Original Research

SEPARATION OF TENDON ENDS AFTER ACHILLES TENDON REPAIR: A PROSPECTIVE, RANDOMIZED, MULTICENTER STUDY

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ABSTRACT

Fifty-seven patients treated for an acute rupture of the Achilles tendon were studied. The patients were randomized into a Mason suture technique or a reinforced continuous six-strand suture technique, and markers were attached to each tendon end perioperatively. The postoperative separation of the markers was studied by repeat radiographic examination. Despite immobilization, separation developed after a biphasic course, and after 7 weeks the mean separation was 10.5 mm. No difference was found between the two techniques. We attempt to correlate the separation to the clinical outcome, examined at 1 year follow up.

From laboratory studies and a small number of human studies is it known that a biphasic separation between tendon ends occurs despite sufficient tendon suture and immobilization.1,2 Such separation also occurs after Achilles tendon repair.3 The separation is known to be associated with increased tendon granulative tissue and adhesion formation around the suture site, as well as delayed collagen maturation.4-6 From clinical observation it is known that some patients treated surgically or conservatively after Achilles tendon rupture have an increase in dorsal range of motion (ROM) combined with a reduction in plantar ROM.7,8 Such a change in ROM after treatment of Achilles tendon rupture might be due to a relative elongation of the tendon.

Ejeskär and Irlstam2 have shown a significant correlation between the size of separation and the clinical outcome for sutured flexor profundus tendons.

Our study investigated whether the clinical outcome after surgical Achilles tendon repair could be correlated to the separation, measured with perioperatively placed metal markers in the tendon ends. At the same time we wanted to examine whether a reinforced suture technique could reduce the separation and perhaps result in a better clinical outcome.

MATERIALS AND METHODS

We compared the Mason suture technique with a continuous six strand suture technique (CSSS) developed by Savage9 for flexor tendon repair (Fig 1). In an earlier10 laboratory study on cadaverous achilles tendons, we found the CSSS technique, modified for Achilles tendon repair, had a significantly better gapping resistance and greater tensile strength than the Mason and Bunnell techniques. In the investigation period, 57 patients with subcutaneous Achilles tendon
rupture were randomly assigned to repair using either the Mason or CSSS technique.

Four categories of patients were not included in the study:
- Patients with a rupture older than 48 hours.
- Patients who had been treated within 6 months with local or systemic corticosteroids.
- Patients who lived outside the county.
- Patients who did not want to participate.

After the patient’s acceptance, the operating surgeon opened a sealed envelope to find which technique would be used. The envelopes were mixed according to a list of random numbers from Geigy Scientific Tables. After randomization, the patients were operated under local anesthesia (1% lidocaine with noradrenaline). The operation was performed through a longitudinal incision at the medial border of the Achilles tendon, and repair was done according to randomization.

In all cases repair was done with a braided polyester suture no. 0 (Ticon®). During the operation a small piece of 2-0 steel wire was introduced transversely through each end of the Achilles tendon approximately 1 cm from the rupture. A knot placed on the wires acted as an anchor. The ends of the wire were cut off under the tendon surface so that the whole wire was covered by tendon. After paratenon and skin closure, a circular plaster of Paris cast was applied extending from the toes to below the knee with the ankle in 25° plantar flexion. After 1 to 2 days of elevation the patients were mobilized, and after 3½ weeks the plaster of Paris was changed to a walking cast with the ankle in neutral position. Seven weeks postoperatively, the cast was removed and the patients were allowed weight bearing as tolerated. The patients were advised to use 1 cm heel lifts for 1 month.

Standardized radiographs (Fig 2) were performed postoperatively, after 2 weeks, before and after cast change at 3½ weeks, after 7 weeks, and at 1 year.

Six patients included in the study were later excluded:
- In three patients the rupture point was close to the calcaneal insertion and the operating surgeon could not use the technique chosen by randomization.
- In two patients who were randomized to the CSSS technique, the operating surgeon could not implement the suture technique.
- In one patient the metal marker loosened.

Forty-seven patients were seen approximately 1 year after the operation. In 30 of these patients plantar flexion strength was measured with an isometric strain gauge. The tests were done by an outside person who was unaware of the size of separation. The measurements were done in three positions: 15° dorsiflexion, 15° plantar flexion, and 30° plantar flexion. All tests were repeated 10 times, and the highest score was used. A relative index was calculated as: strength of the injured side divided by strength of the non-injured side. The results were corrected 5% for right side strength dominance.11

Mann-Whitney’s unpaired rank sum test, rank
correlation (Spearman test), and Fishers' test were utilized in the statistical evaluation. P<.05 was considered statistically significant. The study was approved by the local ethical committee.

