Evaluation of surgical treatment for ruptured Achilles tendon in 31 athletes

R. Jallageas\textsuperscript{a,b,∗}, J. Bordes\textsuperscript{a,b}, J.-C. Daviet\textsuperscript{a,b}, C. Mabit\textsuperscript{c}, C. Coste\textsuperscript{c}

\textsuperscript{a} CRHUMS, centre régional hospitalo-universitaire de médecine du Sport, CHU Dupuytren, avenue du Buisson, 87042 Limoges, France
\textsuperscript{b} Service de MPR, hôpital Jean Rebeyrol, CHU Dupuytren, 87042 Limoges, France
\textsuperscript{c} Service de chirurgie orthopédique, CHU Dupuytren, 87042 Limoges, France

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Summary

Introduction: In the past few decades, the incidence of Achilles tendon rupture has increased in parallel with increased sports participation. Although the optimal treatment remains controversial, there is a trend towards surgical treatment in athletes.

Hypothesis: Surgical repair of ruptured Achilles tendon in athlete results in good functional and objective recovery, irrespective of the type of surgery performed. Subsidarily, are the results different between percutaneous surgery (PS) and standard open surgery (OS)?

Materials and methods: This was a cross-sectional study of 31 patients who presented with a ruptured Achilles tendon that occurred during sports participation. Percutaneous surgery was performed in 16 patients and open surgery in 15 patients between 2005 and 2009. The objective recovery status was evaluated by open chain goniometry, measurement of leg muscle atrophy and assessment of isokinetic strength. The functional analysis was based on the delay, level of sports upon return, AOFAS and VAS for pain.

Results: Our series of Achilles tendon rupture patients consisted of 88% men and 12% women, with an average age of 38 years. In 71% of cases, the rupture occurred during eccentric loading. After a follow-up of 15 months, the muscle atrophy was 13 mm after PS and 24 mm after OS\textsuperscript{P} = 0.01. A strength deficit of 19% in the plantar flexors was found in the two groups. No patient experienced a rerupture. The return to sports occurred at 130 days after PS and 178 days after OS\textsuperscript{P} = 0.005. The average AOFAS score was 94 and the VAS was 0.5. There were no differences in ankle range of motion between the two groups. The majority (77%) of patients had returned to their preinjury level of sports activity.
Introduction

Very few cases of Achilles tendon rupture were described until the middle of the 20th century. In the last two decades, its incidence has increased [1,2]. The advent and popularity of recreational sports have contributed to an upsurge in this injury. The annual incidence of Achilles tendon rupture increased from 18.2/100,000 people in 1984 to 37.3/100,000 people in 1996 in Denmark [3]. Seventy-five percent of Achilles tendon rupture cases described in published studies are sports-related, particularly racket and jumping sports. Most of the patients presenting with an Achilles tendon rupture are men (on average, six men for every woman) [4] and the peak of incidence occurs between 30 and 45 years of age. The treatment protocols have constantly evolved over the past 20 years. As a consequence, there is currently no gold standard for the treatment of Achilles tendon ruptures. Various studies have showed faster return to sports after surgical treatment in athletes. Various open and minimally-invasive surgical techniques have been described, but there is no consensus as to which one is the best. Even if the long-term functional results are good overall [5], there is little information available on quantifiable measures of recovery, especially muscle strength. We wanted to objectively define the residual force deficit over the long-term after surgery. This will help to improve the results and to compare various surgical techniques or rehabilitation protocols.

The primary purpose of this study was to evaluate the functional and objective outcomes in athletes treated surgically for a ruptured Achilles tendon. The secondary purpose was to determine if there were any differences between open and percutaneous surgical repair of the injured tendon.

Material and methods

We performed an observational, cross-sectional study.

Inclusion and exclusion criteria

Patients were included if they had suffered a mid-body rupture of the Achilles tendon during sports activity and were treated with open surgery (OS) or percutaneous surgery (PS) at the Limoges University Hospital between 2005 and 2009. Thirty-five patients were included (Fig. 1).

