International Journal of Physical Education, Sports and Health 2020; 7(6): 99-102

P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (ISRA): 5.38
IJPESH 2020; 7(6): 99-102
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www.kheljournal.com
Received: 03-09-2020
Accepted: 14-10-2020

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Arthroscopic versus ultrasonography-assisted achilles tendon repair

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DOI: https://doi.org/10.22271/kheljournal.2020.v7.i6b.1902

Abstract
Introduction: Achilles tendon rupture constitutes 40% of all operated tendon ruptures. Non-operative treatment results in 8-18% of tendon's re-rupture, compared to 1-4% in the operative treatment. Percutaneous repair is a blind repair, where malalignment of the stumps results in a higher re-rupture rate and decreased strength of the repaired site than the open repair. Arthroscopy and ultrasound are used for minimally invasive surgical repair of the Achilles tendon ruptures.
Aim: To compare the results of the Achilles tendon repair between arthroscopic assistance and ultrasound guidance.
Methods: Thirty patients 28 to 46 years old were operated on for Achilles tendon rupture. Half of them underwent an arthroscopic assisted percutaneous repair and the rest an ultrasound-assisted percutaneous repair. Sutures in the arthroscopic group were passed through the tendon's end under direct vision, whereas the sutures in the ultrasound group were passed with the aid of ultrasound. The foot immobilized with a cast for two weeks followed by a full weight-bearing removable cast for another 4 weeks, and then the patient wore an insole wedge pad underneath the heel for an extra 3 months. Both methods were evaluated using the heel raise test.
Results: All patients showed an excellent outcome according to the heel-raise test. However, the results did not show any statistically significant differences between the outcomes of the ultrasound-assisted and the arthroscopic group.
Conclusions: Both techniques revealed similar positive outcomes. However, ultrasonography showed a better identification of the suture, minimized the sural nerve's injuries, and offered an overview of the gap when closing.

Keywords: Achilles tendon, arthroscopic repair, sural nerve injury, ultrasound-assisted repair

1. Introduction
Achilles tendon rupture constitutes about 40% of all operated tendon ruptures [1, 2]. Non-operative treatment leads to 8-18% of tendon's re-rupture, compared to 1-4% in the operative treatment. Even when operative treatment results in less calf atrophy and a stronger push of [3], the skin complications result in tangly problems to deal with [2-4], due to the lack of adequate soft coverage over the Achilles [5]. Percutaneous repair is a blind repair with the malalignment of stumps to result in a higher re-rupture rate and decreased strength of the repaired site compared to the open repair [3]. Direct inspection of the tendons ends, and stumps approximation is advantageous when tightening the suture to get the best results. Arthroscopy is used for the minimal invasive surgery (MIS) repair of the Achilles tendon ruptures. Recently ultrasound has also been used in Achilles tendon repair. The ultrasound helps to identify the tendon's stumps and the sural nerve, so the orthopaedic surgeon can avoid the nerve when passing the sutures through the tendon. By identifying the sural nerve, the orthopaedic surgeon can set the entry point at a distance from the nerve. The next step is the repair of the lesion, control the trans-tendon passage of the surgical threads, and evaluate the approximation of the tendon edges dynamically. The percutaneous sutures under the ultrasound or arthroscopic control ensure the contact of the tendon edges, with little risk of injury of the sural nerve and minimal skin scarring [6].

2. AIM

The present study aims to compare the percutaneous Achilles tendon repair with the aid of ultrasound or direct arthroscopic vision and compare both techniques' results.

3. Methods

Thirty patients (twenty-eight men and two women) 28 to 46 years of age operated on for Achilles tendon rupture from 2003 to 2017 constituted the study sample. Fifteen of them underwent an arthroscopic-assisted, and the rest had an ultrasound-assisted percutaneous repair.

In the arthroscopic group, the arthroscope was introduced through two lateral portals right on the tendon gap, and two more portals were made on the dorsal surface of the tendon. Sutures were passed throughout the tendon's ends under direct vision. Under continuous gravity irrigation, paratenon, and the ends of the rupture were identified (Figure 1).