RESULTS

The median age was 36 years (range: 21 to 68) and the male to female ratio was 4:1. Almost all ruptures occurred during sports activities, predominantly by badminton (43%) followed by handball and soccer (14% each). The ruptures were evenly distributed between the dominant and the contra-dominant leg.

Of the 51 patients, 24 were randomized in the CSSS group and 27 in the Mason group. Two patients, both in the CSSS group, developed minor skin necrosis; both healed quickly after conservative treatment. No cases of infection or re-rupture occurred.

Clinical follow-up examination was performed after a median of 12 months (range: 7 to 22). Before the clinical examination, the patients were asked to give their opinion of the result. Sixty-three percent were satisfied with the result. Thirty-three percent had only minor complaints and were "nearly satisfied." Four percent were less or not satisfied. Seventy percent continued sports activities at the same level as before the rupture. All patients were able to walk normally and tiptoe on both legs, but 12 patients had a slight feeling of stiffness around the ankle. Seven patients also had slight starting pain. Calf circumference was reduced by 4% (range: 0% to 10%), and the tendon width increased an average of 65%. In 11 patients adhesions between the Achilles tendon and the skin were found, but this group had no more complaints (pain/stiffness) than patients without adhesions. We found no statistical difference between the CSSS and the Mason groups concerning the above parameters.

Separation Between Markers. The separation between the metal markers increased in a biphasic pattern (Fig 3). From the operation until 2 week follow up, the distance increased an average of 3 mm, reaching a plateau where the separation was unchanged until 3½ weeks. From this time and until the 7 weeks follow up, the distance increased to an average of 9.5 mm. After the casts were removed and until 1 year, only a minor increase in the separation was seen, ending with a mean separation of 10.5 mm. The curves for the CSSS and the Mason groups showed the same pattern, and we found no statistical difference in marker separations between the two groups.

Range of Motion. Fifteen patients (32%) had a change of >5° in either dorsal or plantar flexion. Five of these patients had plantar flexion reduction only, and nine patients had a combined reduction. Only one patient had increased dorsiflexion combined with a reduction in plantar flexion (10° reduction in the plantar flexion and a 10° gain in dorsiflexion). Thus, only one patient had a gain in dorsiflexion larger than 5°, and perhaps paradoxically, this patient had one of the smallest marker separations.

Figure 4 shows the change in plantar and dorsiflexion related to the marker separation. There was a small, but nonsignificant, positive correlation. None of the patients with a separation larger than 13 mm had a reduction in dorsiflexion larger than 5° nor the expected increase in dorsiflexion.

Plantar Flexion Strength. All 30 patients treated and seen at follow up at two of our hospitals underwent isometric strength examination of both legs. The group consisted of 15 patients sutured with the CSSS technique and 15 with the Mason technique. The results are shown in Table 1. There were no statistically significant differences between the two repair techniques. The strength index, at 15° dorsiflexion, correlated to the separation shown in Figure 5. The coefficient was close to zero and nonsignificant. The results at 15° plantar flexion showed the same pattern, with a nonsignificant correlation with a coefficient close to zero, and the results at 30° plantar flexion showed a positive, but nonsignificant coefficient (R = .33).

We found no significant difference in the strength reduction between the three ankle positions.

Patients with none or only a small reduction in ROM seem to have a better plantar flexion strength in all ankle positions (Table 2), but we were unable to demonstrate this with statisti-
Table 1

<table>
<thead>
<tr>
<th>Technique</th>
<th>CSSS (N = 15)</th>
<th>Mason (N = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15° dorsiflexion</td>
<td>0.95 ± 0.03</td>
<td>0.91 ± 0.07</td>
</tr>
<tr>
<td>15° planar flexion</td>
<td>0.82 ± 0.07</td>
<td>0.88 ± 0.06</td>
</tr>
<tr>
<td>30° planar flexion</td>
<td>0.90 ± 0.06</td>
<td>0.91 ± 0.07</td>
</tr>
</tbody>
</table>

* mean ± standard error

**D I S C U S S I O N**

A marker study in human Achilles tendon was carried out by Nystöm and Holmlund. They placed markers in the tendon ends in 10 patients treated for acute Achilles tendon rupture, and found a time related separation identical to that in our study, and an end separation of 11 mm after 150 days. Nystöm and Holmlund made no attempt to relate the size of the separation to the clinical outcome, as Ejeskär and Iristam had done in their study of profundus tendon repair.