Patients were excluded if the rupture was more than 8 days old, the rupture was not due to trauma or occurred outside of sports or physical activity, or they were treated conservatively or treated surgically with a method other than open or percutaneous surgery. Additional exclusion criteria were a history of Achilles tendon rupture, Achilles tendinopathy or injury to the leg, ankle or foot that prevents the interpretation of the isokinetic testing on the operated side or the uninjured contralateral side.

Group composition

The choice of surgical technique was left up to the surgeon. There were three senior surgeons and two resident surgeons involved in this series. The patients were distributed into two homogeneous groups (Fig. 1): one group consisted of 15 patients (13 men, 2 women) treated by OS and the other group consisted of 16 patients (13 men, 3 women) treated by PS. The average age was 37 years (range 18–60) for the PS group and 39 years (range 19–71) for the OS group. In 77% of cases, the patients were involved in jumping

![Flow chart summarizing patient selection for this study.](image-url)
sports at the time of tendon rupture: soccer (37%), handball (31%), rugby (13%), basketball (13%) and volleyball (6%). In 10% of cases, the athletes were national level competitors; in 42% they were regional level competitors and in 48% they were recreational athletes; there was no significant difference between the two groups. Weekly training time was 270 minutes (range 180–840) in the PS group and 249 minutes (range 120–900) in the OS group.

**Surgical techniques**

All the patients were treated surgically within 8 days of the rupture, with an average of 1.5 days (range 0–8). During OS, the patient was placed prone with a tourniquet cuff at the base of the thigh. The approach was medial to midline of the tendon. The tendon sheath was dissected. The rupture tendon was repaired in a Kessler pattern using slow absorbable suture. The tendon sheath was then closed, along with the skin, using a water-tight but non-ischemic suture pattern. The postoperative immobilization was 6 weeks long. Patients were seen again at 3 and 6 weeks after the surgery (Table 1).

For patients treated by PS, the material used (Tenolig®, FH Orthopedics, France) consisted of a Dacron suture and needle, with a 5.2 mm metal harpoon, a silastic disc and a large pierced shot. It was implanted with the patient prone, typically under regional anesthesia and without use of a tourniquet cuff. The rupture was located by finger palpation. The surgeon then made a 2-cm incision over the site. The needle was curved as needed and inserted into the tendon axis proximally to distally under visual control. The needle emerged in the medial or lateral retromalleolar groove, depending on the initial entry point, and then the second needle was inserted. Tension was placed on the sutures with the foot in plantar flexion. The foot was immobilized for 3 weeks and then the material removed at 6 weeks. Patients were seen again at 2, 4 and 6 weeks depending on the postoperative rehabilitation protocol used (Table 1).

**Analysis methods**

The primary author performed the functional and objective assessments. The functional recovery was evaluated using the time for return to sports and the level achieved at the return. The number of physiotherapy and days away from work were also taken into consideration. The American Orthopaedic Foot and Ankle Society Score (AOFAS) and Visual Analogue Scale (VAS) for pain were used to evaluate the functional recovery [6].

