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ORIGINAL ARTICLE

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Isokinetic functional results of open and percutaneous Achilles tendon repair

Resultados funcionais Isocinéticos do reparo aberto e percutâneo do tendão de Aquiles

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ABSTRACT

Objective: Achilles tendon (AT) ruptures are common in young athletes. Conservative treatment, open surgery and percutaneous/minimally invasive approaches are advocated by different groups around the world, and data are still conflicting. The objective of this study was to use objective and reliable measurements to compare the isokinetic functional results of patients undergoing open repair with those undergoing a percutaneous approach.

Methods: This was a retrospective comparative study of 38 subjects undergoing two different approaches for the treatment of acute AT ruptures: open and percutaneous. For the functional evaluation, all patients were subjected to analysis of the calf muscle circumference of both legs, along with the following isokinetic measurements: total flexion work, peak flexion torque, total extension work and peak extension torque. The Achilles Tendon Rupture Score (ATRS) and American Orthopedic Foot and Ankle Score (AOFAS) evaluation scales were applied at the final 12-month follow-up.

Results: No serious complications were observed. The mean time to return to sports was 9 months. The AOFAS and ATRS values did not differ significantly between the two groups. The isokinetic variables and circumference in both groups were similar when the non-operated and operated limbs were compared. The groups also did not differ when comparing open and percutaneous approaches.

Conclusion: It can be concluded that the two strategies used in this study achieved similar functional results.

Level of Evidence III; Retrospective Comparative Study.

Keywords: Achilles tendon; Rupture; Minimally invasive surgical procedures; Measures.

RESUMO

Objetivo: A ruptura de Tendão de Aquiles (TA) é frequente em atletas jovens. O Tratamento conservador, a cirurgia aberta e abordagens percutâneas/minimamente invasivas são defendidas por diferentes grupos no mundo, com dados ainda conflitantes. O objetivo deste estudo é comparar resultados funcionais isocinéticos com medidas objetivas e confiáveis, de pacientes submetidos ao reparo aberto e a uma abordagem percutânea.

Métodos: Este é um estudo comparativo retrospectivo com 38 indivíduos submetidos a duas abordagens de tratamento para rupturas agudas do TA: aberta e percutânea. Para a avaliação funcional, todos os pacientes foram submetidos à análise do perímetro dos músculos da panturrilha de ambas as pernas, bem como às seguintes medidas isocinéticas: trabalho total de flexão, pico de torque de flexão, trabalho total de extensão e pico de torque de extensão. As escalas de avalição Achilles Tendon Rupture Score (ATRS) e *America Orthopedic Foot and Ankle Score* (AOFAS) foram aplicadas no seguimento final de 12 meses.

Study conducted at the Hospitals Felício Rocho and Mater Dei, Belo Horizonte, Minas Gerais, Brazil.

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Resultados: Nenhuma complicação grave foi observada. O tempo médio para retorno ao esporte foi de 9 meses. Os valores de AOFAS e ATRS não apresentaram diferenças estatísticas entre os dois grupos. As variáveis isocinéticas e a perimetria foram similares em ambos os grupos, quando comparados os membros operados e aos não operados, e também não diferiram na comparação entre as abordagens aberta e percutânea.
Conclusão: Pode-se concluir que as duas estratégias usadas nesse estudo alcançaram resultados funcionais similares.
Nível de Evidência III; Estudo Retrospectivo Comparativo.

Descritores: Tendão do calcâneo; Ruptura; Procedimentos cirúrgicos minimamente invasivos; Medidas.

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INTRODUCTION

Achilles tendon (AT) rupture is a common injury in young athletes, with an incidence ranging from 6 to 18 per 100,000 individuals per year[1,2]. Recently, many studies have shown that this type of rupture does not occur in healthy tendons but in a tendon that has tendinosis, but which is often asymptomatic[3].

The treatment of AT rupture has evolved over the years and has given rise to a heated debate about which treatment option is best for patients. Conservative treatment, open surgery and percutaneous/minimally invasive approaches are advocated by different groups around the world.

Although there is still controversy over whether conservative treatment can restore AT strength as effectively as surgical treatment, a recent meta-analysis showed that conservative treatment based on functional rehabilitation and early mobilization had similar rupture recurrence rates to and fewer complications than surgical treatment[4].

