Dynamic Ultrasound as a Selection Tool for Reducing Achilles Tendon Reruptures

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Background: The optimal method of treatment for acute tendo-Achilles ruptures continues to be debated.

Hypothesis: The reported lower rerupture rate for operatively treated patients is an effect of tendon end apposition during the healing process, and patients in whom apposition can be demonstrated using ultrasound will have a similar rate of rerupture if treated nonoperatively.

Study Design: Cohort study; Level of evidence, 2.

Method: The authors reviewed all patients with an Achilles tendon rupture who were treated to a standard protocol during a 5-year period (2000-2005). Patients with a gap of 5 mm or more in equinus on ultrasound underwent surgery; those with a gap of less than 5 mm received nonoperative treatment. All patients were followed up to a minimum of 12 months.

Results: After exclusions, 125 patients were included: 67 treated operatively and 58 nonoperatively. There were 2 reruptures in the nonoperative group and 1 with surgery. There was no significant difference between the groups for any complication.

Conclusion: Reduction of rerupture and surgery risks may be possible using dynamic ultrasound case selection. Further studies are needed to show whether functional results are the same with surgical and nonsurgical treatment when dynamic ultrasound criteria are used for case selection.

Keywords: Achilles tendon; ultrasound; preselection tool; rerupture

Tendo-Achilles (TA) rupture is a common injury seen by orthopaedic surgeons. The injury follows sudden and forced ankle dorsiflexion and commonly occurs in men between the ages of 30 and 50 years.

The management of this injury has remained controversial, with comparative studies suggesting that surgical repair reduces the rate of rerupture.[2,5,18,20] Surgical intervention, even with local anesthesia and percutaneous techniques, has an increased complication rate.[2,3,5,18,20,26] Therefore, cast and splint techniques are used and preferred for the elderly and sedentary patient and those with significant medical comorbidities.

Ultrasound may be used to confirm a TA rupture and identify the location of the injury within the tendon.[14,15] However, its role in assessing tendon gap closure in plantar flexion to select the method of treatment for an acute TA rupture has not been widely reported.

We hypothesized that the reported lower rerupture rate for operatively treated patients is an effect of tendon-end apposition during the healing process and that patients in whom apposition in equinus can be demonstrated using ultrasound will have a similar rate of rerupture if treated nonoperatively.

Since January 2000, our unit's protocol was that all patients with a residual gap in the TA of 5 mm or more with the foot in equinus were assigned to receive surgical repair; those patients in whom the tendon ends were apposed or less than 5 mm apart in equinus were treated nonoperatively.

This study was designed to assess the role of dynamic ultrasound as a selection tool in the management of TA rupture.

PATIENTS AND METHODS

During a 5-year period (January 2000-January 2005), all patients referred to our institution with clinical suspicion of an acute TA rupture (fewer than 7 days from the injury) were eligible for inclusion in this prospective protocol-driven study. Daily trauma clinics with a specialist orthopaedic surgeon allowed review of all patients referred from the emergency department the day after injury. Those referred from outside sources were assessed within a few days of injury.

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Ultrasound

Patients meeting the inclusion criteria underwent dynamic ultrasound by a specialist in musculoskeletal radiology on the next available list. At ultrasound, clinical suspicion of a TA rupture was confirmed. The location of the rupture, together with measurement of the gap between the tendon ends, were recorded with the foot in the resting position (static technique). The foot on the injured side was then moved into as much plantar flexion as pain allowed (dynamic technique). The gap between the tendon ends was recorded and compared with that measured in the resting position. The site of rupture was marked on the skin. The patients returned to the trauma clinic the next day for a decision on the method of treatment.

Protocol

Treatment was based on the following protocol. Those patients with a gap between the tendon ends of 5 mm or more (dynamic technique) received operative treatment. When the tendon ends apposed or the dynamic gap was measured as less than 5 mm, the patient received nonoperative treatment (Figure 1). All patients were informed of the advantages and disadvantages of each treatment method. Only 4 patients declined the recommended treatment; all had been recommended nonoperative treatment.

