Surgical Versus Nonsurgical Treatment of Acute Achilles Tendon Rupture

A Meta-Analysis of Randomized Trials

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Background: Surgical repair is a common method of treatment of acute Achilles rupture in North America because, despite a higher risk of overall complications, it has been believed to offer a reduced risk of rerupture. However, more recent trials, particularly those using functional bracing with early range of motion, have challenged this belief. The aim of this meta-analysis was to compare surgical treatment and conservative treatment with regard to the rerupture rate, the overall rate of other complications, return to work, calf circumference, and functional outcomes, as well as to examine the effects of early range of motion on the rerupture rate.

Methods: A literature search, data extraction, and quality assessment were conducted by two independent reviewers. Publication bias was assessed with use of the Egger and Begg tests. Heterogeneity was assessed with use of the I^2 test, and fixed or random-effect models were used accordingly. Pooled results were expressed as risk ratios, risk differences, and weighted or standardized mean differences, as appropriate. Meta-regression was employed to identify causes of heterogeneity. Subgroup analysis was performed to assess the effect of early range of motion.

Results: Ten studies met the inclusion criteria. If functional rehabilitation with early range of motion was employed, rerupture rates were equal for surgical and nonsurgical patients (risk difference = 1.7%, p = 0.45). If such early range of motion was not employed, the absolute risk reduction achieved by surgery was 8.8% (p = 0.001 in favor of surgery). Surgery was associated with an absolute risk increase of 15.8% (p = 0.016 in favor of nonoperative management) for complications other than rerupture. Surgical patients returned to work 19.16 days sooner (p = 0.0014). There was no significant difference between the two treatments with regard to calf circumference (p = 0.357), strength (p = 0.806), or functional outcomes (p = 0.226).

Conclusions: The results of the meta-analysis demonstrate that conservative treatment should be considered at centers using functional rehabilitation. This resulted in rerupture rates similar to those for surgical treatment while offering the advantage of a decrease in other complications. Surgical repair should be preferred at centers that do not employ early-range-of-motion protocols as it decreased the rerupture risk in such patients.

Level of Evidence: Therapeutic <u>Level I</u>. See Instructions for Authors for a complete description of levels of evidence.

The Achilles tendon is the most commonly ruptured tendon in the body[1]. Risk factors for primary acute rupture include male sex, use of steroids or fluoroquinolones, and prior rupture on the contralateral side. Diagnosis is made on the basis of a palpable gap and a positive Thompson test. If the physical examination is equivocal, ultrasonography or magnetic resonance imaging can be used to confirm the diagnosis[2-4].

Treatment options for acute Achilles tendon rupture include nonsurgical and surgical management. If the treating physician opts for nonsurgical treatment, the patient is treated nonoperatively in a cast, cast-boot, or splint with the foot placed in plantar flexion, with or without early physiotherapy. Surgical options include open, minimally invasive, and percutaneous repair of the tendon[5].
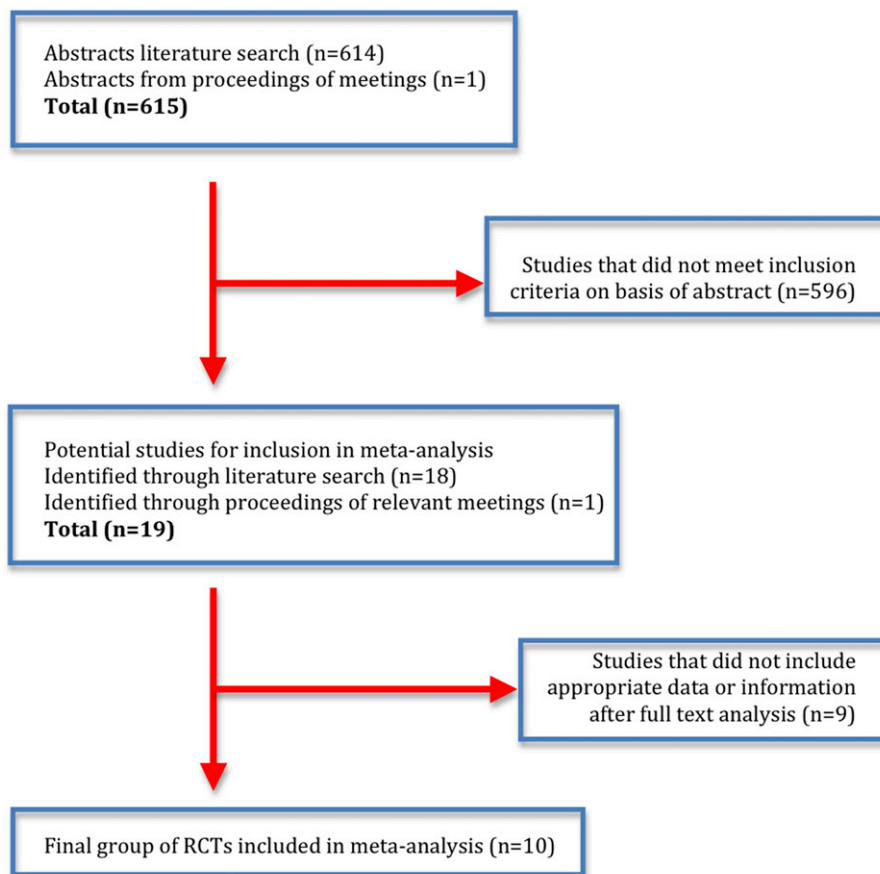
Fig. 1

