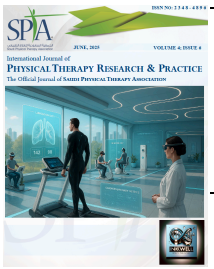

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Original Article

Comparing Outcomes of Surgical and Nonsurgical Management for Achilles Tendon Ruptures: A Systematic Review and Meta-Analysis

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Abstract

Background: Achilles tendon rupture is a common injury, and the optimal management approach—surgical or conservative—remains debated. The current systematic review and meta-analysis aim to compare surgical and conservative management strategies, considering efficacy and safety, by assessing the functional outcomes, rate of complications, and rate of re-rupture. **Methods:** A comprehensive literature search was conducted across multiple electronic databases to identify eligible randomized controlled trials (RCTs) comparing surgical and conservative management of Achilles tendon rupture. The main key outcomes included Achilles Tendon Score (ATRS), Complications incidence, including the incidence of deep vein thrombosis (DVT). For meta-analysis, effect sizes, confidence intervals, and heterogeneity were calculated depending on a random-effects model. **Results:** The results of the current review showed a substantial advantage of surgical management showed a significant advantage in ATRS scores (pooled estimate: 2.241; 95% CI: 1.004–3.478; $p < 0.001$). Regarding safety, no significant difference was found in DVT incidence (pooled estimate: 0.460; 95% CI: 0.163–1.302; $p = 0.144$; $I^2 = 0\%$); the surgical group showed a non-significant increase in infection rates (pooled estimate: 2.217; 95% CI: 0.763–6.446; $p = 0.144$; $I^2 = 0\%$) and conservative management had a significantly higher rate of re-rupture (pooled estimate: 0.182; 95% CI: 0.085–0.391; $p < 0.001$; $I^2 = 0\%$). **Conclusion:** Surgical management is associated with a lower risk of re-rupture, while both approaches yield comparable long-term functional outcomes.

Keywords: Achilles tendon rupture, Surgical management, Conservative treatment, Meta-analysis, Clinical outcomes, Complications.

Introduction

Achilles tendon ruptures are among the most common injuries in the lower extremities, particularly affecting individuals who engage in recreational sports and physical activities (Sankova et al., 2024; Tarantino et al., 2020). The Achilles tendon, the largest and strongest tendon in the body, plays a crucial role in gait mechanics by enabling plantar flexion and facilitating efficient movement (Finni & Vanwanseele, 2023; Marrone et al., 2024). Despite its strength, excessive strain can lead to an Achilles tendon rupture, accounting for nearly 20% of all major tendon injuries worldwide (Chen et al., 2009; Sankova et al., 2024). The incidence of Achilles tendon rupture has increased over time, particularly among middle-aged individuals with active lifestyles (Ganestam et al., 2016; Ho et al., 2017; Lantto et al., 2015).

Surgical treatment, whether open or minimally invasive, restores tendon continuity, reduces re-rupture rates, and promotes faster functional recovery (Kołodziej et al., 2013; Yilmaz, 2014). However, it carries risks such as infection and sural nerve injury (Wang et al., 2024; Yang et al., 2018). Conversely, conservative management relies on functional rehabilitation protocols that emphasize early mobilization while avoiding surgical risks, though it may be associated with a higher risk of re-rupture (Soroceanu et al., 2012; Willits et al., 2010).

Numerous randomized controlled trials (RCTs) have compared surgical and conservative treatments, evaluating outcomes such as re-rupture rates, functional recovery, return-to-activity timelines, and complication rates. However, these RCTs have reported conflicting findings. For example, Willits et al. (2010) found no significant difference in functional outcomes between surgical and non-surgical management, whereas Olsson et al. (2013) reported better strength and endurance with surgical intervention. Similarly, while Keating et al. (2011) observed lower re-rupture rates in surgically treated patients, Metz et al. (2019) highlighted an increased risk of wound-related complications. These inconsistencies contribute to uncertainty regarding the optimal management approach.