The choice of open or percutaneous repair was made by the patient after an informed discussion with the operating surgeon. Surgical repair was performed as soon as possible by or under the direct supervision of the orthopaedic surgeon. Standard approach and techniques were used for both procedures.[3,5,18,20,26] Postoperatively, the patients were ambulated nonweightbearing on the injured side and discharged within 24 hours. Those patients treated nonoperatively were placed in a below-knee plaster cast with the foot in full plantar flexion to ensure tendon-end apposition.

Rehabilitation

Both groups received the same rehabilitation program.[22] A nonweightbearing equinus cast was applied for the first 3 weeks, and a below-knee removable cast in 10° to 15° of equinus with a heel block was applied from 3 to 6 weeks. This was subsequently changed to a removable commercial ankle boot with an insole heel-raise. Ambulation on the affected side was as follows: first 3 weeks, nonweightbearing; 3 to 6 weeks, touch weightbearing; 6 to 8 weeks, partial weightbearing to a maximum of 40 lb; and after 8 weeks, full weightbearing. Patients were ambulated under the guidance of our physical therapy department and commenced active ankle joint motion from 3 weeks leading to a progressive strengthening rehabilitation program.

Follow-Up

Patients who received operative treatment were reviewed 2 weeks after surgery for wound inspection and removal of stitches. All patients attended follow-up at 3, 6, and 8 weeks and reattended at 4 and 6 months after injury. Where progression was satisfactory (no pain, full weightbearing unaided, resolution of any complication, return to preinjury occupation), patients were discharged from the trauma clinic at 6 months. Follow-up was continued with the physical therapy department with a final review at 12 months. Any patient in whom there was a complication or less than expected progress was referred back to the trauma clinic for review by the treating orthopaedic surgeon. Return to sports was allowed after 6 months at the earliest.

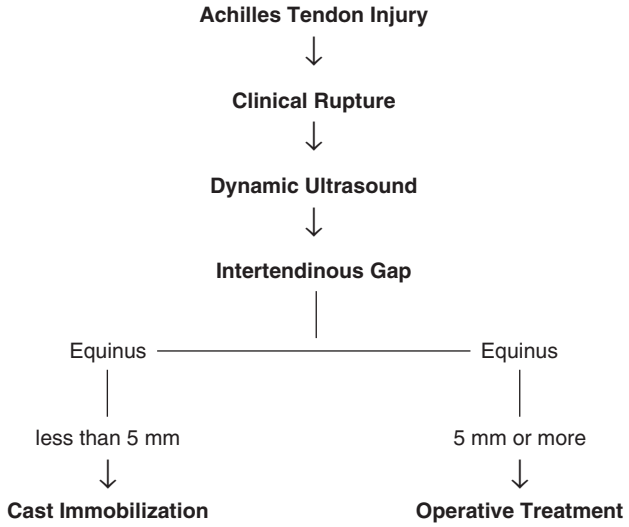

Figure 1. The protocol used to determine the treatment method.

Exclusion Criteria

Patients assessed more than 7 days after injury and those with a previous TA rupture on the same side or preexisting TA pain were excluded at the outset of this study. Patients in whom the ultrasound showed only a partial rupture, a musculotendinous junction rupture, or a muscular tear and those who did not follow the recommended treatment path were excluded, but their outcomes were monitored.

Data

The recorded data included clinical findings and mechanism of injury, ultrasound scan measurements of tendon gap in the resting (static) and equinus (dynamic) foot positions, and the distance of the rupture from the TA insertion. The complications in the operative and nonoperative treatment groups, in particular rerupture, were compared.

Analysis of Results

The proportion of patients experiencing complications in each treatment group were independently analyzed using the Fisher exact test. This test was selected (as opposed to the χ^2 test) because of the low complication events in both groups. The groups were compared with respect to age, sex, and

mechanism of injury using the 2-sample *t* test for age and the χ^2 test for other variables.

RESULTS

There were 156 patients with a suspected acute TA rupture who underwent ultrasound assessment. Of these, 5 patients had no rupture, 15 had tears at the musculotendinous junction, 7 were shown to have only a muscle tear, and 4 patients declined the recommended treatment. The results of these patients were not analyzed. The number of patients entered into the study was therefore 125, composed of 88 men and 37 women. There were 67 patients in the operative group (37 open and 30 percutaneous repairs) and 58 in the nonoperative group. No patients were lost to follow-up, either at 6 months from the trauma clinic or at 12 months from the physical therapy department.