Literature search strategy and results. RCT = randomized controlled trial.

Advocates of nonsurgical treatment argue that the tendon apposition achieved by keeping the foot in plantar flexion is sufficient to allow adequate healing of the ruptured tendon. In theory, healing is achieved without the high complication risk associated with surgical treatment. Major complications secondary to surgical treatment of acute Achilles tendon rupture occur in up to 10% of cases and include deep infection, skin necrosis, tendon necrosis, and a draining sinus. The prevalence of minor complications is also substantial, with up to 15% of patients developing skin problems. However, despite these concerns, surgical repair of acute Achilles tendon rupture remains a common treatment in North America[2-6].

The majority of surgeons who choose to repair Achilles tendon ruptures do so because nonsurgical treatment has been thought to be associated with an unacceptable rate of rerupture. In fact, according to some studies, the rerupture rate following nonsurgical treatment is as high as 10% to 12%. Surgery, on the other hand, lowers the rate to <3%. The surgical repair of acute Achilles tendon rupture has been further supported by an expected-value decision analysis study[7]. Thus, the risk of complications associated with surgery has appeared to be an acceptable trade-off for patients and surgeons who pursue surgical treatment[2-5].

Traditionally, the affected limb has been immobilized for a minimum of six to eight weeks prior to starting range-of-

motion exercises; this is intended to protect the surgical repair (if surgical treatment is chosen) or to maintain tendon apposition (if nonsurgical treatment is chosen). However, more recently, functional bracing and modified postoperative regimens allow patients to perform daily active plantar flexion exercises as soon as ten days following injury. This is thought to stimulate tendon-healing, and it may lower the rerupture rate that is typically associated with nonsurgical treatment[8].