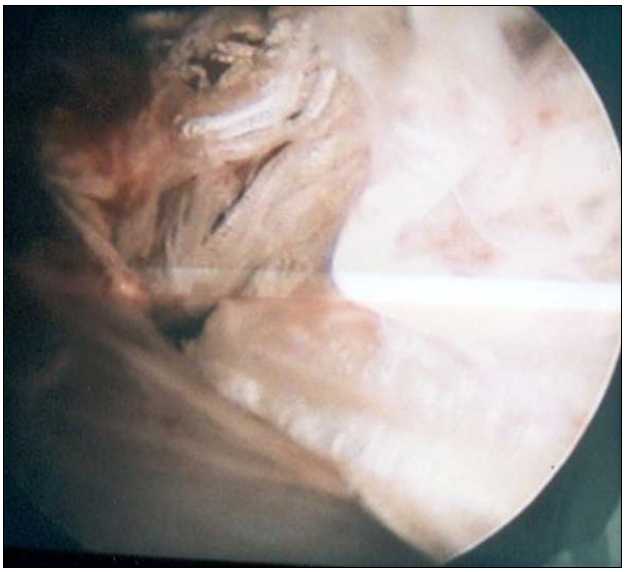

Fig 1: The tendon ends identification.

A needle passed percutaneously and checked with the arthroscope to ensure passing through the lips of the tendon stumps (Figure 2).

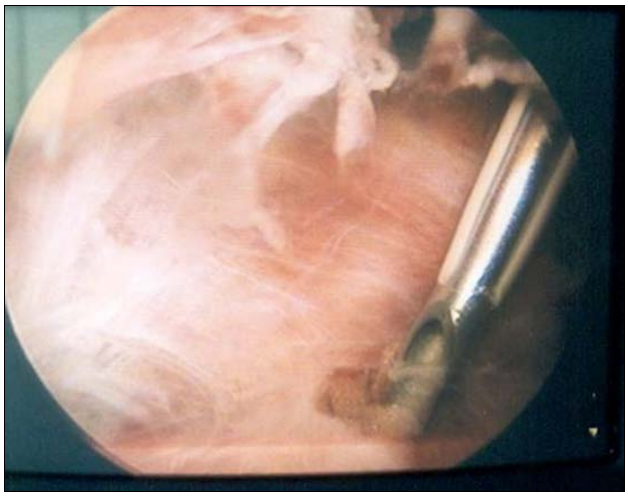

Fig 2: Controlling the suture passing.

The tendon's gap closure was inspected with the arthroscope (Figure 3), and one or more additional sutures were added until the ends were adequately approximated.

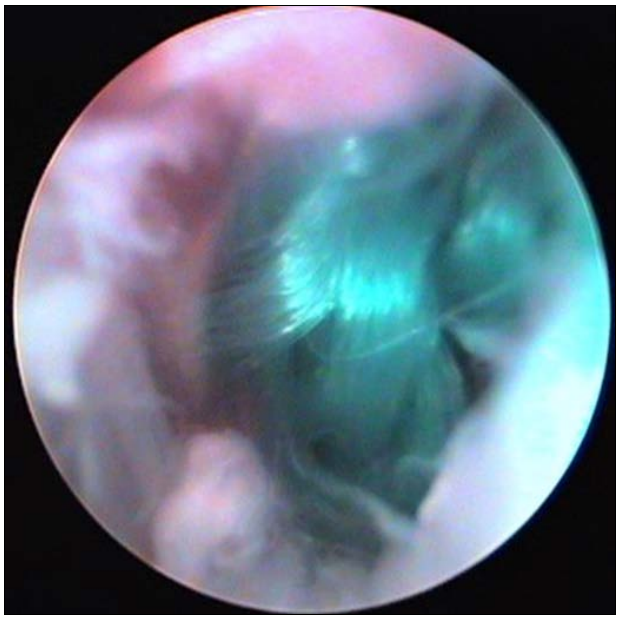

Fig 3: Knot and tendons gap checking.

In the ultrasound-assisted group, the portals were performed at the same place as in the arthroscopic group. The initial gap and sural nerve were identified. The sural nerve was not clearly identified in 4 patients. A strong forceps introduced to pull-stretch and immobilize the tendons ends. The sutures were passed within the middle of the tendon mass, and exit throughout the tendon ends under ultrasound vision (Figure 4).