We found a biphasic separation with a primary separation between the time of operation and the 2 week follow up. A second separation phase was seen between 3.5 and 7 weeks postoperatively. This is in accordance with experimental studies in which the first phase of separation has been shown to take place the first 5 days after the operation. A phase of nonseparation follows until days 17 to 20, where a second phase of separation starts. After the 40th day no additional separation occurred.

The first phase of separation is explained by an edematous softening of the tendon ends which occurs in the histologic inflammatory phase. This softening permits some slackening of the suture. The second phase of separation is still in dispute. Studitsky has shown that 17 to 21 days are needed for complete regeneration and re-innervation of a muscle cell degenerated after a tenotomy. This paralysis could explain the nonseparation phase and the re-innervation after 17 to 21 days—the beginning of the second phase of separation.

Application of intratendinous-placed metal markers resulted in some sources of error. The distance between the markers and the film plate gave a magnification around 10% depending on whether the radiographs were taken with or without a leg cast. In this study the distance between the radiograph source and the film plate was fixed at 100 cm. Another source of error was due to incorrect focus. The majority of ruptures occurred in the area 3 cm to 7 cm above the calcaneus, but for practical purposes we chose to focus at the medial malleolus, aware of the magnification we caused. But all things considered, we believed that the errors concerning radiograph exposure were identical for both groups.

Another possible source of error was due to the tension in the repair. The tendon ends after rupture were as usual strongly frayed, and during the repair an abbreviation or elongation could accidentally arise. Because all ankles were immobilized in 25° planar flexion, different tension in the repairs might result. If a tendon was sutured short, and thus with increased tension, this could theoretically result in an increased primary separation during the inflammatory phase (0 to 5 days), where a marked decrease of the holding power of tendon by the suture occurs. Despite these sources of error, we believe the method with intratendinous-placed markers was usable to reflect the separation, and presumably the only usable method in...
human studies.

We used steel 3-0, although a 5-0 with a single knot is visible on radiograph through a circular plaster of Paris cast. It is sometimes difficult to cut markers short enough and prevent protrusion beyond the tendon surface. Negligence on this point probably caused dislocation of a marker observed in one patient.

**Correlation between marker separation and clinical outcome.** If a large marker separation expressed tendon elongation, then one would expect to find increased dorsiflexion and a peak torque occurring in a more dorsiflexed joint angle, which is not necessarily advantageous. Surprisingly, we found only one patient with reduction in plantar flexion and gain in dorsiflexion; this change could not be explained by a large separation. Overall, we could not statistically significantly correlate the separation and change in ankle movement.

We found no correlation between separation and the plantar flexion strength, measured by isometric strain gauge. As an expression of an elongation of the tendon, we had expected a positive correlation between marker separation and plantar flexion strength when the measurements were performed with a dorsiflexed ankle position. In the same way we had expected to possibly find a negative correlation when the measurements were performed at 30° plantar flexion; this expression of the peak torque occurred in a more dorsiflexed joint angle.

**Mason Versus CSSS Suture Technique.** Despite the fact that our laboratory tests have shown that the CSSS technique had significantly higher gap resistance than the Mason technique, this could not be demonstrated in the clinical study.

We found no clinical advantage to using the CSSS technique over the Mason technique, and find no reason to use this more extensive technique in Achilles tendon repair.

**CONCLUSION**

Despite failure to correlate the separation between sutured Achilles tendon ends to the clinical outcome, we believe that the method, with markers placed in the tendon ends, can give important information about what happens to tendons after suture when exposed to different circumstances (ie, early mobilization). Perhaps the error due to different tension in the repairs might be minimized in further studies. Also, we did not find any clinical advantage in using a stronger and more extensive suture technique. Consequently, we recommend a simple suture technique.

Finally, our results seem to indicate that none or only a small reduction in ROM results in a good plantar flexion strength.

**REFERENCES**


**Table 2**

<table>
<thead>
<tr>
<th>Ankle Position</th>
<th>Change in ROM</th>
<th>NS p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>15° dorsiflexion</td>
<td>0.87 ± 0.09</td>
<td>0.96 ± 0.04</td>
</tr>
<tr>
<td>15° plantar flexion</td>
<td>0.76 ± 0.05</td>
<td>0.91 ± 0.04</td>
</tr>
<tr>
<td>30° plantar flexion</td>
<td>0.84 ± 0.08</td>
<td>0.96 ± 0.05</td>
</tr>
</tbody>
</table>

* mean ± standard error