The objective evaluations consisted of measurement of the range of motion of the talotibial joint with a goniometer (in degrees) with the subject lying supine and the patella facing up; neutral position (0°) was defined as the patient’s foot being perpendicular to the lower leg. Muscle atrophy in the lower leg was measured at the level of the largest circumference of the calf [7]. All patients underwent isokinetic testing with a Cybex Norm® dynamometer at an average of 15 months post-surgery (range 6–27). After a 10-minute warm-up on a stationary bicycle, the patients were evaluated while lying supine (7°), with the hip at 60° and the knee at 90°. The dynamometer axis was aligned with the ankle rotational axis. The patient wore their typical sports shoes and the foot was attached to an adjustable arm provided by the manufacturer. The straps were tightened to make sure that the footwear, knee and pelvis could not contribute to the ankle movement. One series of three repetitions at 30°/s and one series of 20 repetitions at 120°/s over a range of 40° plantar flexion and 20° dorsiflexion were performed once the patient had been familiarized with the apparatus. Verbal encouragement was provided to ensure that the patient exerted maximum force during the movements. The non-operated side was always evaluated first to avoid anxiety over the process. The dynamometer was calibrated according to the manufacturer’s recommendations. The subject was allowed to warm up and train on the apparatus before the measurements began. The isokinetic force deficit was expressed as a percentage according to the following formula: 1–(operated side/healthy side).
Table 2  Patient characteristics.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Total (n = 31)</th>
<th>OS (n = 15)</th>
<th>PS (n = 16)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>38.2 (12.1)</td>
<td>39.1 (14.7)</td>
<td>37.3 (9.9)</td>
<td>ns</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>26 (83)</td>
<td>13 (86)</td>
<td>13 (81)</td>
<td></td>
</tr>
<tr>
<td>Female, n (%)</td>
<td>5 (17)</td>
<td>2 (14)</td>
<td>3 (19)</td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>177 (9.0)</td>
<td>174 (9.8)</td>
<td>177 (7.1)</td>
<td>ns</td>
</tr>
<tr>
<td>Mass (kg)</td>
<td>77 (10.6)</td>
<td>76 (10.8)</td>
<td>77.5 (10.3)</td>
<td>ns</td>
</tr>
<tr>
<td>Injured side</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right, n (%)</td>
<td>16 (51)</td>
<td>7 (44)</td>
<td>9 (60)</td>
<td>ns</td>
</tr>
<tr>
<td>Left, n (%)</td>
<td>15 (49)</td>
<td>9 (56)</td>
<td>6 (40)</td>
<td>ns</td>
</tr>
<tr>
<td>Take-off foot, n (%)</td>
<td>22 (71)</td>
<td>9 (40)</td>
<td>13 (60)</td>
<td>ns</td>
</tr>
<tr>
<td>Competition level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National, n (%)</td>
<td>3 (9.5)</td>
<td>1 (6.5)</td>
<td>2 (13.5)</td>
<td>ns</td>
</tr>
<tr>
<td>Regional, n (%)</td>
<td>13 (42)</td>
<td>8 (50)</td>
<td>5 (33)</td>
<td>ns</td>
</tr>
<tr>
<td>Amateur, n (%)</td>
<td>15 (48.5)</td>
<td>7 (43.5)</td>
<td>8 (53.5)</td>
<td>ns</td>
</tr>
</tbody>
</table>

OS: open surgery; PS: percutaneous surgery.

Statistical analysis

Qualitative parameters in the two surgery groups were compared either with a Chi-square test or a Fisher’s exact test, depending on the number of expected frequencies and the number of categories. Since the data in this small patient series was not normally distributed, a non-parametric Mann-Whitney U test was used to compare quantitative parameters. A significance threshold of 0.05 was chosen for all the statistical testing. The statistical analyses were performed with Statview 5.0 and SAS 9.1.3 (SAS Institute, Cary, USA).

Results

All the patients were reviewed again between 6 and 27 months after surgery, with an average of 15 months. Four patients were lost to follow-up (Fig. 1). The anthropometric characteristics of our population are given in Table 2.

Table 3  Postoperative complications following Achilles tendon surgery.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Total (n = 31)</th>
<th>OS (n = 15)</th>
<th>PS (n = 16)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate complications, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>25 (80.5)</td>
<td>13 (86)</td>
<td>12 (75)</td>
<td>ns</td>
</tr>
<tr>
<td>Rupture</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Local infection and delayed healing</td>
<td>5 (16)</td>
<td>1 (7)</td>
<td>4 (25)</td>
<td>ns</td>
</tr>
<tr>
<td>Deep venous thrombosis</td>
<td>1 (3.5)</td>
<td>1 (7)</td>
<td>0</td>
<td>ns</td>
</tr>
<tr>
<td>Secondary complications, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>26 (87)</td>
<td>13 (86)</td>
<td>13 (81)</td>
<td>ns</td>
</tr>
<tr>
<td>Rupture</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Paresthesia in the sural nerve area</td>
<td>3 (9.5)</td>
<td>0</td>
<td>3 (19)</td>
<td>ns</td>
</tr>
<tr>
<td>Deep venous thrombosis</td>
<td>2 (6.5)</td>
<td>2 (14)</td>
<td>0</td>
<td>ns</td>
</tr>
</tbody>
</table>