Two previous meta-analyses of randomized and pseudo-randomized trials comparing surgical with nonsurgical treatment have already been published, with the latest one including studies up to 2004[9,10]. The authors concluded that although surgical treatment significantly reduced the risk of rerupture of the tendon, it also led to a higher rate of other complications. However, since the latest of the two previously published meta-analyses, several additional randomized controlled clinical trials have sought to clarify the best treatment for acute Achilles tendon rupture[11-13]. These trials, particularly those using functional bracing, have challenged the conclusions of the previous meta-analyses. Because of the conflicting results in the current body of literature, a reexamination of the evidence is needed to take into consideration the new trials. The aim of the present meta-analysis was to compare surgical with nonsurgical treatment with regard to the rerupture rate, overall rate of other
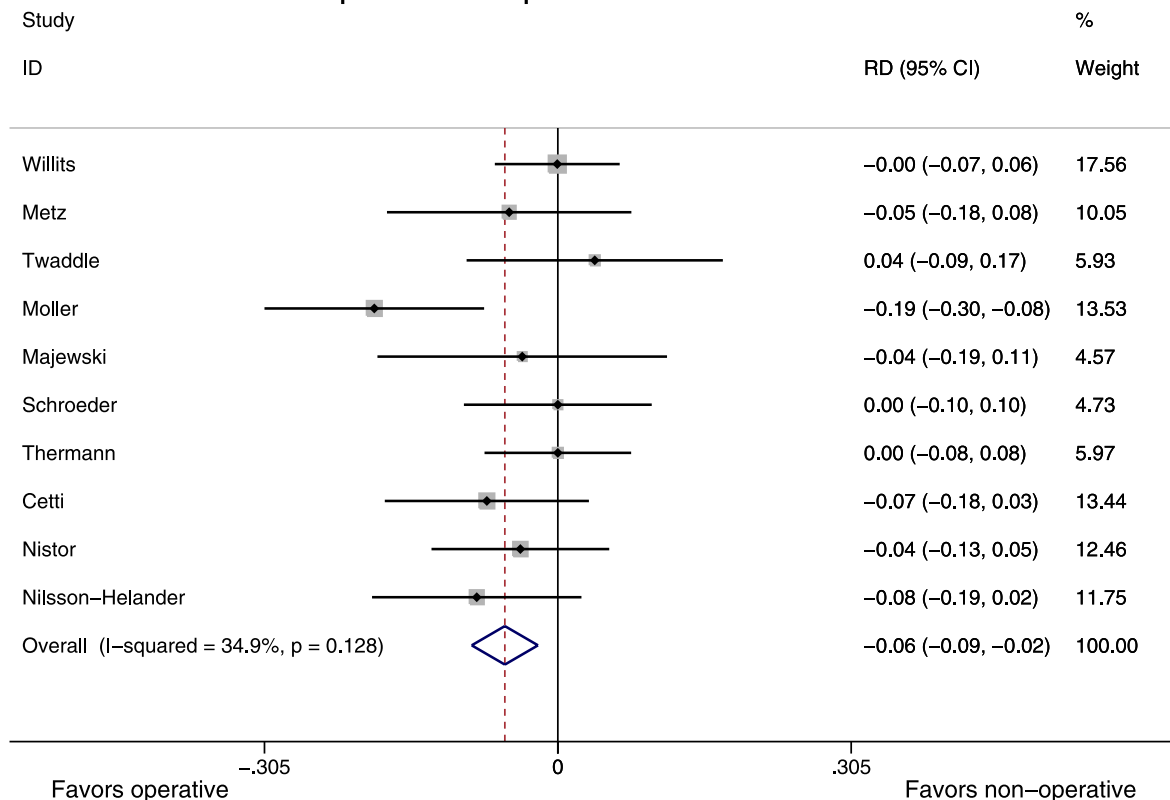
Fig. 2

Pooled results for the rerupture rate; results favoring operative intervention are plotted on the left. The risk difference between the two groups was 0.055, or 5.5%, in favor of surgery (p = 0.002). RD = risk difference, and CI = confidence interval.

complications, return to work, strength, calf circumference, and functional outcomes, as well as to explore the effects of early range of motion on the rerupture rate.

Materials and Methods

Study Selection

Two reviewers independently searched the most commonly used medical databases (Cochrane Central Register of Controlled Trials, MEDLINE, Web of Science, and Embase) from January 2005 through December 2011, using the search strings "Achilles tendon"[MeSH] OR "achilles"[tw] OR "tendoachilles"[tw] OR "calcaneal"[tw] OR "calcanean"[tw] OR "calcaneus"[tw] AND "rupture"[MeSH] OR "rupture"[tw] OR "ruptures"[tw] OR "ruptured"[tw] OR "lesion"[tw] OR "lesions"[tw] OR "tear"[tw] OR "tears"[tw] and random*. We also scanned the reference lists of the included articles for additional articles that met the inclusion criteria, and we searched proceedings of relevant meetings from 2005 to 2011 to identify unpublished reports.