Key gaps in the literature include variability in rehabilitation protocols, inconsistencies in follow-up durations, and a lack of consensus on patient selection criteria for each treatment approach. The ongoing debate over the preferred management strategy necessitates a comprehensive systematic review and meta-analysis to synthesize existing findings and guide clinical decision-making.

The present systematic review and meta-analysis aim to compare the outcomes of surgical and conservative management in patients with Achilles tendon ruptures based on RCT data. The primary objective is to assess differences in re-rupture rates, functional recovery, and return-to-activity timelines. The secondary objective is to evaluate complication rates associated with each treatment method, including infection risk, sural nerve injury, and long-term functional deficits.

Methodology

A systematic review and meta-analysis were conducted to compare surgical and conservative management of patients with Achilles tendon rupture, focusing on functional and clinical outcomes. The primary objective of this review was to assess differences in re-rupture rates, functional recovery, and return-to-activity timelines. Secondary outcomes included complication rates, quality of life (QoL) as reported by patients, and time until returning to sport. The study adhered to the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to ensure methodological transparency and rigor. This study was registered in the International Prospective Register of Systematic Reviews (PROSPERO) (ID: CRD42024567494).

Eligibility Criteria

The inclusion criteria for studies in this review included RCTs involving patients older than 18 years diagnosed with acute Achilles tendon rupture, comparing surgical and conservative management, and reporting at least one of the primary outcomes of interest, including functional recovery, re-rupture rates, or incidence of complications. Excluded were studies focused on chronic or partial ruptures, the pediatric population, those not reporting relevant outcomes, non-RCTs, review articles, or studies that did not provide access to full-text data.

Search Strategy

A comprehensive literature search was conducted across multiple databases including, PubMed, Embase, and the Cochrane Library, covering all studies published up to 2023. Keywords and Medical Subject Headings (MeSH) terms such as “Achilles tendon rupture,” “surgical treatment,” “conservative management,” and “clinical outcomes” were used. Boolean operators (AND, OR) were applied to refine the search. An example of the search strategy used in PubMed was: (“Achilles tendon rupture” MeSH OR “Achilles tear” OR “tendon injury”) AND (“surgical treatment” OR “operative repair”) AND (“conservative management” OR “nonoperative treatment”).

Citation tracking and a manual search of the references of searched articles were conducted to ensure the inclusion of the most relevant studies.

Study Selection

Two independent reviewers screened the titles and abstracts of identified articles, and full-text reviews confirmed the studies' inclusion. Any conflicts between the reviewers were resolved through discussion or with revisions from a third reviewer, and the selection process was documented using the PRISMA flow diagram (Figure 1).

Data Extraction

A pre-defined data extraction form developed as an Excel sheet was used to collect available data on study characteristics, patient demographics, treatment strategies, follow-up durations, and measured outcomes. The extraction process was reviewed and validated by experts in the field. Primary outcomes included functional recovery, measured using the Achilles Tendon Rupture Score (ATRS), and re-rupture rates. Secondary outcomes included complication rates, quality of life (QoL), and time to return to sport. QoL was measured using patient-reported outcome measures (PROMs) such as the Short Form 36 (SF-36) and the EuroQol-5D (EQ-5D), which assess physical health, emotional well-being, and social functioning. The inclusion of the Visual Analog Scale (VAS) for pain assessment was reconsidered, as it does not directly align with the study's primary aim of evaluating functional recovery and re-rupture rates.

Participant Characteristics

The included studies had varying patient characteristics. In general, the mean age of participants ranged from 30 to 60 years, with most studies including individuals who were active in recreational or sports activities at baseline. The majority of participants were male, with activity levels varying from recreational athletes to physically active individuals. Common comorbidities in the included studies included diabetes, obesity, and hypertension, which were considered when analyzing outcomes. The sample sizes of the included studies ranged from 30 to over 100 participants, with most studies adequately powered to detect differences in the primary outcomes. Power analyses were conducted in most studies to ensure statistical adequacy for detecting significant differences in outcomes such as re-rupture rates and functional recovery.

