Research Article

Systematic review and meta-analysis on the clinical outcome of early vs delayed Tendoachilles repair following Tendoachilles injury

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Abstract

Background: Surgical repair is a common treatment for Achilles tendon rupture. The interval before repair may influence outcome, but the evidence is inconsistent, largely from small observational cohorts with differing definitions of delay. Objective: To compare the clinical outcomes of early (≤14 days) and delayed (>14 days) surgical repair after complete Achilles tendon rupture. Methods: A systematic review and meta-analysis was conducted according to PRISMA 2020 guidelines. The search for randomised and observational comparative studies was performed through PubMed, Embase, Cochrane Library, Web of Science and Scopus databases and the first 200 records of Google Scholar without language or date restrictions. Studies comparing early and delayed surgical repair in adult patients were included. Data extraction and risk of bias assessment were carried out by two independent reviewers. Overall complications were pooled as Mantel–Haenszel odds ratio, and heterogeneity was measured using I^2. Results: Five non-randomised comparative cohort studies (359 early repairs and 249 delayed repairs) were analysed. In general, the rate of complications was found to be 12.8% for early repairs and 14.1% for delayed repairs (OR 0.74, 95% CI 0.45–1.23; $I^2 = 54\%$). This was a non-statistically significant difference and favoured early repair. The analysis was mostly dependent on one study. Re-ruptures were registered in one study, and the number of events was 13 for the acute, delayed, and chronic groups, and none for the subacute group. The primary outcome measure, the Achilles Tendon Total Rupture Score, was not pooled. Conclusion: Early repair within 14 days was not significantly associated with fewer postoperative complications than delayed repair, although the point estimate favoured early surgery. The evidence is limited by small, mostly retrospective studies and moderate heterogeneity. Prospective studies with standardised timing categories and patient-reported outcomes are needed.

Keywords: Achilles tendon rupture; Early repair; Delayed repair; Time to surgery; Systematic review; Meta-analysis; Achilles Tendon Total Rupture Score.

1. Introduction

Achilles tendon rupture is one of the most common tendon injuries of the lower limb. It mainly affects active adults in mid-life, and men are affected about three times as often as women [1]. A Danish nationwide registry recorded 33,160 ruptures over two decades with a steadily rising incidence, particularly after 50 years of age [1]. Finnish national data show incidence almost doubling, from 17.3 to 32.3 per 100,000 person-years, between 1997 and 2019 [2]. Comparable growth and changing management patterns have been described in Ontario, Canada [3]. As the injury becomes more frequent in an ageing, recreationally active population, decisions about how and when to treat it carry growing clinical and socioeconomic weight.

Repair of the tendon by surgery vs non-surgical management has been the key question. In a meta-analysis of randomized and observational trials, the risk of tendon rupture was reduced while other complications were increased when surgery was used [4]. The most extensive multicentre randomized trial to date reported no differences in patient-reported functional outcome at 12 months between non-surgical treatment, open surgery and minimally invasive surgery. Rupture rate was higher after non-surgical treatment compared to surgical treatment groups (6.2% vs. 0.6%) [5]. Network and pairwise meta-analyses of re-rupture and complication rates between different treatment approaches have since been undertaken [6,7]. Based on such evidence, the number of non-surgical treatment has been increasing

in some countries [1,2].

Whereas surgery is selected, the period from injury to repair represents a less studied but potentially modifiable prognosis factor. In a study involving 228 Swedish patients who underwent surgery during a 10-day period, repair performed within 48 hours had better one-year patient reported outcomes and lesser number of adverse events compared to repair performed after 72 hours. Good outcomes were seen in 71% and 44% of the patients respectively, while adverse events developed in 1.4% and 14.8% of patients [8]. On the other hand, a recent study involving 350 patients showed no effect of timing on the total complication rate, but those operated upon within the first week had higher physical function scores [9]. Interpretation is made difficult by inconsistent terminology. Acute, delayed and chronic ruptures have different definitions with cutoffs from 48 hours [8] to two or six weeks [10]. Late presentation or diagnosis has been reported in up to one in five patients [10].

Comparative case series with few patients show that outcomes are similar for those who undergo repair at >14 days after rupture to acutely repaired patients using minimal access surgery [10,11]. Meta-analysis revealed no difference in the Achilles tendon Total Rupture Score between acute and delayed repairs; however, more complications occur with a delay, which become apparent when mean delay is >28 days [12].