Open surgery, which for a long time has been considered by many as the "gold standard", restores triceps surae strength and has low re-rupture rates; however, it can involve major complications, such as wound necrosis and deep infection[5,6]. To overcome this situation, different percutaneous or minimally invasive techniques have been described on a large scale, and good results have been obtained[7-10].

Many studies have compared percutaneous/minimally invasive approaches with open repair and have found equivalent functional results, better cosmetic appearance, lower wound complication rates and no increased risk of re-rupture for the former[11].

The objective of this study is to compare the isokinetic functional outcomes of patients undergoing open repair with those undergoing a percutaneous approach for the treatment of AT rupture.

METHODS

This work was approved by the Research Ethics Committee with registration in the Brazilian Platform under CAAE number 61046616.3.1001.5125.

This was a retrospective comparative study of 38 subjects, 35 male and 3 female, with a mean age of 47 years

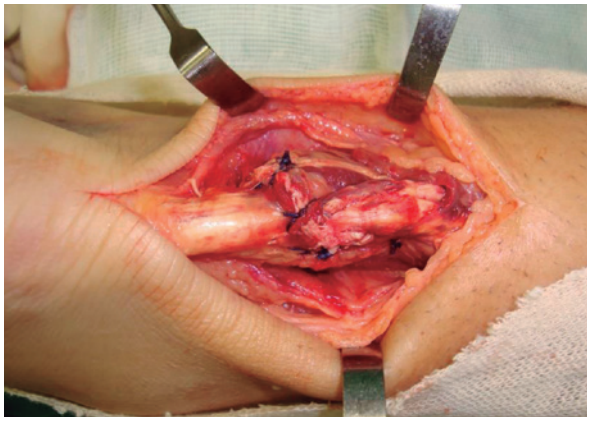

Figure 1. Percutaneous repair.
Source: Author's personal archive.

Figure 2. Open repair.
Source: Author's personal archive.

and with acute AT rupture, between January 2014 and July 2015. All injuries were approximately 2-6cm from the AT insertion point. Eighteen patients underwent percutaneous repair as described by Carmont and Mafulli[12] (Figure 1), and 20 underwent traditional open repair (Figure 2). Open repair was performed with a posteromedial incision and a modified Bunnell suture. Percutaneous repair was performed via four mini-incisions proximal to the AT defect, four mini-incisions distal to the AT defect, and one incision on the AT defect, through which a needle was passed in order to make a Bunnell suture. In the lateral incisions, deep tissue curettage was performed with a clamp to directly view the tendon for the passage of the needle, thereby avoiding sural nerve injury. The percutaneous repair was performed by a different surgeon than the one responsible for the open repair.

After surgery, patients followed the same postoperative protocol, which comprised functional rehabilitation with early mobilization and load support. Immediately after surgery, in all cases, a posterior plaster splint was used to keep the foot in the equinus position. The splint was removed after two weeks, and a boot was fitted, maintaining the foot in the equinus position, thereby enabling the foot to become weight bearing. During this period, active mobilization of the ankle was allowed. The equinism was gradually reduced up to the sixth week, when the boot was removed and the patient was allowed to walk without orthosis. After removal of the orthosis, patients were referred to physical therapy, which started with isometric strengthening and range of motion gain. Passive stretching of the tendon was allowed after 12 weeks. After 16 weeks, patients were allowed to resume their sports/recreational activities, under supervision. The mean follow-up period was 33 months (minimum of 12 months).

All patients completed a demographic data questionnaire. The Achilles Tendon Rupture Score (ATRS) and American Orthopedic Foot and Ankle Score (AOFAS) scales were applied to each patient at the final follow-up session. For the functional evaluation, all patients were subjected to analysis of the calf muscle circumference of both legs (10cm distal to the anterior tibial tuberosity) and to isokinetic measurements during the final follow-up session. The isokinetic measurements (isokinetic dynamometer - Biodex System 3 Pro, Biodex Medical Systems Inc., Shirley, USA)[13] considered were total flexion work, peak flexion torque, total extension work and peak extension torque. All patients were asked about their personal satisfaction and return to sports at the end of treatment.