We included studies of patients with acute Achilles tendon rupture from any cause. All randomized controlled trials comparing surgical intervention with non-surgical treatment were considered for inclusion. For a study to be considered for inclusion, treatment had to have been initiated within three weeks of the rupture. Surgical treatment included open or minimally invasive techniques. Nonsurgical management included casting or splinting. There were no restrictions on inclusion on the basis of weight-bearing status or use of early range of motion. Trials that included patients with delayed presentation (beyond three weeks) and trials that included patients being treated for rerupture were excluded. Duplicate data were excluded. There were no language restrictions, and foreign-language papers were translated.

The quality of each study selected for inclusion was evaluated by two independent reviewers with use of the bias tool recommended by the Cochrane

Handbook for Systematic Reviews of Interventions, version 5.0.2[14]. We attempted to clarify any uncertainties in results or methodology by means of personal correspondence with the authors. Because all of the included studies were randomized controlled trials of similar methodological quality, they were not weighted on the basis of methodology.

Data Extraction and Outcome Measures

Data were extracted independently by two reviewers with use of standardized extraction forms. The primary outcome of interest was the rerupture rate. Secondary outcomes included the rate of other complications, strength, range of motion, time to return to work, calf circumference, and functional outcomes.

Statistical Analysis

If the standard error was not reported, it was imputed with use of the technique described by Ma et al.[15]. If neither the mean nor the standard error was reported, these were imputed from the median and range with use of the technique described by Hozo et al.[16]. Publication bias was assessed with use of the Begg and Egger tests. These tests examine funnel plot asymmetry and the adjusted rank correlation to determine the presence of publication bias. Dichotomous variables were expressed as the risk difference or the risk ratio. Continuous data were reported as the weighted mean difference (for outcomes measured with use of a single scale) or as the standardized mean difference (for outcomes measured with use of different scales). Heterogeneity across the combined data was assessed with use of the I^2 test. A p value of <0.15 on the I^2 test was considered an indicator of significant heterogeneity. Pooled summary statistics were calculated with use of a fixed-effect model if heterogeneity was not significant or with use of a random-effect model if heterogeneity was significant. Differences were considered significant if the p value was <0.05. Meta-regression and subgroup analysis were employed to assess factors responsible for heterogeneity of the primary outcome.
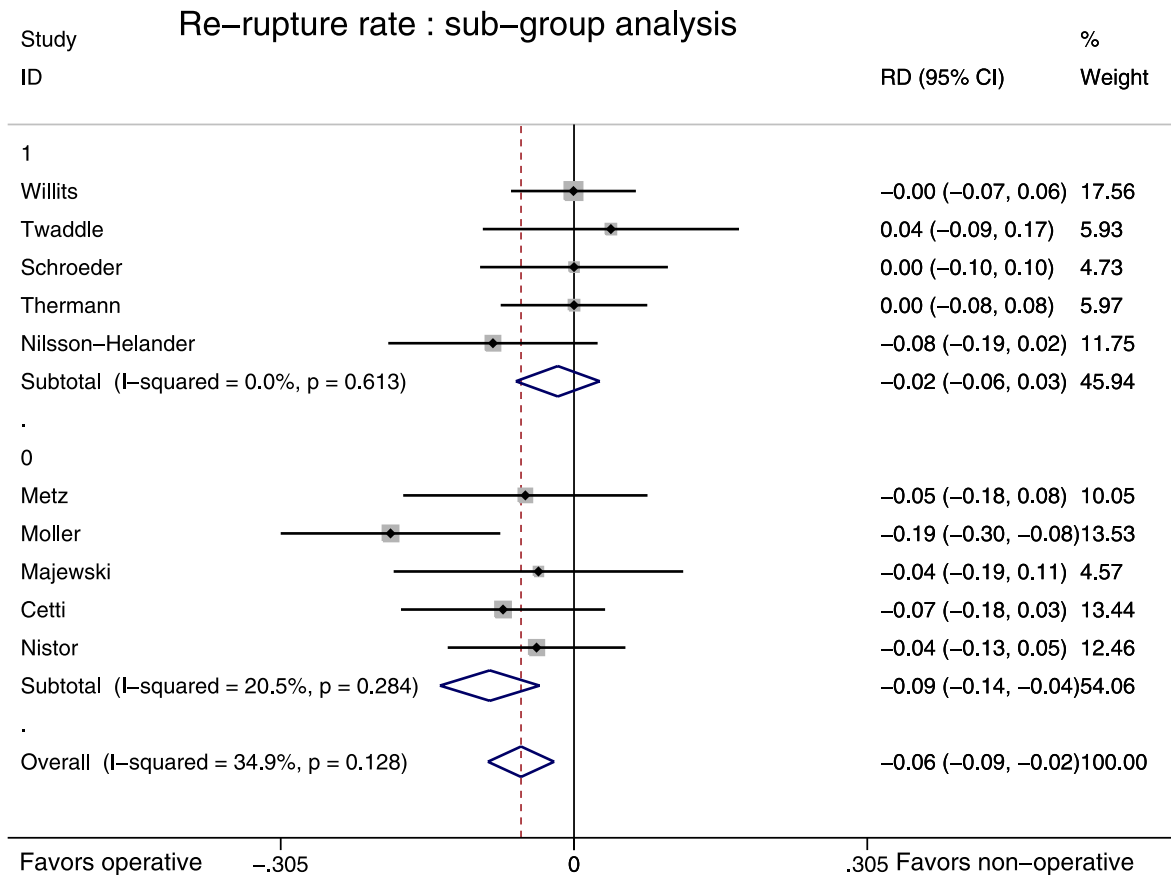
Fig. 3