There is thus still some controversy over timing in terms of evidence, with most studies having been based on small observation groups. The most directly related meta-analysis [12], which looked at three databases, called for more rigorous trials and was subsequently supported by larger observation data [9]. We thus decided to conduct a systematic review and meta-analysis of clinical outcomes following early and late repair of Achilles tendon ruptures, looking at patient function and re-ruptures among other factors, and taking into account the definition of delay.

Materials and Method

Study Design and Registration

This systematic review and meta-analysis (SRMA) was aimed at the clinical consequences of early and late surgical treatment of Achilles tendon rupture. This systematic review was carried out and presented in accordance with the PRISMA statement 2020 [13] and recommendations of Cochrane handbook for systematic reviews of interventions [14]. In order to make the process transparent and repeatable, the protocol was prospectively registered on PROSPERO (registration number CRD_____) prior to starting the screening process [15]. Only peer-reviewed publications were considered, hence no ethical approval or informed consent was necessary.

Eligibility Criteria

Eligibility followed the PICOS framework.

- **Population:** skeletally mature adults (≥18 years) with a complete Achilles tendon rupture treated surgically.
- **Intervention:** early repair, defined as surgery within 14 days of injury.
- **Comparator:** delayed repair, defined as surgery more than 14 days after injury.
- **Outcomes:** at least one outcome listed under "Outcomes of the Study".
- **Study design:** Observational studies like prospective or retrospective comparative cohort or case–control studies directly comparing early with delayed repair.

Inclusion Criteria

- Patients aged 18 years or older with a complete Achilles tendon rupture managed by surgical repair.
- Direct comparison of an early and a delayed repair group, with time from injury to surgery explicitly reported.
- At least one outcome of interest reported, with a minimum follow-up of six months.
- Full-text availability, in any language.

Exclusion Criteria

- Partial ruptures, insertional or bony avulsions, re-ruptures and revision procedures.
- Nonoperative-only comparisons and single-arm series without a comparator.
- Case reports, reviews, editorials, cadaveric or animal studies, and conference abstracts without extractable data.
- Overlapping patient populations (the most complete report was retained).
- Studies with incomplete or inconsistent outcome data where the corresponding authors did not provide clarification.

Study Selection and Search Strategy

Searches were conducted in PubMed, Embase, Cochrane Library, Web of Science, and Scopus from their inception to October 2026, along with the first 200 results from Google Scholar without language and date limitations. Search strategy used controlled vocabulary terms (MeSH / Emtree) together with free-text terms for population, intervention and comparator using boolean operators. For instance: ("Achilles tendon"[MeSH] OR "Achilles tendon") AND (rupture* OR tear* OR injur*) AND (early OR acute OR immediate OR delayed OR late OR chronic OR neglected OR "time to surgery" OR timing) AND (repair OR surgery OR surgical OR reconstruction OR suture). Full search strategies for each database can be seen in Supplementary File 1. Hand searching of reference lists of included articles and relevant systematic reviews, and checking for trials in trial registers were performed to find ongoing trials. References were exported to reference management software and duplicates removed. Two independent reviewers assessed titles and abstracts followed by full-text articles. Any disagreement was solved either through discussion or third reviewer, and Cohen's Kappa was calculated. The process of selection is illustrated in a PRISMA 2020 flow diagram (Figure 1).

