Validity and Reliability of Mini-Invasive Surgery Assisted by Ultrasound in Achilles Tendon Rupture

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ABSTRACT

Introduction: The surgical treatment for Achilles tendon rupture has become very popular in the last years, because of the good outcomes and the low re-rupture rate. Aim: The aim of this study is to compare the results between open surgery and percutaneous ultrasound-assisted surgery. Methods: All patients who underwent an Achilles tendon surgical repair in the last 3 years were included, resulting in a total of 56 patients (40 M and 16 F) with an average age of 53 years. Of these patients, 36 were treated with an open suture, while 20 with a mini invasive ultrasound assisted suture. At a minimum follow-up of one year, patients were evaluated echographically, using both the Achilles Tendon Rupture Total score (ATRS) and the McComis score, and performing the ultrasounds bilaterally to assess both the structure and the diameter of tendons. Results: Both groups of patients showed an average ATRS score >80. The McComis score was 54.18 vs. 56.25 (p>0.05). Plantar flexion and dorsal flexion work were not similar (p>0.05). On average, the calf circumference of the operated side was decreased compared to the healthy side between the groups (p>0.05). The thickness of the operated tendons evaluated with ultrasound measurement compared to the average tendon, (p<0.05). Conclusion: The ultrasound-assisted tenorrhaphy is a reliable treatment with good clinical and functional outcomes; anyway, the percutaneous technique and the open surgery show similar results.

Keywords: Achilles, Ultrasound-assisted, Percutaneous, Tenorrhaphy, Suture.

1. INTRODUCTION

The Achilles tendon is the strongest tendon of the human body. Its tensile strength is 50 to 100N/mm² (1, 2). Unfortunately, this tendon frequently undergoes a spontaneous rupture, 2-6 cm proximally to the insertion on the calcaneous area because of the poor vascularization of this area.

Subcutaneous Achilles tendon ruptures occur by an indirect trauma. A correlation between this lesion and highly competitive sports has been demonstrated (3). Some sports can cause the weakening of the tendon (by micro-trauma or ischemia). There is an increased interest in this pathology because of its correlation with the increasing practice of non-competitive sports, especially among middle-aged individuals, usually without an adequate training.

Several methods have been proposed for the treatment of this rupture, but there is no evidence about the superiority of one of them (4-7). Non operative treatments consist in immobilizing the ankle in plantar flexion for 8-10 weeks using plaster cast (8). Non-operative management avoids surgery risks, but may result in a decreased tendon resistance and a mean re-rupture rate of 20% (9). The indication for this treatment is for patients with low functional activity.

The surgical treatment has become very popular in the last years, also for the low re-rupture rate. The purpose of surgery is to restore the continuity of the tendon, retrieve the strength of plantar flexion, avoid retraction, and allow earlier return to pre-injury activity. Traditional open surgical technique has been associated with a high rate (11%) of wound complications (i.e. necrosis, infections, adhesions etc.) (10, 11).

Percutaneous methods described firstly by Ma and Griffith (12) avoids most of disadvantages of open surgical treatment.
2. AIM

The aims of this study were: to evaluate the safety and effectiveness of mini-invasive ultrasound-assisted surgery; and to compare the results between open surgery and mini-invasive ultrasound-assisted surgery.

3. METHODS

In our study, a series of consecutive patients who underwent an Achilles tendon suture consequently to an acute tear, from 2012 to 2015, were included. We excluded all the patients who had a tear more than two weeks before, an open injury or a distal tendon stump of less than 3 cm from the insertion.

The diagnosis was made in all cases with both clinical and ultrasound evaluations. The study population consisted in 56 patients (40 M and 16 F) with an average age of 53 years (34-68). The right tendon was involved in 30 cases, while the left tendon in 26 cases. The average follow-up was at least 12 months from surgery. The patients were divided into 2 groups, based on the different treatment performed:

Total amount of 36 patients were treated with a traditional open surgery, with an “end to end” pull-out suture and 20 patients were treated with a Ma and Griffith percutaneous ultrasound-assisted suture technique. The patients’ randomization principle was based on their decision of which treatment they decided to choose.

All patients were fully informed about the 2 types of surgical treatment with their pros and cons and the corresponding surgical and conservative alternatives. Patients were treated according to the ethical standards of the Helsinki Declaration and were invited to read, understand and sign the informed consent form.