OS: open surgery; PS: percutaneous surgery.

Immediate complications

There were no immediate complications in 25 of our patients (13 OS, 12 PS). There were five cases of local infection or delayed healing and one case of deep venous thrombosis after OS (Table 3).

Secondary complications

There were no secondary complications in 26 of our patients. There were three cases of sural nerve paresthesia after PS; one of these cases was still present 15 months after the surgery. There were two cases of deep venous thrombosis after OS (Table 3).

Functional results

The average amount of time away from work was 70 days (Table 4). Patients underwent an average of 30 physiotherapy sessions after the surgery. Return to sport occurred after
130 days within the PS group and 178 days in the OS group ($P = 0.0054$); the average for both surgery groups combined was 153 days (Table 4). All patients returned to their sport after the surgery and 80% of them had returned to their preinjury level, independent of the type of surgery performed (Table 4). The AOFAS score was 96 after PS and 91 after OS ($P = 0.05$). The average VAS for pain was 0.5 (Table 5).

**Objective results**

There was no evidence of the different surgical procedures leading to differences in ankle range of motion (Table 5). Muscle atrophy was 13 mm after PS versus 25 mm after OS ($P = 0.01$). There was a 19% deficit in the plantar flexion strength at the slow (30°/s) and fast (120°/s) speeds, independent of the type of surgery performed (Table 6).

**Discussion**

The return to daily living activities after surgery is an important outcome. This occurred after 70 days in our study, which was consistent with some published studies [8, 9], but divergent from others [10], especially American or Anglo-Saxons studies where the return to work occurs between day 22 and 30 after surgery [11–13]. This difference could be the results of differences in the sick leave system between countries.

In various published reports, the return to sports occurred between day 154 and 273, no matter the type of treatment used [14–16]. In our study cohort, the return to sport occurred 153 days after surgery on average (range 91–246). It was faster after PS ($P = 0.0054$), which was a difference with current published studies [10]. Percutaneous surgery uses a dynamic tendon repair procedure that reduces the length of postoperative immobilization and allows for an earlier return to walking and activities of daily living [17]. This hypothesis was backed up with the Ozkaya study [14].

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### Table 4: Functional evaluation after an average of 15 months after surgery.

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>PS</th>
<th>OS</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of physiotherapy sessions</td>
<td>$30 \pm 14$ [10–64]</td>
<td>$28$ [10–50]</td>
<td>$31$ [10–64]</td>
<td>ns</td>
</tr>
<tr>
<td>AOFAS score</td>
<td>$93.9 \pm 6.15$ [80–100]</td>
<td>$95.9$ [85–100]</td>
<td>$91.6$ [80–100]</td>
<td>0.05</td>
</tr>
<tr>
<td>Return to sport (days)</td>
<td>$153 \pm 50$ [61–428]</td>
<td>$130$ [61–428]</td>
<td>$178$ [91–246]</td>
<td>0.0054</td>
</tr>
<tr>
<td>Level at return</td>
<td>Same: $24$ (77.5%); Lower: $7$ (22.5%); Stopped: $0$</td>
<td>$13$ (81%); $3$ (19%); $0$</td>
<td>$11$ (73.5%); $4$ (26.5%); $0$</td>
<td>ns</td>
</tr>
</tbody>
</table>

OS: open surgery; PS: percutaneous surgery.