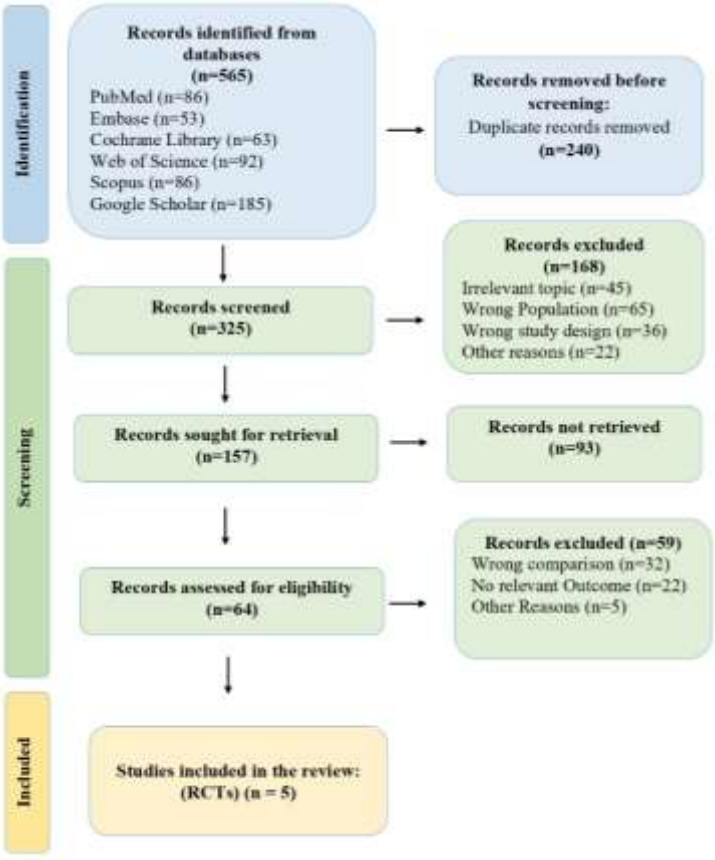


Figure 1: PRISMA flow chart

Data Extraction

Two independent reviewers performed data extraction using an Excel sheet pre-piloted beforehand. The variables that were extracted included: the first author and year; country; study design; sample size; characteristics of participants (age, gender, degree of rupture); definition of operative time and mean operative time in each study group; operative technique; postoperative management; outcome measures and their timing; primary findings; and any adverse effects. Any discrepancies between the two reviewers were resolved either by consensus or by consultation with a third reviewer. Authors of studies where data was missing or inconsistent were contacted.

Quality Assessment —Risk of Bias Tool

Two reviewers independently assessed the risk of bias in non-randomised studies using the Risk of Bias In Non-randomised Studies of Interventions (ROBINS-I) tool [17], with particular attention to potential confounding, as patients

presenting late may differ systematically from those receiving acute treatment. Disagreements between reviewers were resolved by consensus.

Outcome of the Study

The main result was the ATRS [19,20], at the maximum follow-up period of 12 months or more. The secondary results were re-rupture, complications, return to play/sport or work, calf muscle strength or calf raise test, and tendon elongation. The complications were deep infection, wound healing complication, deep vein thrombosis and sural nerve damage.

Statistical Analysis

The meta-analyses were carried out using Review Manager (RevMan) Version 5.4 [21]. The results for continuous variables were reported as mean differences (MD) with 95% confidence intervals (CI). The results for dichotomous variables were pooled using risk ratio (RR) with 95% CI through the Mantel-Haenszel method. A random effects model was chosen due to anticipated heterogeneity. The degree of heterogeneity was measured using I^2 statistic and interpreted based on Cochrane recommendations [23]. The observational data were analyzed; where possible, effect estimates adjusted for confounding factors were used instead of unadjusted ones. Sensitivity analysis was conducted after excluding studies at high risk of bias.

Results

Study Selection and Characteristics

A total of 565 studies were captured from database searches. Excluding 240 duplicates, 325 studies were screened, out of which 168 were found to be ineligible based on title/abstract screening (mainly due to incorrect population (n=65) or irrelevant topic (n=45)). Full texts of 157 records were sought, and 93 could not be retrieved; out of the remaining 64 full-text articles, 59 were excluded (incorrect comparison (n=32), no relevant outcome (n=22) or others (n=5)), leaving only five articles for further synthesis (Figure 1).

Five included studies, published between 2018 and 2025, are all non-randomised comparative cohort studies (four retrospective studies). These studies are conducted in China, Sweden, United Kingdom, Italy, and the United States. Ma et al. [25] and Carmont et al. [10] are small case series with 24 and 18 patients, respectively, while the largest study is by Hewitt et al. [9], with 350 patients operated at different sites in one institution. In all included studies reporting sex, men predominated, and there was also similarity of mean age in those reporting ages (42.3 ± 10.9 versus 44.8 ± 11.8 years in Ma et al.; 47.7 ± 14.6 versus 48.4 ± 14.9 years in Carmont et al.).

Definitions varied greatly in terms of timing (Table 2). The average time to surgery was 5.75 and 19.5 days in Ma et al. [25] and 6.2 and 21.4 days in Maffulli et al. [11], respectively. Hewitt et al. [9] distinguished four periods: acute, 0-6 days; subacute, 7-13 days; delayed, 14-41 days; and chronic, more than 42 days. Svedman et al. [8] defined their delayed period as more than 72 hours up to 10 days. Open repair was applied in Ma et al. and Svedman et al., minimally invasive/percutaneous repair was used in Carmont et al. [10] and Maffulli et al., while both techniques were combined in Hewitt et al.