Both treatments were performed with the patient in prone position and without the use of tourniquet, under local regional anesthesia. The end-to-end pull out suture was made Approximating the ruptured ends of the tendon with No. 5 nonabsorbable tension suture, using a modified Kessler stitch through the stump 2.5 cm from the rupture. The Ma and Griffith percutaneous suture technique consisted first in the palpation of the tendineous gap. Ultrasoundography was used to determine the location of the stumps and disappearance of the gap upon flexion of the foot was checked on the ultrasound images. In all cases we used the ACUSON Sequoia Ultrasound System by Siemens (Figure 1). The sural nerve was identified too. Then, six small skin incisions, 3 medially and 3 laterally, were performed at a distance of 2 cm one from each other. The proximal and distal incisions were determined based on the location of the tear. If required by the level of the intersection with the sural nerve, the lateral entry point was shifted medially to avoid injuring the sural nerve during insertion of the needle. Then, under ultrasound control, the tendon was sutured with a FiberWire 2 (Arthrex®), inserting the needle through one of the incisions, exiting from the opposite one, re-entering to the near one, and repeating this passage for 2-3 times (Figure 2). Progression of each needle was monitored on the transverse ultrasound image to allow proper positioning within the tendon. After tensioning and tightening of the sutures, ultrasonography was used to check that the two tendon stumps were in close contact with each other.

4. RESULTS

All the 56 patients were evaluated with a minimum follow-up of 12 months. Clinical evaluation included functional assessment of the ability to perform 5x10 repetitive single affected-side heel rises and surgery-related complications. Ultrasound control was made to evaluate both the structure and the diameter of the tendon. Table 1 reports the average values for the ATRS questionnaire and McComis score. Both groups reached high scores (>85) in ATRS questionnaire, with no statistical difference between open and percutaneous repair. The McComis score for the percutaneous and open surgical technique (56.25 vs 54.18, respectively) were not statistically significant differences either.

Regarding the joint balance measurements obtained, no statistically significant differences were found between the two groups in plantar and dorsal flexion (30°).
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The mean calf diameter was 36.1 cm in open surgery, and 34.7 cm in the ultrasound group. The calf circumference of the treated leg was decreased compared to the healthy side.

Statistically significant differences were observed in the average thickness in the frontal plane of the tendons (p < 0.05), because the operated patients had an average thickness of 12 mm and 15 mm in comparison with the non-operated tendons whose average diameter it was 5 and 6 mm respectively.

We found a greater increase in the diameter of the tendons treated with open surgery than the ones treated with the percutaneous technique. The echographic structure of tendons treated with open surgery showed an increased fibrillar degeneration and disparity compared to tendons treated percutaneous not operated of 1.5 cm and between the groups treated with different techniques the difference was not significant (36.1 vs 34.7).

In 2019, Maffulli et al (18) enrolled 28 consecutive patients (21 men and 7 women; median age, 46 years) with chronic closed ruptures of the Achilles tendon who had undergone reconstruction with a free semitendinosus tendon graft. They assessed the Achilles tendon Total Rupture Score (ATRS), maximum calf circumference, and isometric plantar flexion strength before surgery and at the last follow-up. Outcome of surgery and rate of complications were also recorded. The median follow-up after surgery was 31.4 months.

Their overall results of surgery were: excellent/good in 26 (93%) of 28 patients. The ATRS improved from 42 (range, 29-55) to 86 (range, 78-95) (P < .0001). In the operated leg, the maximum calf circumference and isometric plantar flexion strength were significantly improved after surgery (P < .0001); however, their values remained significantly lower than those of the opposite side (P < .0001). All patients were able to walk on tiptoes and returned to

<table>
<thead>
<tr>
<th>Tab.1</th>
<th>ATRS</th>
<th>Mc Comis</th>
<th>Pl. flex</th>
<th>Dors. flex</th>
<th>Diamcalf</th>
<th>Diamtend</th>
<th>ATRS</th>
<th>McComis</th>
<th>Pl. flex</th>
<th>Dors. flex</th>
<th>Diamcalf</th>
<th>Diam. Tend.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>87.67</td>
<td>56.25</td>
<td>30.06</td>
<td>27.6</td>
<td>36.16</td>
<td>12.39</td>
<td>85.21</td>
<td>54.18</td>
<td>33.16</td>
<td>25</td>
<td>34.7</td>
<td>5</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>2.32</td>
<td>3.62</td>
<td>2.13</td>
<td>2.05</td>
<td>2.74</td>
<td>0.38</td>
<td>0.38</td>
<td>0.43</td>
<td>0.62</td>
<td>0.59</td>
<td>0.64</td>
<td>0.55</td>
</tr>
<tr>
<td>Std. Error of Mean</td>
<td>0.38</td>
<td>0.60</td>
<td>0.35</td>
<td>0.33</td>
<td>0.45</td>
<td>0.38</td>
<td>0.43</td>
<td>0.62</td>
<td>0.59</td>
<td>0.64</td>
<td>0.55</td>
<td>0.39</td>
</tr>
<tr>
<td>Lower 95% CI of Mean</td>
<td>86.8</td>
<td>55.11</td>
<td>29.33</td>
<td>26.74</td>
<td>35.13</td>
<td>11.61</td>
<td>85.15</td>
<td>52.68</td>
<td>31.6</td>
<td>23.64</td>
<td>33.54</td>
<td>4.18</td>
</tr>
<tr>
<td>Upper 95% CI of Mean</td>
<td>88.37</td>
<td>57.56</td>
<td>30.78</td>
<td>28.1</td>
<td>36.98</td>
<td>13.17</td>
<td>86.95</td>
<td>55.32</td>
<td>34.1</td>
<td>26.36</td>
<td>35.86</td>
<td>5.81</td>
</tr>
</tbody>
</table>
their pre-injury working occupation. No infections were recorded (18). Their conclusion were (18): mini-invasive reconstruction of the Achilles tendon, with a gap lesion larger than 6 cm, using the ipsilateral free semitendinosus tendon graft provides a significant improvement of symptoms and function, although calf circumference and ankle plantarflexion strength do not fully recover (18).