There was no statistically significant difference between the 2 treatment groups for any of the following variables. The mean age of the nonoperative group was 43.9 years (range, 26-85 years) and 41.0 years (range, 26-80 years) for the operative group ($P = .14$). The gender distribution between the 2 groups was as follows: female patients, 18 nonoperative and 19 nonoperative ($P = .74$); male patients, 40 nonoperative and 48 operative ($P = .74$). The activity at the time of rupture for the nonoperative versus operative groups was as follows: sport, 45/58 (77.6%) versus 52/67 (77.6%; $P = 1.0$); walk/fall, 13/58 (22.4%) versus 14/67 (20.9%; $P = .84$). The 1 remaining patient in the operative group sustained a TA rupture while running to cross a road. Badminton and squash were the sports played at the time of rupture in approximately 60% of the patients in both treatment groups.

The complications are shown in Table 1. In the nonoperative group, there were 2 reruptures in 58 patients (3.4%) occurring at 9 and 11 weeks, respectively; there was 1 deep vein thrombosis (1.7%). There was 1 rerupture in the operative group (1.5%), which occurred 4 weeks after percutaneous repair. This was treated with an open repair. Two patients who had open repair had a superficial wound infection that resolved with oral antibiotic treatment. Two patients treated by percutaneous repair complained of numbness in the area of skin supplied by the sural nerve. This fully recovered in both within 6 months. In each treatment arm, there was 1 patient with chronic pain over the TA itself; no causes were identified.

None of the *P* values were significant at the 5% level (Table 2), indicating that there was evidence of no difference in the rerupture rate or any of the other complications between the 2 treatment groups.

TABLE 1
The Complications in the Operative and Nonoperative Groups

Complication	Operative	Nonoperative
Rerupture	1/67	2/58
Chronic pain	1/67	1/58
Numbness (sural nerve)	2/67	0/58
Superficial wound infection	2/67	0/58
Calf deep vein thrombosis	0/67	1/58

DISCUSSION

Injury to the TA is commonly caused by sudden and forced movement at the ankle joint, often during sports activities.[10] The diagnosis of a TA rupture is based on patient history and physical examination. Ultrasound may be used to confirm the diagnosis and to monitor tendon healing.[4,14,15] A large gap in the tendon leads to increased scar tissue, which is characterized by poor tensile strength. This may increase the risk of rerupture.[2,8]

The current literature considers the main advantage of operative repair to be the reduced rate of rerupture.[2,5,8,9,18,20,22,26] This difference has been attributed to the greater strength of the repair with surgery. In a multicenter prospective randomized trial of 112 patients, Moller et al[18] reported a rerupture rate of 20.8% (11/53 patients) for the nonoperative group and 1.7% (1/59) for those treated with surgery. A criticism of this study is that identical rehabilitation programs were not employed for both treatment groups. In a review of the literature, Popovic and Lemaire[21] and Wong et al[28] concluded that lower rerupture rates were to be expected with surgical repair. Lo et al[13] performed a meta-analysis on 17 observational and 2 randomized studies, reporting pooled rerupture rates of 11.7% (nonoperative) and 2.8% (operative). In a review of prospective randomized trials, Bhandari et al[1] reported pooled rerupture rates of 13% (nonoperative) and 3.1% (operative). Recently, Khan et al[11] performed a meta-analysis on 12 randomized controlled trials comparing the rerupture rate between operative and nonoperative interventions. They reported that operative treatment was associated with a significantly lower risk of rerupture (relative risk, 0.27), with pooled rates of 3.5% (operative) and 12.6% (nonoperative).

The poor results of nonoperative treatment in the literature may be related to the random allocation of patients into treatment groups and poorly defined selection criteria. Some patients in the nonoperative groups of these studies would not have had tendon apposition at any time. Evidence of this can be found in our study; of 125 patients, 67 were treated operatively because of lack of tendon apposition.