Table 2: Injury Characteristics and Surgical Intervention Details

Author and year	Injury characteristics	Early repair group	Delayed repair group
Ma et al. (2020)	Primary Achilles tendon rupture with acute or delayed presentation; chronic tendinopathy excluded. Confirmation method, rupture location, injury mechanism and open/closed status: NR.	Definition: ≤14 days. Time to surgery: 5.75 ± 3.4 days. Sample size: 12. Technique: Open end-to-end repair using Krackow sutures reinforced with 1-0 Vicryl. Graft: None reported. Rehabilitation: NR.	Definition: >14 days (14–28 days). Time to surgery: 19.5 ± 4.1 days. Sample size: 12. Technique: Open repair using the same reported suture technique. Graft: None reported. Rehabilitation: NR.

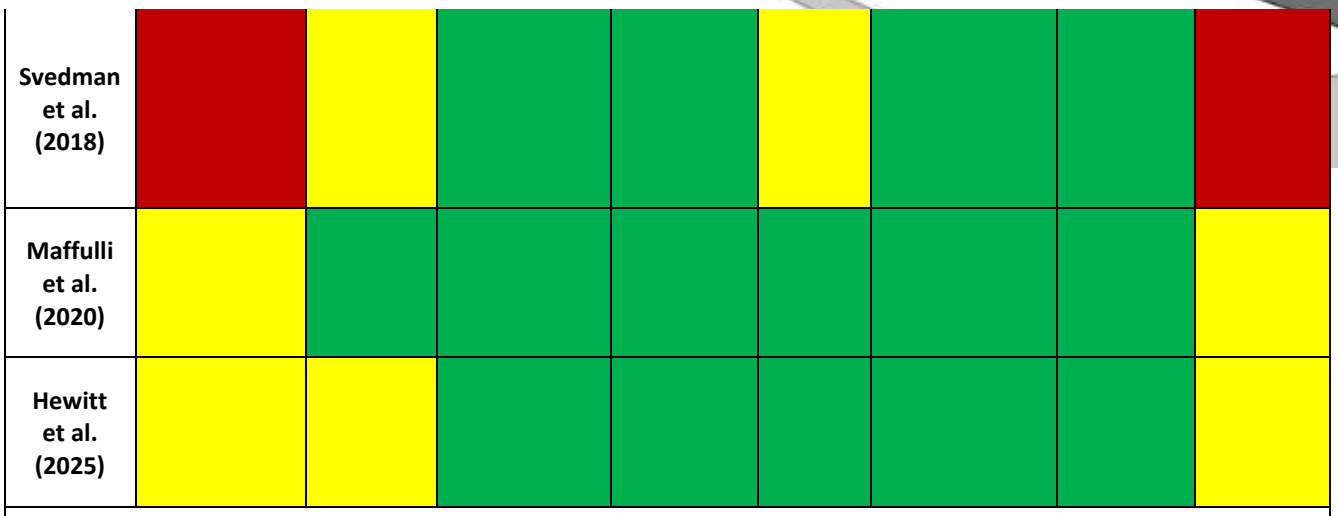
Carmont et al. (2020)	Clinical diagnosis based on a reported pop, palpable gap, abnormal calf-squeeze test and altered Achilles tendon resting angle (ATRA). Closed primary ruptures; injuries occurred during activities of daily living and sports.	Definition: ≤14 days. Time to surgery: Exact interval requires verification. Sample size: 9. Technique: Minimally invasive repair using modified Bunnell/Kessler and Silfverskiöld sutures. Rehabilitation: Functional brace.	Definition: >14 days (14–42 days). Time to surgery: Exact interval requires verification. Sample size: 9. Technique: Minimally invasive repair with a larger incision to address adhesions; similar suture techniques. Rehabilitation: Functional brace.
Svedman et al. (2018)	NR	NR	Definition: Reportedly >72 hours, up to 10 days; verify the original article. Sample size: 104. Technique: Open surgical repair. Rehabilitation: NR.
Maffulli et al. (2020)	NR	Definition: ≤14 days. Time to surgery: 6.2 ± 2.1 days. Sample size: 30. Technique: Percutaneous/minimally invasive repair. Rehabilitation: Early controlled motion.	Definition: 14–30 days. Time to surgery: 21.4 ± 4.8 days. Sample size: 30. Technique: Percutaneous/minimally invasive repair. Rehabilitation: Early controlled motion.
Hewitt et al. (2025)	Operative Achilles tendon ruptures and patients aged under 18 years. Sports-related injuries accounted for 74.6%, most commonly basketball and soccer	Definition: Acute (0–6 days) and subacute (7–13 days). Sample size: 247. Surgical technique: Open repair (modified Krackow/Kessler) and percutaneous repair (PARS).	Definition: Delayed (14–41 days) and chronic (42 days or more). Sample size: 103. Surgical technique: Open and percutaneous repairs, with a higher proportion of open repairs used as time to surgery increased.