In 2015, Maffulli et al (19) published the paper about 21 patients undergoing minimally invasive reconstruction using a transfer of the ipsilateral peroneus brevis (PB) (five patients) or the free ipsilateral semitendinosus tendon (ST) graft with or without interference screw fixation (ten and six patients, respectively). We assessed the maximum calf circumference and isometric plantarflexion strength before surgery and at the last follow up (19). The Achilles tendon total rupture score (ATRS) and number of single-leg heel lifts on the affected leg were evaluated at the last follow up. The median follow up was 39 months. The outcome of surgery was excellent/good in 17 (81 %) of 21 patients. In the operated leg, the maximum calf circumference and isometric plantarflexion strength were significantly improved after surgery (P<0.0001). The average ATRS was 86 (range 79-92), and the average number of single-legged heel lifts was 33 (range 11-48). No further re-ruptures were recorded (19).The conclusions were: minimally invasive ipsilateral PB transfer and free ipsilateral ST graft with or without interference screw fixation are safe and effective procedures to reconstruct the Achilles tendon after a re-rupture, providing a significant improvement of the symptoms and function in the midterm (19). Kosanovic et al. (20) performed a modified Bunnel's percutaneous technique to suture the Achilles tendon. The authors only dealt with the early diagnosis of chronic rupture (< 8 weeks). The authors reported a patient with tendon non-union, which would normally be considered a re-rupture. This technique may have some merits in the early stages of chronic rupture, but larger numbers required. In another study (21), with a modified percutaneous technique in larger gaps, a total of 10 mini-incisions were made on either side of the tendon. Sutures were passed proximally and distally in a figure-of-eight fashion, and the ends delivered and tied in the two middle stab incisions. A validated outcome measure, greater detail in methodology and results would help interpret future series of this promising technique (22). Most tears and tendinopathy lesions occur approximately two to six centimeters from the insertion of the Achilles tendon on the calcaneus (23). In this area, complete tears are easily differentiated from partial tears, but the nearby plantaris tendon, lying medially, can be mistaken for an intact Achilles tendon (23). When diagnosis is doubtful, US examination may provide dynamic imaging, and ankle dorsiflexion may be helpful to detect tendon discontinuity (23). Therefore, baseline US appearance is not able to predict clinical outcome. In Achilles tendinopathy, grey-scale ultrasonography is a cost-effective method to examine the Achilles tendon (23). As grey scale sonography is operator dependent, and relies on the detection of hypoechoic lesion and assessment of tendon thickening and widening, it was hoped that the addition of color or power Doppler assessment would add objective evidence of pathology.

Instead the ultrasound assisted tenorrhaphy is an easy procedure, with a short learning curve, and it useful to preserve the blood supplies of the paratenon and soft tissues, suggesting a better healing of the wound and the tendon. The intra-operative use of ultrasonography does not significantly increase the operating time. Ultrasonography improves the reliability of suture positioning by providing real-time images of the boundaries of the tendon and their relationships with the sural nerve. The learning curve for ultrasound evaluation of the Achilles tendon was extremely short. Evaluation of the sural nerve proved more challenging but was facilitated by the clear visibility of the external saphenous vein traveling alongside the nerve.

In 2011 Saxena et al. showed the importance of the ability to perform 5 sets of 25 single-legged heel raises in post operative patients. We usually reduce the number of repetitions according to a low average training level of our population (24).

6. CONCLUSION

The ultrasound assisted tenorrhaphy is a feasible treatment with a good clinical and functional outcome, low rate of complication. The authors conclude that this technique should be the golden standard, due to lower risk of wound dehiscence, infections or sural nerve injuries in comparison to open surgery. Ultrasound assistance is very important confirm the localization of the sural nerve, the accurate detection of the tendon ends, and ensures that the ends of the tendon are brought on passive plantar flexion.

REFERENCES

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