Using ultrasound to determine which treatment the patient receives has been addressed in only 2 prospective and 1 retrospective study.[7,24,27] Our study benefits from much greater patient numbers. We have consistently used, and as unit policy, a gap in the TA of 5 mm or more on ultrasound with the ankle in plantar flexion as the threshold for operative treatment. Five millimeters was chosen based on a previous study in our unit[26] in which ultrasound was routinely performed but not used as a treatment selection tool. Because of the irregular and variable tendon-end appearance on ultrasound, we determined that a 5-mm gap would reliably confirm nonapposition. A gap of 5 mm was also used for treatment selection by Thermann et al[24] and more recently by Weber et al.[27]

TABLE 2
P Values for Each Complication When Comparing the 2 Treatment Methods

Outcome	Operative Group, % (n = 67)	Nonoperative Group, % (n = 58)	Difference	95% Confidence Interval	*P*
Rerupture	1.5	3.4	–1.9	–7.5 to 3.6	.60
Chronic pain	1.5	1.7	–0.2	–4.7 to 4.2	.72
Numbness	3.0	0	3.0	–1.1 to 7.1	.50
Wound infection	3.0	0	3.0	–1.1 to 7.1	.50
Deep vein thrombosis	0	1.7	–1.7	–5.0 to 1.6	.46

Thermann et al[24] reported on 50 patients (28 nonoperative and 22 surgical) randomized to receive treatment based on ultrasound, reporting similar results for each group with no reruptures. The results were published in the German literature in 1995, but the exact methodology was considered unclear in a Cochrane review.[10] This may explain why this article has not led to a change in practice. Eylon et al[7] used ultrasound in a different way to distinguish between a partial- and full-thickness Achilles tendon tear. Patients with a partial musculotendinous junction or proximal muscle tear were treated nonoperatively. Those with a full tendon rupture underwent operative repair.

Weber et al[27] retrospectively reviewed 47 patients, 24 operative and 23 nonoperative, treated in sequential groups from 1993 to 1998. They reported a rerupture rate of 5.3% (1/19) and 17% (4/23) for the operative and nonoperative groups, respectively. However, ultrasound was used to select only the nonoperative group, as the operative group was previously treated. The authors found only 1 patient in whom tendon apposition to less than 5 mm was not possible. In our study, apposition was not achieved in 54% (67/125) on ultrasound.

Our study, composed of 125 patients (67 operative and 58 nonoperative), demonstrated 1 rerupture in the operative group and only 2 reruptures for patients treated nonoperatively when using ultrasound to select treatment. The rerupture rate of 3.4% in the nonoperative group is comparable with the results of most operative series. The number of patients in our study is large in comparison with most studies reporting on TA ruptures but, more significant, is much larger than the published literature using ultrasound to determine treatment. Patients were followed up to a minimum of 12 months; no patients were lost to follow-up. In previous comparative studies, all reruptures occurred within the first 18 weeks.[14,23]

Previous randomized controlled studies comparing operative and percutaneous repair have shown no significant difference in rerupture rate.[6,12] Recently, Cretnik et al[6] compared complications between operative and percutaneous methods of treatment. They reported no significant difference in the rerupture rate between the 2 groups (2.8% operative vs 3.7% nonoperative). Placing both percutaneous and open repairs into the operative treatment arm of our study is therefore reasonable.

Comparisons of functional outcome of treatments have been addressed previously in the literature.[2,17,18] Cetti et al[2] reported that operatively treated patients had a significantly higher rate of resuming sports activities, less calf atrophy, and better ankle movements at 1-year follow-up. More recently, Moller et al[17,18] found no significant difference between patients receiving operative or nonoperative interventions with regard to time to return to work, resuming sports, range of active ankle movements, endurance testing, and isokinetic strength measurements. Our study focused on the rerupture rates; therefore, functional outcome measures (push-off strength, range of movement, and return to sport) and patient satisfaction were not assessed. Functional outcome assessment would be valuable when planning future studies.