Quality Assessment and Risk of Bias

All the included studies were assessed using the ROBINS-I tool (see Table 4). The main source of bias was confounding – late-presentation patients could be systematically different from the early presentation ones, and the technique of treatment also differed between groups. The cause of late presentation was not specified in the extracted data; four out of five studies were retrospective.

Table 4: Risk of bias assessment of the included non-randomised studies using the ROBINS-I tool

Study	D1: Confounding	D2: Selection	D3: Classification	D4: Deviations	D5: Missing Data	D6: Measurement	D7: Reporting	Overall Bias
Ma et al. (2020)								
Carmont et al. (2020)								



Clinical Outcomes

The main outcome was ATRS [19,20]. ATRS results were reported by Ma et al. [25], Carmont et al. [10] and Maffulli et al. [11] (the latter up to 12 months), as well as the percentage of participants with ATRS > 80 at one-year follow-up by Svedman et al. [8]. Hewitt et al. [9] reported PROMIS Physical Function rather than ATRS (Table 3).

Table 3: Clinical outcomes and complications

Author and year	Functional outcomes	Tendon healing and recovery	Physical and clinical outcomes	Complications and adverse events	Patient satisfaction and quality of life
Ma et al. (2020)	ATRS; Tegner activity score	NR	Visual analogue scale (VAS)	Transient sural nerve symptoms (1 early, 1 delayed); wound infection (1 delayed). No re-ruptures or thromboembolic events.	NR
Carmont et al. (2020)	ATRS; Tegner score; Halasi score; physical activity score	Relative ATRA; calf circumference	Heel-rise height index (HRHI); heel-rise repetition index (HRRI)	Wound infection (2 delayed); iatrogenic sural nerve injury (1 delayed); DVT (1 early). No re-ruptures.	Patient's Perception of Performance (PPP)
Svedman et al. (2018)	Proportion with ATRS >80 at 1 year	NR	NR	Overall adverse events; DVT	NR
Maffulli et al. (2020)	ATRS at 12 months; return to sport/work	NR	Calf strength	Complications; re-rupture	NR
Hewitt et al. (2025)	Patient-Reported Outcomes Measurement Information System Physical Function (PROMIS PF)	NR	Foot and Ankle Single Assessment Numeric Evaluation (FA SANE)	Overall rate 16%. Included minor/major wounds, DVT, sural nerve injury, neuropathic pain, and 13 re-ruptures (higher re-rupture rates in acute, delayed, and chronic	PROMIS Pain Interference (PI)

				groups compared to zero in subacute).	

Re-rupture was described in more detail only in the study of Hewitt et al. [9], where there were 13 re-ruptures among the acute, delayed and chronic groups and no re-ruptures in the subacute group. No re-ruptures were reported by Ma et al. [25] and Carmont et al. [10], whereas Maffulli et al. [11] mentioned re-rupture without providing any numbers.
Overall postoperative complications were calculated using all the five studies (Figure 2). Postoperative complications happened in 46 of 359 patients (12.8%) following early repair and 35 of 249 (14.1%) following delayed repair. Mantel-Haenszel odds ratio under the fixed-effects model was 0.74 (95% CI 0.45–1.23; Z = 1.16, p = 0.25), showing a non-significant trend in favour of early repair, with moderate heterogeneity (I^2 = 54%; χ^2 = 8.65, df = 4, p = 0.07). The largest study by Svedman et al. [8] made up 34.5% of the weight of evidence and demonstrated much lower frequency of postoperative complications following early repair (1 out of 70 versus 15 out of 104; OR 0.09, 95% CI 0.01–0.67). which largely determined the direction of the pooled estimate. Maffulli et al. [11] favoured delayed repair (2 of 21 versus 0 of 21; OR 5.51, 95% CI 0.25–122.08), on very few events.