Pooled results for the subgroup analysis of the rerupture rate; results favoring operative intervention are plotted on the left. The upper portion of the figure shows a significant difference in the trials that did not use early range of motion, whereas the lower portion shows that there was no significant difference in the trials that used early range of motion. RD = risk difference, and CI = confidence interval.

Source of Funding

Results

Studies and Baseline Patient Characteristics

Our search of the databases yielded a total of 614 articles, and one additional study was indentified through scanning of conference proceedings and has since been published. All abstracts were examined, and 596 were considered to not meet the inclusion criteria. A total of nineteen studies were considered for inclusion and the full text was obtained. After consideration of the entire article, ten studies were considered to meet the inclusion criteria (Fig. 1)[11-13,17-23].

Baseline patient characteristics are presented in the Appendix. The ten selected studies included 418 patients who were treated surgically and 408 patients who underwent nonsurgical treatment. The patients were predominantly male, and the mean age in each patient group was 39.8 years.

Rerupture

All ten of the studies reported the rerupture rate[11-13,17-23] (Fig. 2). The pooled results show that the absolute risk difference between the groups was 5.5% in favor of surgery (p = 0.002). This cor-

responded to a risk ratio of 0.4 in favor of surgery. Of note, there was significant heterogeneity among the studies (p = 0.13 for the I^2 test). The number needed to treat (the number of patients who would need to be treated in order to prevent one rerupture) was eighteen patients.

Since there was significant heterogeneity among the studies, factors that were potentially responsible for the heterogeneity were explored with use of meta-regression. The use of functional rehabilitation was a significant cause of heterogeneity (p < 0.05). The other factors that were considered (study size, duration of follow-up, and year of publication) were not significant. A stratified analysis of rerupture rates according to functional rehabilitation was therefore performed (Fig. 3).

The results of the stratified analysis showed that if a functional rehabilitation protocol with early range of motion was used, surgical treatment and nonsurgical treatments were equivalent with regard to the rerupture rate (absolute risk difference = 1.7%, p = 0.45), suggesting that no absolute risk reduction was achieved by performing surgery. However, if the treatment protocol used after the rupture included prolonged immobilization, the absolute reduction in the rerupture risk obtained by surgical intervention was 8.8% (p = 0.001). These results suggest that surgical and nonsurgical treatments were

Complications : pooled results

Study ID		RD (95% CI)	% Weight
Willits		0.07 (0.01, 0.13)	12.41
Metz		−0.15 (−0.34, 0.04)	10.21
Moller		0.18 (0.08, 0.29)	11.80
Majewski		0.10 (−0.04, 0.25)	11.15
Schroeder		0.07 (−0.06, 0.20)	11.40
Thermann		0.15 (−0.03, 0.32)	10.58
Cetti		0.12 (−0.04, 0.28)	10.93
Nistor		0.69 (0.55, 0.83)	11.34
Nilsson–Helander		0.22 (0.02, 0.41)	10.18
Overall (I–squared = 90.1%, p = 0.000)		0.16 (0.03, 0.30)	100.00