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### Table 5: Clinical assessments after an average of 15 months post-surgery.

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>PS</th>
<th>OS</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS (/10)</td>
<td>$0.5 \pm 0.21$ [0–3]</td>
<td>$0.4$ [0–3]</td>
<td>$0.7$ [0–2]</td>
<td>ns</td>
</tr>
<tr>
<td>Muscle atrophy (mm)</td>
<td>$18.8 \pm 12.85$ [–37–14]</td>
<td>$13.3$ [–37–14]</td>
<td>$24.7$ [–37–10]</td>
<td>0.01</td>
</tr>
<tr>
<td>Plantar flexion uninjured side (degrees)</td>
<td>$41 \pm 4$ [34–53]</td>
<td>$40$ [24–48]</td>
<td>$42$ [34–53]</td>
<td>ns</td>
</tr>
<tr>
<td>Dorsiflexion uninjured side (degrees)</td>
<td>$20 \pm 3$ [14–26]</td>
<td>$20.5$ [14–26]</td>
<td>$19.5$ [16–23]</td>
<td>ns</td>
</tr>
</tbody>
</table>

OS: open surgery; PS: percutaneous surgery.
showing that early rehabilitation leads to highly satisfactory clinical and functional results, while not increasing the risk of rerupture.

Various studies have reported that 85% to 100% of patients were able to return to sport, no matter which level they competed at [18–20]. Only 77% of patients returned to sport in the Landaalst study [10], but the study population included non-athletes, which could partly explain why 23% of the population had abandoned all physical activity. In our study, 80% of patients returned to their preinjury level of sports participation, which was consistent with the meta-analysis by Khan [5]. Mandelbaum [17] reported that 100% of patients had returned to preinjury levels, but study population mainly consisted of high-level athletes and the postoperative assessments were performed after 24 months. In our study, 100% of patients had returned to their sport of choice. This could be attributed to the relatively high level of sports competition in our study population, as this was independent of the ability level. Our patients practiced at their sport for an average of 4 hours and 20 minutes per week, which is relative high.

The functional results after PS, evaluated with the AOFAS score, were comparable to published results [15,18]. Only Garrido [19] reported better results, but these were after 22 months of follow-up. The AOFAS score was better in the PS group (P = 0.05), which can be attributed to percutaneous surgery being able to restore the dynamics of the Achilles muscle-tendon unit earlier [20]. Studies on the isokinetic evaluation of ankle flexors after surgical repair of the Achilles tendon are fairly rare and typically look at a limited number of subjects. In terms of recovery of isokinetic strength at 12 months after the surgery, there seems to be no differences between minimally-invasive and open surgery techniques [21], which was consistent with the findings of the current study. The dorsiflexion muscles had no isokinetic strength deficit, as previously reported by Lepiliha [22] or Gigante [23], even though different speeds were used (30°/s, 90°/s, 240°/s). Independent of the surgical technique, Dauty [24] found a 27% deficit in athletes 4 months after surgery, which improved to 18% at 6 months and 7% at 12 months when measured at 60°/s. In the current study, we found a strength deficit greater than the one reported by Dauty [24], but similar to the one reported by Chillemi [25]. This difference could be the result of the patients being higher-level athletes in the Dauty study [24] or having received a more intense rehabilitation protocol after surgery, however, these parameters were not described in his study. The strength deficit found in the current study could have been overestimated because of the variability in the postoperative assessment time point (6 to 27 months).

The degree of muscle atrophy is a function of immobilization: One study [26] found greater than 10% muscle atrophy after 6 weeks of immobilization; conversely, after early post-surgical mobilization, less than 2 cm of muscle atrophy was reported in other studies [8,27,28]. These results are even better after minimally-invasive surgery, where 1 cm of atrophy has been reported [29,30]. These differences between the two types of surgery were also found in the current study. However, some authors have stated that muscle atrophy is not a reliable criterion [15]. When looking at control groups of paired healthy subjects, there was a 7 ± 8 mm difference between the calf of the dominant and non-dominant legs, even though there was no significant difference in strength. Also, the surgical technique had no effect on the recovery of joint range of motion; only early return to weightbearing and rehabilitation can ensure that joint range of motion returns [14].