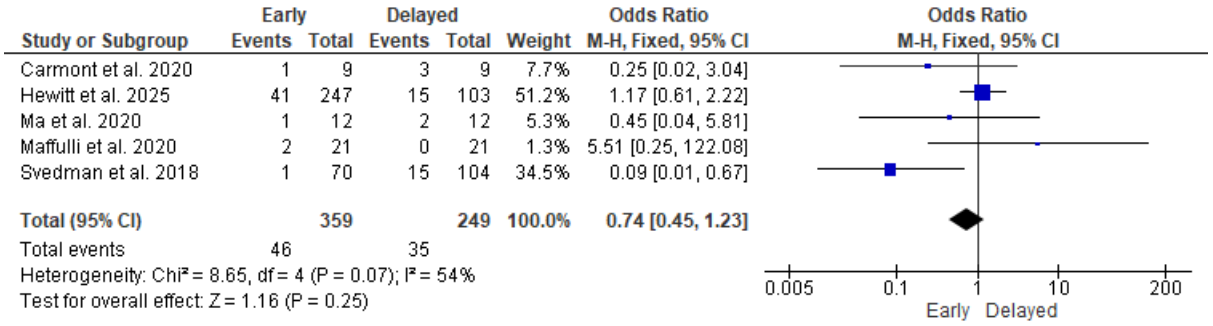


Figure 2: Forest plot comparing overall postoperative complications between early and delayed repair

The studies by Ma et al. [25] involved the occurrence of temporary sural nerve symptoms in one participant of each group and one delayed wound infection. The study by Carmont et al. [10] involved delayed-group complications of two wound infections and one iatrogenic sural nerve injury, while the early-group complication was one deep vein thrombosis. Complications were reported by Hewitt et al. [9] as occurring at a rate of 16% (56 of 350), consisting of wound issues, deep vein thrombosis, sural nerve injury and neuropathic pain (Table 3).
Calf strength, heel rise performance, sport/work return and quality of life of the participants were evaluated in some of the studies (Table 3). Heel rise height and repetition indices and calf circumference were reported by Carmont et al. [10], while Maffulli et al. [11] reported calf strength and sport or work return, and PROMIS Physical Function, Pain Interference and FA SANE were reported by Hewitt et al. [9]. [Values to be entered from extracted data.] The only outcome measured for pooling in this review was complications.

Methodological Considerations

The only timing subgroup that had no cases of re-rupture in the Hewitt et al. study was the subacute subgroup [9]; therefore, re-rupture did not increase monotonically with increasing time to surgery. Comparisons of subgroups were limited by timing cut-off point due to different cut-off points used in other studies. Randomized versus observational study comparisons could not be conducted since there was no randomized controlled trial, and publication bias was not assessable due to less than ten studies contributing to each outcome.

Discussion

Principal Findings

In this systematic review and meta-analysis of five non-randomized comparative studies (608 patients analyzed), there

was no statistically significant difference in the risk of postoperative complications for early repairs (within 14 days) versus delayed repairs (beyond 14 days). The odds ratio for early repair was 0.74 (95% confidence interval: 0.45–1.23), and the result was highly dependent on the study by Svedman et al. [8], which made up more than one-third of the total weight. Heterogeneity was moderate. There was not enough data about re-rupture. The result found by Hewitt et al. [9], where re-ruptures appeared in acute, delayed, and chronic groups but not in the subacute group, is not monotonous in relation to time.

Comparison with Previous Evidence

Our pooled estimate's directionality concurs with He et al. [12], who noted increased risks with a delayed repair, especially with mean delay surpassing 28 days. However, our delayed groups had smaller average delay compared to that: the average delays for Ma et al. [25] and Maffulli et al. [11] were about 20 days (Table 2). Hence, our 14-day cut-off may have only included the earlier part of the delay range where harm was identified and patients treated later than four weeks after rupture are understudied. Similarly, there was no apparent difference between groups by timing in Hewitt et al. [9], although improved functional results were identified for surgery within a week. This finding is compatible with ours as far as complications are concerned. Improved patient-related outcomes within a year and reduced adverse events with the repair done within 48 hours compared to those repaired within 72 hours were identified by Svedman et al. [8]. This study is heavily reflected in our pooled estimate, yet its group definitions were not fully extracted. Carmont et al. [10] and Maffulli et al. [11] found similar outcomes with delayed repair compared to acute repairs.