NOTE: Weights are from random effects analysis

Favors operative   −.825   0   .825   Favors non–operative

Fig. 4
Pooled results for the rate of complications other than rerupture; results favoring operative intervention are plotted on the left. The risk difference was 15.8% in favor of nonsurgical treatment. RD = risk difference, and CI = confidence interval.

equivalent with regard to rerupture if the protocol after the rupture included early range of motion. However, if functional rehabilitation was not employed, surgical repair reduced the absolute rerupture risk by 8.8% and the number needed to treat was therefore twelve patients. Of note, the studies within each subgroup did not show any further evidence of significant heterogeneity (p = 0.61 for the I^2 test in the functional rehabilitation group and p = 0.28 in the casting group).

Other Complications
Nine studies reported the total rate of complications other than rerupture[12,13,17-23] (Fig. 4). Complications included deep and superficial wound infections, skin and tendon necrosis, fistulas, scar adhesion, sural nerve damage, decreased ankle motion, overlengthening of the tendon, deep venous thrombosis, and pulmonary embolus. The meta-analysis indicated that the risk difference was 15.8% in favor of nonsurgical treatment (p = 0.016). This translated into a risk ratio of 3.897, and one additional complication other than rerupture could be expected for every seven patients treated surgically.

Time to Return to Work
Four studies reported the time to return to work, expressed as days until work was resumed[17,19,22,23] (see Appendix). Fixed-effect

analysis showed that, on average, patients whose Achilles tendon rupture was repaired surgically returned to work 19.16 days earlier than patients who underwent nonsurgical treatment (95% confidence interval [CI], 3.9 to 34.0; p = 0.0014).

Range of Motion
Three studies reported the range of ankle motion, expressed as the difference in plantar flexion (in degrees) compared with the contralateral side[11,13,19] (Fig. 5). Fixed-effect analysis showed that active plantar flexion relative to the contralateral side was 1.07° less in patients undergoing nonsurgical treatment (95% CI, 0.17° to 1.96°; p = 0.019). However, although these results were statistically significant, they do not represent a clinically important difference.

Calf Circumference
Three studies reported the calf circumference, expressed as the difference in circumference (in cm) compared with contralateral side[11,13,19] (see Appendix). Fixed-effect analysis showed no significant difference between the two groups (p = 0.357).

Strength
Six studies reported strength, which was expressed with use of different scales in each study[12,13,18-20,22] (Fig. 6). Random-effect