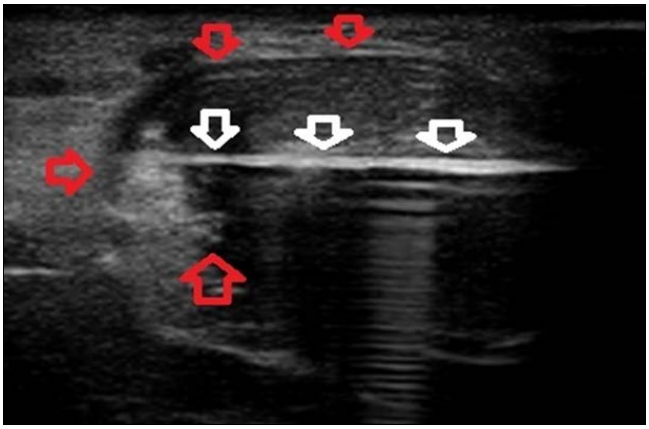

Fig 4: Passing the needle through the tendon mass

The gap closure was monitored ultrasonographically during the sutures tightening (Figure 5).

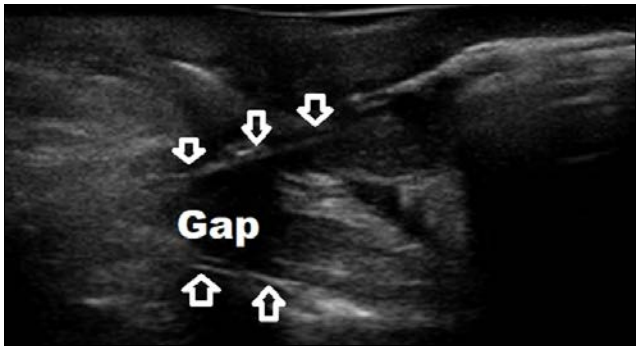

Fig 5: Approximating the tendons ends. Notice the sutures (white arrows).

In both techniques, gap inspection during passive ankle motion was the final step of the operation. There was not complete closure of the gap, especially in the ventral and lateral part, but endoscope and ultrasound helped to identify that and put another supporting suture.

Postoperatively, all patients were mobilized with partial to full weight-bearing in a below-knee plaster in gravity equinus position for two weeks. Subsequently, the plaster was cut to a removable full weight-bearing back slab, the sutures were removed, and active ankle mobilization started for an additional month after the cast removal during the 6-week post-op. Following that, patients wore an insole wedge pad underneath the heel for three more months.

The evaluation was performed using the heel raise test [7], which includes the following procedure. The patient was in a standing position, barefoot, supported by the dominant hand on the wall, and with the elbow in a semi-flexed position. Then, the patient had to perform a maximum range of plantar flexion movements on their healthy leg. At full flexion position, the researchers marked the maximum height of the patient's head on an instrument with adjustable height. The patient had to execute the maximum number of plantar flexions possible, as fast as possible. The test ended when the patient failed to reach the determined height due to fatigue. Then, patients had to perform the same test with the operated leg. The researchers registered the number of repetitions using a digital counter.

The researchers performed statistical analysis using the IBM SPSS v.26 program. At first, they performed a frequencies analysis. Pearson's Chi-Square test was used to investigate the correlation between the patients' age and test scores. Finally, they examined the differences in the means and standard deviations between groups using independent samples T-test.

3.1 Ethical considerations: This study followed all fundamental ethical principles that govern research, such as full confidentiality regarding the patients' data, the safety of the material, and the anonymity of the participants. Finally, the study protocol complied with the Helsinki Declaration and was approved by the Ethical Committee of the Panarkadikon General Hospital of Tripoli, Greece.

4. Results

In the arthroscopic group, there were no infection or skin healing problems, but two patients of this group developed sural neuralgia. It one patient of the two, sural neuralgia subsided without any further treatment. However, in the other patient, there is still some loss of sensation in the little toe's outer surface and a small area around the lateral lip of the foot. In the ultrasound-assisted group, there were no complications.

According to the heel lift-up counts, the age was not correlated either to the healthy Achilles score (p=0.093), neither to the operated one's score (p=0.327).

In the ultrasound-assisted group, the mean score of the contralateral healthy Achilles was 30.50, compared to the 35.40 for the arthroscopic group, but this difference was not statistically significant (p=0.414) (Table 1).

Similar results were observed for the operated Achilles between the two groups. More specifically, in the ultrasound group, the mean score was 27.10, and in the arthroscopic group 31.60. This difference was also not statistically significant (p=0.364) (Table 1).