Possible Explanations

There could be several reasons for a time-dependent effect in this situation; however, there was no way to verify any of them based on the presented results. Retraction of tendon ends occurs along with filling of the space with scar tissue over time, making the procedure difficult. Carmont et al. [10] made a bigger cut to solve problems with adhesions among the delayed treatment group (see Table 2). The share of open procedures in Hewitt et al.'s [9] study increased with a higher amount of time to surgery. So, the technique becomes a confounding factor, and some of the delayed groups in multiple studies had a more complex surgery. However, early surgery was conducted in swollen soft tissues, and waiting for the swelling to go away could partially compensate for the biological benefit of early repair.

Clinical Implications

It is currently unclear whether it is necessary to perform repair in 14 days. If surgical intervention is performed, then early repair continues to be appropriate, but delay in itself should not preclude repair of a rupture. It is important to note, however, that terminology related to time is not consistent; for example, acutely, sub-acutely, delayed and chronically ruptured patients may have thresholds of 48 hours up to six weeks. In future reports, the time between the incident and surgery should be recorded continuously with a threshold provided to enable analysis of any relationship.

Limitations

Several limitations exist in this review. Firstly, all included studies are non-randomised, and four were retrospective, hence selection bias and confounding by age, sex, injury severity, comorbidity, and reasons for the delay. Comorbidity or activity level are not described in Table 1. Secondly, there is limited number of studies. Two of five included studies had only 12 and 9 patients in each group, and the confidence interval includes any effect ranging from a 55% reduction to a 23% increase in complications; thus, this review could not exclude any clinically important difference. Thirdly, there was moderate heterogeneity ($I^2 = 54\%$) caused mainly by one study. Fourthly, one included study (Ma et al. [25]) is a preprint that has not been peer-reviewed. Fifthly, categories of the timing, surgery type and outcomes differed, and several extracted fields were not provided in these studies. Sixthly, the main outcome could not be combined, hence this review did not give any quantitative conclusion about the patient-reported functional outcomes that are identified in the Introduction as the most relevant.

Table 1: General study characteristics and participant demographics

Author and year	Country	Journal	Study design	Study setting	Study duration	Total N	Early N	Delayed N	Age (years), mean ± SD	Sex (M:F)

Ma et al. (2020)	China	Research Square (preprint)	Retrospective comparative cohort	Wannan Medical College, Yijishan Hospital	Jan 2014–Jul 2017	24	12	12	Early: 42.3 ± 10.9; Delayed: 44.8 ± 11.8	Early: 10:2; Delayed: 9:3
Carmont et al. (2020)	UK/Sweden	Knee Surgery, Sports Traumatology, Arthroscopy	Retrospective matched cohort	Princess Royal Hospital, Shropshire, UK	2014–2017	18	9	9	Early: 47.7 ± 14.6; Delayed: 48.4 ± 14.9	Early: 9:0; Delayed: 8:1
Svedman et al. (2018)	Sweden	The American Journal of Sports Medicine	Retrospective comparative cohort	NR	NR	228	70	104	NR	NR
Maffulli et al. (2020)	Italy/UK	The American Journal of Sports Medicine	Comparative cohort	Academic orthopaedic centres	NR	60	30	30	NR	NR
Hewitt et al. (2025)	USA	The Orthopaedic Journal of Sports Medicine	Retrospective Cohort	Single institution, multiple sites (Univ. of Colorado)	Oct 2016–Mar 2022	350	247 (116 Acute, 131 Subacute)	103 (78 Delayed, 25 Chronic)	Overall: 41 ± 12.4; Acute: 41.2 ± 12.1; Subacute: 39.1 ± 11.2; Delayed: 42 ± 13.7; Chronic: 46.4 ± 14.4	Overall: 280:70

Conclusion

There were no statistically significant differences in post-operative complication rates between early repair of ruptured Achilles tendon within 14 days and delayed repair in five comparative non-randomized studies; however, the point estimate was in favor of early surgical repair. The available data are hampered by small sample sizes, retrospective design, high heterogeneity and unclear timing. There is a need for prospective studies using clear categories of timing, predefined ATRS outcome criteria at least one year after surgery and detailed data on re-ruptures and complications to evaluate possible benefits of early repair in patient reported function and repairs done beyond 28 days.

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