For the isokinetic evaluation, all patients underwent a warm-up comprising walking on the ground for five minutes. They then sat in the isokinetic dynamometer chair, and straps were placed over the trunk, pelvis and thigh for stabilization. The anterior seat inclination was 70º, and the participant's distal thigh was supported on the device's limb support cushion, so that the knee remained flexed between 30º and 40º. This range was checked by the analyst using a goniometer. The dynamometer rotational axis was aligned with the lateral malleolus, and the bare foot was attached to the base of the isokinetic dynamometer ankle support, so that the plantar surface of the foot was completely supported on this base attached to the dynamometer (Figure 3).

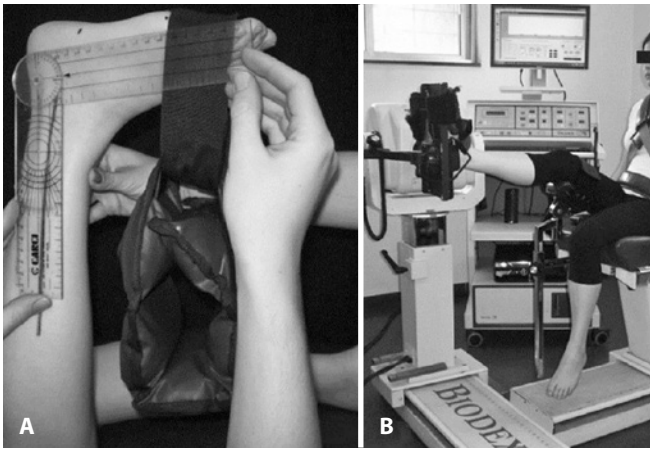

Figure 3. Positioning of patient for isokinetic examination.
Source: Author's personal archive.

The protocol consisted of concentric and eccentric evaluations of the flexor muscles, within a range of 10º of extension and 20º of flexion, repeated five times at a speed of 30º/s. First, the participant was familiarized with the system by performing five repetitions using submaximal contractions. Throughout the test, the participant was instructed to use maximum force when executing the movements. Standard verbal encouragement was provided by the researcher to ensure that subjects exerted the maximum force possible. In addition, isokinetic dynamometer testing was performed by only one evaluator with extensive experience using the equipment. Flexor muscle performance was analyzed using peak concentric and eccentric torque, normalized by body weight, and maximum concentric and eccentric work in one repetition, also normalized by body weight[14,15].

Statistical analysis was performed using Fischer's exact test for categorical variables and Student's t test for intergroup comparisons. Data were recorded in a Microsoft Excel spreadsheet (Microsoft Corporation, USA) and analyzed using SPSS 23.0 (SPSS Inc., Chicago, IL, USA). P values of < 0.05 were considered statistically significant.

RESULTS

A total of 26.3% of patients reported symptoms in the AT prior to the rupture, and 29% had at least one risk factor for AT rupture, among which obesity and smoking were the most common. The mean time between injury and surgery was 7.8 days. No open or associated injury was observed. Eighty-six percent of patients were recreational athletes, with soccer being the most common sport. The mean time to return to sports was 9 months, with only two patients feeling unable to return to their athletic activities after that time. No serious complications were observed.

Table 1 shows the ATRS and AOFAS values for both the open and percutaneous approaches. Both groups achieved high scores (> 95) on the two scales, with no significant difference between groups.

Table 2 shows the personal satisfaction results. Only one patient in each group was unhappy with the results, and the comparative results between the two groups were not significantly different.

Table 3 shows the isokinetic results. The operated limb exhibited the same performance as the non-operated limb in the patients' final follow-up session, and the results for concentric and eccentric peak torque and work were statistically equivalent. There was no difference between the open and percutaneous groups, indicating functional isokinetic equivalence in the results of these two approaches.

Table 4 shows the circumference, measured 10cm distal to the anterior tibial tuberosity. As observed, the values of the operated and non-operated limbs were not significantly different, nor were those of the open and percutaneous techniques.