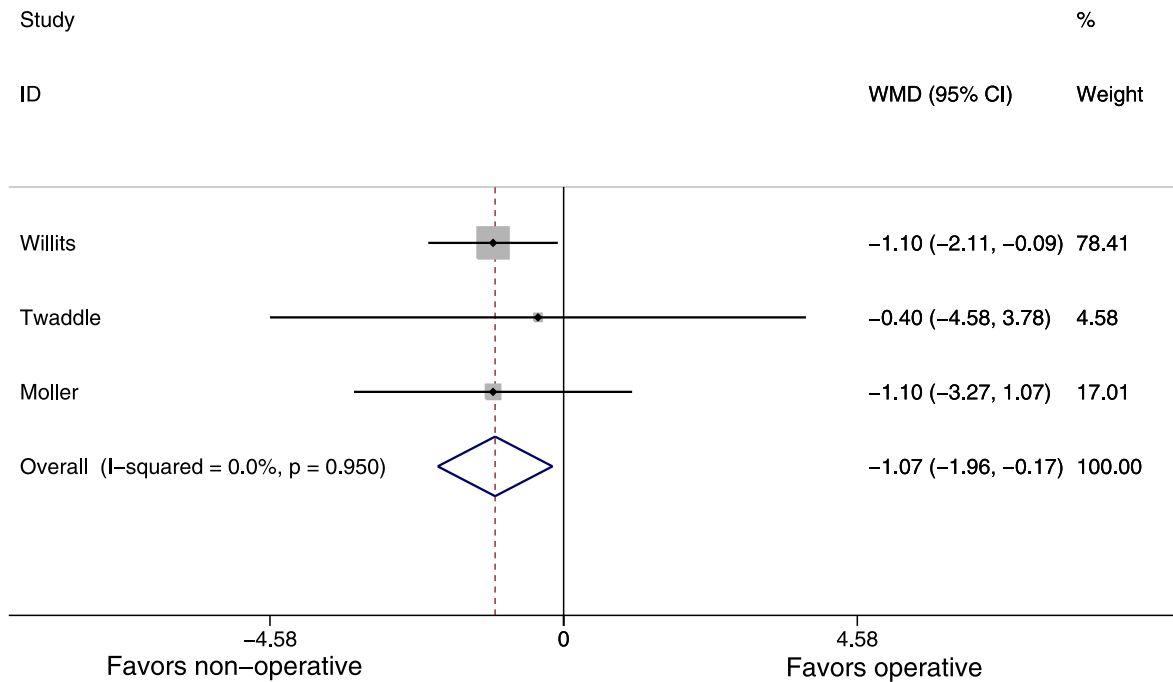## Range of motion : pooled results
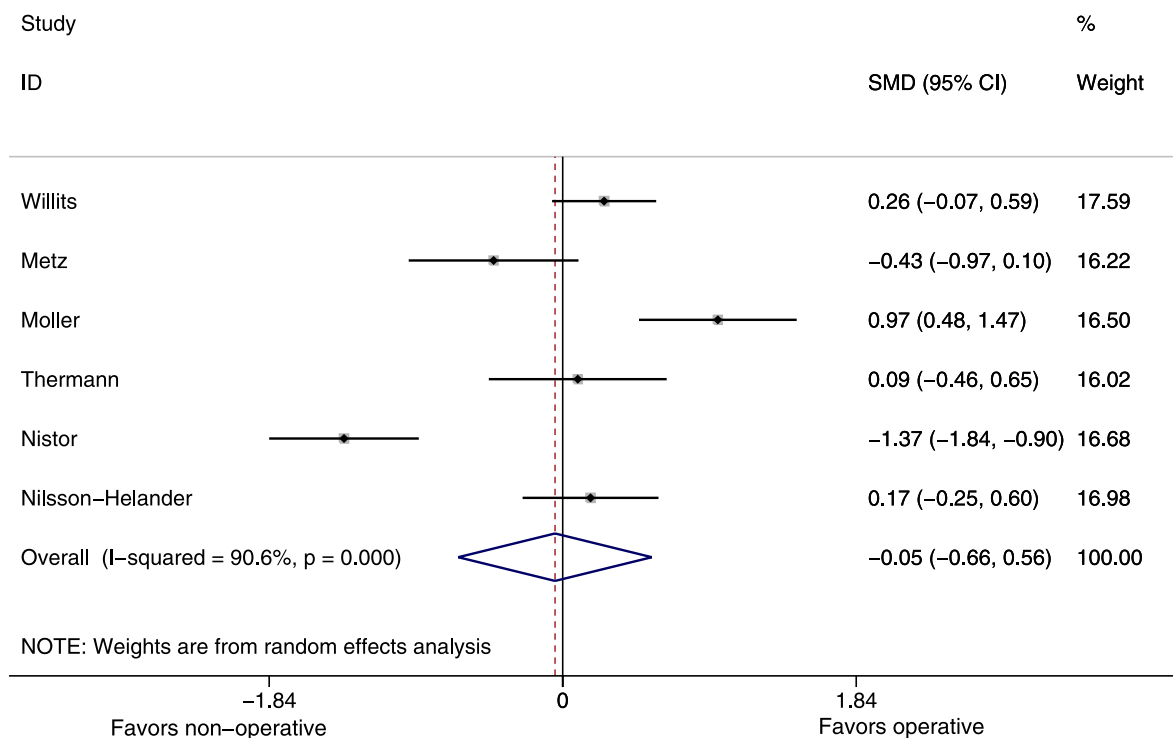

Fig. 5

Strength : pooled results

Fig. 6

Fig. 5 Pooled results for range of motion; results favoring operative intervention are plotted on the right. WMD = weighted mean difference, and CI = confidence interval. **Fig. 6** Pooled results for strength; results favoring operative intervention are plotted on the right. SMD = standardized mean difference, and CI = confidence interval.

analysis showed that the standardized mean difference did not differ significantly between the two groups (p = 0.806).