Of the various potential surgical complications, rerupture is the most feared [13]. This mainly occurs in the first 2 or 3 weeks after the surgery, when the patient starts weightbearing. In the current study, none of the patients experienced rerupture, no matter which type of surgery was used. This was consistent with other published reports [5,27,28,31]. Furthermore, there was a 12% rate of minor complications (such as superficial infection at the surgical site or problems related to healing) [5]. The low rate of skin-related complications was likely related to strict monitoring during the postoperative recovery stage. The main complication of percutaneous techniques is the occurrence of injuries in the area of the sural nerve; the rate varies between 0 and 23% [32,33]. Lansdaal [10] reported that 9.2% of patients had discomfort related to a sural nerve injury; this rate was 19% in the current study. These cases of paresthesia are secondary to the formation of a hematoma around the nerve during the surgical phase [34]. The large number of surgeons and low number of patients could explain the values found in the current study. However, all of these

### Table 6: Isokinetic strength at an average of 15 months after surgical repair of the Achilles tendon (in Nm).

<table>
<thead>
<tr>
<th></th>
<th>Total n = 27</th>
<th>OS n = 14</th>
<th>PS n = 13</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deficit (%)</td>
<td>Deficit (%)</td>
<td>Deficit (%)</td>
<td></td>
</tr>
<tr>
<td>Plantar flexion 30°/s</td>
<td>19 (56; 171)</td>
<td>19.5 (56; 171)</td>
<td>18 (64; 135)</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td>–8 (–60; 24)</td>
<td>–8 (–52; 24)</td>
<td>–7.5 (–60; 16)</td>
<td>ns</td>
</tr>
<tr>
<td>Dorsiflexion 120°/s</td>
<td>19 (26; 104)</td>
<td>18 (26; 104)</td>
<td>19.5 (30; 85)</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td>–6 (–52; 24)</td>
<td>–7.29 (–80; 25)</td>
<td>–4.5 (–62; 23)</td>
<td>ns</td>
</tr>
</tbody>
</table>

OS: open surgery; PS: percutaneous surgery.
nerve injuries were limited to sural area paresthesia and only one case had not resolved at the 15-month follow-up. The only major complication was the occurrence of deep venous thrombosis in two cases (6.5%). However, the risk of deep nervous thrombosis is not correlated to the treatment, but is a consequence of the lower leg being immobilized [35].

The strong points of this study were the quantitative evaluation of the recovery from surgical treatment of mid-body Achilles tendon ruptures in athletes, which found no differences as a function of the type of surgery performed, no reruptures, early return to sport and a better AOFAS functional score after PS. But this study also had certain limitations. The small number of subjects, the variable postoperative evaluation period (5 to 27 months), the heterogeneous age of our population and the non-homogeneous level of sports competition, along with the different rehabilitation protocols used limit the interpretation of the results in the current study. Also, the evaluation of the level of return to sport was very subjective. Some questions remain unanswered, namely the presence of a muscle deficit, despite the good functional scores. This begs the question, if the muscle deficit was completely eliminated, would the functional result be even better?

Conclusion

The results of surgical treatment for ruptured Achilles tendon are good overall. By combining the simplicity of conservative treatment and the reliability of standard surgical treatment, percutaneous surgery is the treatment of choice to achieve excellent results and reduce the length of postoperative immobilization. Although there were no significant differences in the strength of the ankle plantar flexors as a function of surgery type, athletes receiving percutaneous surgery seemed to return to sports faster and had less muscle atrophy. However, there were more nerve-related complications with PS. The current study was consistent with other published studies in that percutaneous surgery was not found to be better than standard open surgery.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References