Table 1. ATRS and AOFAS results

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

Table 2. Personal satisfaction

Surgical technique	Satisfaction				Total		P-value
	Very satisfied		Satisfied				
	N	%	n	%	n	%	
Open	19	50	1	2.6	20	52.6	0.730
Closed	17	44.8	1	2.6	18	47.4	
Total	36	94.8	2	5.2	38	100	

Table 3. Isokinetic analysis

Isokinetic variables	Surgical technique				P-value
	Open		Percutaneous		
	Operated limb	Non-operated limb	Operated limb	Non-operated limb	
Peak torque					
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
Work					
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

Table 4. Circumference measurements

Variables	Surgical technique	n	Mean	P-value
Circumference of operated limb	Open	20	37.9	0.913
	Percutaneous	18	37.8	
Circumference of non-operated limb	Open	20	38.7	0.664
	Percutaneous	18	39.1	

DISCUSSION

The ideal procedure for AT rupture should minimize morbidity, optimize the return to activities, prevent complications and lead to a good cosmetic appearance. The quality of studies comparing the open strategy with the minimally invasive/percutaneous approach is heterogeneous, and most studies report subjective results, without structured methods for evaluating the effectiveness of the techniques. This study is one of the few in the literature that reports isokinetic results, which represent a reliable and objective way to measure strength. It supports the claim that the open approach has functionally equivalent results to those of a percutaneous approach when used in functional rehabilitation.

Biomechanically, comparisons between open and percutaneous repairs are conflicting. Some researchers have

reported that percutaneous repairs are stronger than open repairs, while others have shown that they are weaker and susceptible to premature stretching of the tendon[16,17]. A very interesting and well-designed study compared the open approach to the most common minimally invasive techniques (Achillon, PARS and SpeedBridge) and demonstrated the susceptibility of the latter to early stretching of the repair. The authors therefore suggested that minimally invasive repairs may require more careful postoperative protection to prevent a potential defect or gap[18].

Chan et al. compared open sutures with the Achillon system and reported that both gait analysis and reduction of both peak torque and total work observed on the injured side were similar in the minimally invasive and open approaches[19]. Gigante et al. also used isokinetic measurements and found equivalent results for the open and percutaneous strategies in a retrospective study of 40 patients[20]. These findings are consistent with those observed in this study.

Other retrospective studies have also shown similar functional results, confirming the benefits of minimally invasive approaches, such as reduction of surgical time, lower incidence of complications, and shorter required time for return to sports activities and work[21]. The largest single center series in the literature, with 270 patients, reported similar results between PARS and open repair, without significant differences in postoperative complication rates[22].

More robust data provide good evidence of the benefits of minimally invasive approaches. A meta-analysis of controlled studies reported no significant differences in the incidence of re-rupture, tissue adhesion, sural nerve injury, deep infection or deep vein thrombosis. However, minimally invasive techniques have demonstrated significant reductions in the risk of superficial infection and have recorded three times greater patient satisfaction[23]. A more recent meta-analysis conducted by Yang et al.[24] with 815 subjects observed similar functional results between percutaneous and open approaches. They observed a higher incidence of sural nerve injury in the percutaneous group but with the advantages of shorter operation time, lower deep infection rate and higher AOFAS scores.

The importance of this study is that it demonstrates equivalence in the functional results of the open and percutaneous techniques in AT repair. The existence of comparison groups and a reliable and well executed functional analysis using isokinetic calf strength measurements confer reliability to the results. The limitations of this study are its retrospective design and its small number of patients.

CONCLUSION

We can conclude that the isokinetic functional results of patients undergoing open and percutaneous repair of AT injuries are equivalent. More studies with a prospective design are needed to confirm this conclusion.

Authors' contributions: Each author contributed individually and significantly to the development of this article: PSOL (https://orcid.org/0000-0001-6771-4524)*: conceived and planned the activities that led to the study, wrote the article, participated in the review process and interpreted the study results; TSB (https://orcid.org/0000-0001-9244- 5194)*: wrote the article, participated in the review process and interpreted the study results; JMBM (https://orcid.org/0000-0002-4224-8149)*: conceived and planned the activities that led to the study and interpreted the study results; FASL (https://orcid.org/0000-0001-5214-2420)*: participated in the review process and interpreted the study results; GMA (https://orcid.org/0000-0003-2607-8730)*: participated in the review process and interpreted the study results; DSB (https://orcid.org/0000-0001-5404-2132)*: conceived and planned the activities that led to the study, participated in the review process, performed the surgeries and approved the final version. *ORCID (Open Researcher and Contributor ID).

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