Functional Outcomes

Four studies reported functional outcomes, expressed with use of different scales (the Musculoskeletal Functional Assessment Instrument [MFAI], Functional Index for the Lower Leg and Ankle [FIL], Leppilahti score, and modified Leppilahti score) in each study[11,13,19,22] (see Appendix). Fixed-effect analysis showed that the standardized mean difference did not differ significantly between the two groups (p = 0.226).

Discussion

This study suggests that surgical treatment and nonsurgical treatment of acute Achilles tendon rupture were equivalent with regard to rerupture rate when the nonsurgical treatment protocol included early range of motion. However, if such functional rehabilitation was not employed, surgical repair reduced the rerupture risk by 8.8%, with the number of patients needed to treat to prevent one rerupture being twelve. This should be contrasted against the cumulative burden of complications in these individuals: according to the published data, two of these twelve patients will experience a complication following surgery.

The risk of other complications for surgically treated patients was 3.9 times that of nonsurgically treated patients, which resulted in an absolute risk increase of 15.8%; one additional complication other than rerupture could be expected for every seven patients treated surgically. It is important to mention that the complications reported in the published randomized controlled trials included both minor and major complications. Another important aspect of clinical decision-making is the prevalence of major skin complications in the surgical treatment group. Unfortunately, the data did not allow us to differentiate between major and minor complications or between skin complications and other types of complications in our analysis.

According to the meta-analysis, patients undergoing surgery returned to work nineteen days sooner, on average, than patients undergoing nonsurgical treatment. However, these results are based on a small number of studies, and those studies did not report which criteria were used to determine when a patient should be allowed to resume work activities. Further studies on this subject should be performed using predetermined criteria that patients in both groups must meet prior to returning to work.

The difference in active plantar flexion between the two groups was not clinically important. There was no significant difference between nonsurgical treatment and surgical treatment with regard to calf circumference, strength, or functional outcomes.

Although two meta-analyses have been published previously, our study includes foreign-language papers, contains a substantial number of new randomized trials that have been published since 2004, and includes a subgroup analysis of the rerupture rate. According to the results of our meta-analysis, nonsurgical treatment represents a reasonable treatment choice at centers that use functional rehabilitation with early range of motion since surgical repair did not decrease the rerupture rate

and was associated with a higher rate of other complications. Surgical repair can be considered at centers that do not employ early range of motion, or for patients who are poor candidates for this more time-consuming post-injury protocol; although it was associated with a higher overall rate of other complications, it reduced the rerupture rate. The increased risk of having a complication other than a rerupture in the surgical group (risk difference, 15.8%) appears to be more important that the increased risk of having a rerupture (risk difference, 8.8%) in the nonsurgical group. Nevertheless, given that not all complications are major, some patients and surgeons may consider the increased rate of other complications following surgical treatment to be an acceptable trade-off for the reduced rerupture rate. We believe that this information should be part of the informed consent discussion when surgery is being considered.

This meta-analysis shows that surgical treatment and nonsurgical treatment using functional rehabilitation were equivalent with regard to rerupture rate, range of motion, calf circumference, and functional outcomes. However, further research on Achilles tendon rupture treatment is warranted. For instance, randomized trials are needed to compare percutaneous repair with nonsurgical treatment to determine the difference in complications between the two treatment modalities. Another area for future research is the study of criteria that would allow physicians to select patients who would be appropriate for nonsurgical treatment.

Appendix

eA A table summarizing patient demographics in the included studies and figures showing the pooled data for return to work, calf circumference, and functional outcomes are available with the online version of this article as a data supplement at jbjs.org. ∎

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