Factors that may influence the rerupture rate include age of the patient, the rehabilitation program, and the method and quality of the diagnostic examination. In our study, there was no significant difference with respect to age or mechanisms of injury. In a single-surgeon study using a combined nonoperative and orthotic treatment protocol, Wallace et al[25] reported only 3 reruptures out of 145 (2%). Ultrasound was not used to confirm the diagnosis of either acute rupture or rerupture. It is to be noted that in addition to the 3 complete reruptures, there were 5 "partial" reruptures diagnosed clinically. In contrast, in our study, ultrasound was used to confirm all diagnoses to avoid bias and to exclude musculotendinous ruptures. Early functional rehabilitation has been shown to be safe and beneficial for tendon healing[16,19]; we adopted a modification of the recognized Sheffield regimen.[15,17,20] Because all patients in our study received the same accelerated functional rehabilitation regardless of treatment, we consider achieving the low rerupture rate in the nonoperative group an effect of appropriate patient selection by dynamic ultrasound.

Variability in ultrasound reporting was minimized by using a limited number of specialist musculoskeletal radiologists working to an agreed protocol, but it remains observationally subjective. Gap measurements were computed directly on the real-time scan image. We are therefore confident of the accuracy of ultrasound. Early availability of ultrasound examination may be difficult to achieve in some trauma departments. The allocation of patients into 1 of the treatment groups was always made after consultation with a specialist orthopaedic surgeon. These measures ensured accuracy of application of our selection criteria and allowed us to reliably assess the relationship between ultrasound and rerupture rates.

Our study showed no statistical difference in rerupture rates between the operative and nonoperative groups. The

point estimate for the difference indicates only a 1.9% lower rerupture rate in the operative group compared with the nonoperative group (confidence interval, –7.5 to 3.6). To detect a reduction in the pooled rerupture rate from 12.6% of previous studies to 3.5% (equivalent to pooled rate for operatively treated cases),[11] 144 patients would be required in the nonoperative arm of a study for a 5% significance level and a power of 80%. The power of our study is therefore 40%. This number of patients would exceed all previous studies on the management of acute TA ruptures. Our study, comprising 125 patients, ran during a 5-year period. Although ours is one of the larger published studies, a study of higher power would now be appropriate.

A previous randomized controlled trial by Webb (unpublished data, 2000) from our unit compared nonoperative and operative outcomes. This study was primarily reviewing percutaneous repair and did not use ultrasound as a selection tool, but nevertheless, the results offered a historical control for our study. Webb reported a rerupture rate of 10.8% for patients treated nonoperatively, compared with 3.4% for the present study.

We hypothesize that operative repair only results in a greater tensile strength initially, and this advantage will not be maintained long term providing there is tendon apposition during the healing process. Furthermore, a surgical repair has the potential for nerve injury, chronic wound pain, and the uncommon but significant complication of deep infection. Consideration must also be given to the increased costs relating to hospital admission and the risks of anesthesia.

A limitation of the study is its prospective comparative design as opposed to a randomized trial in which one cohort receives ultrasound as a selection intervention and the other cohort receives treatment based on randomization. Given the published rerupture rates in the literature from randomized controlled trials and meta-analyses, it would be difficult to secure ethical approval for such a study. As a result of our study, there is now an argument for randomizing patients with tendon apposition on ultrasound into operative and nonoperative treatment. This position is only borne of the knowledge from this study. In addition, functional outcome has not been addressed and would be a consideration when choosing between the 2 treatment options.

In this study, the selection of treatment method was based solely on whether apposition was determined by the diagnostic ultrasound intervention. Our results demonstrate evidence of no difference in rerupture rates between the 2 treatment groups and suggest that the high rerupture rates for nonoperative treatment reported in the literature may be related to lack of tendon apposition during the healing process. There was, however, a lower rate of rerupture in the operative group. A study of higher power is needed to draw any definite conclusions on the use of dynamic ultrasound as a selection tool. Given that almost 300 patients would be required to obtain a power of 80%, a multicenter trial using dynamic ultrasound for treatment selection is clearly now appropriate.

Continuing data collection will address the limitations, but the conclusion has been drawn that selecting patients to receive nonoperative treatment using dynamic ultrasound may help reduce the risk of rerupture.

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