerve injuries in the percutaneous repair group, but with the advantages of less operation time and deep infection and higher AOFAS scores.

Reliable and well-executed functional evaluation by isokinetic measures of calf strength was performed in the present study. Nevertheless, this study is a retrospective comparative methodology investigation, and surgical time was not measured. Also, we acknowledge that we only performed isokinetic testing at low angular velocities (30°/s), which only partially reflects the actual use that the patients will make of the operated limb. It is possible that other differences between the two surgical approaches would have become evident had higher angular velocities been used. Nevertheless, authors that used higher and functional speed for isokinetic testing (60°/s, 120°/s and 180°/s) also did not find any difference in the calf strength of limbs of patients who had undergone an open or a percutaneous repair [25,26].

There are no evidence-based guidelines to choose the type of operative management of ruptures of the Achilles tendon. Two classification systems have been proposed [31,32], both based on the length of the tendon defect. However, neither of these two

classifications system is evidence-based, and these classification have been developed for the management of chronic, not acute Achilles tendon ruptures.

Given the design of the present study, the evidence given for assessing post-surgical outcomes and for establishing causation is not as strong as that which would be produced by a randomized controlled trial. The injury reported in the present study is common, and, given the similar clinical and functional results obtained employing the open and percutaneous repairs, a randomized controlled trial would likely be long and costly, necessitating large numbers of patients.

In conclusion, both approaches used in this study produced similar functional outcomes. These results arise from the meticulous management of soft tissue when performing the open approach and the well executed percutaneous approach, in order to avoid injury to the sural nerve. Randomized controlled trials are required to address the issue of the comparison between open versus minimally invasive AT surgery. In our hands, minimally invasive surgery provides similar results to those obtained with open surgery, but with decreased perioperative morbidity, decreased duration of hospital stay, and reduced costs. Multicenter studies with longer follow-up are needed to clarify the long-term advantages of these techniques over traditional ones.

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Conflict of interest

The authors declare that there are no conflicts of interest.

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