Finally, the ultrasound-assisted repaired Achilles achieved 90.11% compared to the score of healthy individuals, and the arthroscopic repaired Achilles reached 91.12% in contrast to the healthy individuals. Still, these differences were not statistically significant (p=841) (Table 1).

All patients returned to their previous activity level, and all except the sural neuralgia patients stated that they were willing to undertake the operation again if needed.

Table 1: Independent samples T-test for endoscopic and ultrasound-assisted Achilles repair scores (number of the heel raise above 5cm for each leg)

	n	mean±sd	*p*-value
Operated Achilles endous	15 15	31.60±14.19 27.10±6.96	0.364
Non operated Achilles endous	15 15	35.40±17.05 30.50±8.97	0.414
% difference endous	15 15	91.12±12.91 90.11±10.81	0.841

5. Discussion

Most studies in the literature refer to good results about percutaneous techniques and low complication rates[8]. Practically, there were no skin complications, unlike open surgery [9]. However, some studies report inferior results when compared with open repair surgery. Nerve entrapment was ranged from 10 –13% [10-12].

Metz compared minimally invasive repair surgery versus non-operative treatment where the complications, excluding re-rupture, was found 21% for surgical treatment and 36% for non-operative treatment. Patients returned to their normal routine activities earlier in the operative repair group (59 days) than the non-operative group (108 days) [13]. Ultrasonography has been used in percutaneous Achilles repair, offering good visualization of tendon approximation [14]. The placement of intra-tendinous needles was studied by Soubreyrand *et al*., who showed the effectiveness of ultrasound as an intra-operative tool during the percutaneous repair. They observed that 55% of the needles were positioned correctly when imaging was not used, whereas all needles were placed correctly, and the stump approximation was validated using the ultrasound [15].

Bisaccia *et al*. concluded that ultrasound-assisted tenorrhaphy gives excellent clinical and functional output with a lower risk of infection and sural nerve injury than open surgery. Thus, ultrasound assistance confirms the localization of the sural nerve; the tendon ends' accurate detection and ensures that the position of the tendon ends is located on passive plantar flexion [16]. Giannetti *et al*. also confirmed that this technique minimizes potential injury of the sural nerve, restricts wound complications, and provides a substantial repair of the Achilles [17]. Additionally, Zappia *et al*. showed that intraoperative ultrasound gives reliable assistance during the percutaneous repair of Achilles tendon rupture [18].

Avoiding the lateral aspect of the tendon where the sural nerve is passing and putting the sutures in the medial 2/3 of the tendon could minimize the chances of injuring it. By using the ultrasound, the sural nerve could be identified in most cases and thus avoiding it [19].

The passage of the suture through the tendon mass could be successfully controlled only by ultrasound since the endoscope can visualize just the suture passing through the tendon's end. Thus, the ultrasound seemed to be superior to the endoscope in this area. In blind percutaneous surgery, the malalignment of the stumps is not low [10, 11]. Using either the endoscope or the ultrasound, the tendon stumps' malalignment can be avoided, and the approximation of the

tendon ends can be visualized and controlled. In both techniques, a gap was left after the initial suture, and additional sutures were needed to minimize the gap.

6. Conclusions

Arthroscopic and ultrasonography assisted percutaneous Achilles tendon repair seems to be useful in determining the initial gap and its sufficient closure. It aids in passing the suture through the tendon's ends, thus avoiding the stumps' malalignment. The main advantage of ultrasonography is depicting the entire muscle and tendon so that the orthopaedic surgeon can precisely guide the suture through the main muscle-tendon mass. However, this is not possible with the arthroscope. Besides, identifying and avoiding the sural nerve is another advantage of the ultrasound compared to the arthroscopic assisted Achilles tendon repair. It also results in minimal complication and early mobilization and recovery, even though a large number of patients are needed to validate the results of this study. This study presented similar outcomes on both arthroscopic and ultrasound-assisted repair of the Achilles. Still, ultrasonography seems to be better than endoscopy in assisting Achilles tendon repair because the orthopaedic surgeon controls suture passing throughout the tendon mass, and there are fewer chances to injure the sural nerve.

Funding

The authors have no funding to report.

Competing interests

The authors have declared that no competing interests exist.

Acknowledgments

The authors have no support to report.

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