Risk of Bias Assessment

To ensure the quality of the included studies, the Cochrane Risk of Bias 2 (RoB2) tool for randomized trials was used to assess the risk of bias. Two independent reviewers evaluated the studies across different key domains, including randomization, allocation concealment, blinding,

and outcome reporting. Inter-rater reliability was assessed using kappa statistics to ensure consistency. Disagreements between reviewers were resolved through discussion.

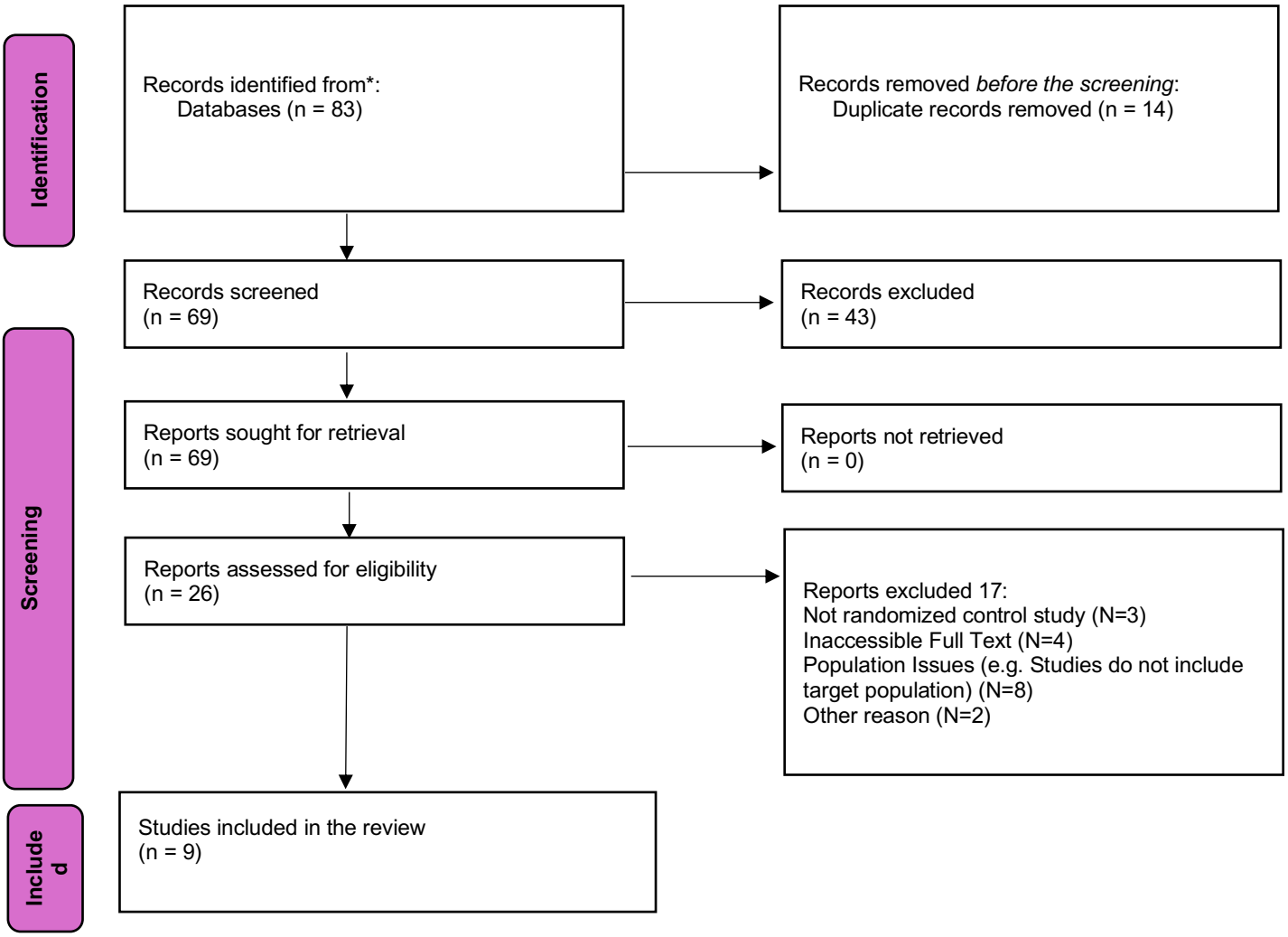

Figure 1: PRISMA flow diagram of including studies

Data Analysis

Review Manager (RevMan) version 5.4 was used for statistical analysis, utilizing a random-effects model to assess the heterogeneity between studies. Pooled estimates were reported as odds ratios (OR) and mean differences (MD), with 95% confidence intervals (CI). The I^2 statistic was used to assess heterogeneity, with values above 50% indicating moderate to high heterogeneity. Funnel plots and forest plots were used to visually present the results.

Surgical and Conservative Procedures and Preparation

Surgical management included open and minimally invasive Achilles tendon repair techniques, with variations in suture methods and postoperative immobilization. Conservative management involved functional rehabilitation protocols, emphasizing early weight-bearing and progressive mobilization. The preparation, execution, and rehabilitation phases of each treatment were documented to assess their impact on patient outcomes.

Results

Study characteristics

The current review included nine randomized controlled trials (Fischer et al., 2021; Keating & Will, 2011; Iikka Lantto et al., 2016; Maempel et al., 2020;

Manent et al., 2019; Metz et al., 2009; Möller et al., 2001; Myhrvold et al., 2022; Olsson et al., 2013), Figure 1 that were conducted across different countries, including Norway (Myhrvold et al., 2022), Australia (Maempel et al., 2020), Germany (Fischer et al., 2021), Spain (Manent et al., 2019), Finland (Iikka Lantto et al., 2016), Sweden (Möller et al., 2001; Olsson et al., 2013), Netherland (Metz et al., 2009), and the UK (Keating & Will, 2011; Maempel et al., 2020). The review included different outcomes that were assessed by different studies, including complications, functional performance, quality of life, or patient-reported outcomes. Despite the differences in follow-up durations, ranging from 10 months to 180 months, the majority of studies reported no significant differences in long-term outcomes between surgical and conservative management groups. Key findings indicated no significant disparities in patient-reported outcomes (such as ATRS, VAS, SF-36, and EQ-5D) or satisfaction scores between groups (Maempel et al., 2020; Myhrvold et al., 2022; Olsson et al., 2013). However, studies like Lantto et al. (2016) and Möller et al. (2001) highlighted a surgical advantage in strength recovery and faster recovery times but noted a higher rate of scar-related complications (Iikka Lantto et al., 2016; Möller et al., 2001) (Table 1).

Table 1: General characteristics of included studies.

Study ID	Study design (e.g., randomized controlled trial, cohort study, case-control study, etc.)	Country of origin	Outcomes being measured (e.g., complications, quality of life, etc.)	Follow-up duration in months	Outcomes
(Myhrvold et al., 2022)	Randomized controlled study	Norway	ATRS, VAS, SF-36, Heel-Rise Test, ROM, LSI, CMJ	12 months	No significant difference
(Maempel et al., 2020)	Randomized controlled study	Australia, UK	SMFA, ATRS, EQ-5D, satisfaction.	180 months	No significant long-term differences in patient-reported outcomes, satisfaction, or re-rupture rates between groups.
(Fischer et al., 2021)	Prospective randomized clinical trial	Germany	PFF	24 months	No significant difference
(Manent et al., 2019)	Randomized controlled trial	Spain	VAS, Heel-Rise Test, ROM, Functional Index for Lower Leg and Ankle	N/A	Faster recovery in surgical groups but more scar-related complications
(Iikka Lantto et al., 2016)	Prospective Randomized Trial	Finland	Leppilahti Achilles Tendon Performance Score, Isokinetic Calf Muscle Strength (peak torque), ROM, QOL, VAS, Complication, Heel-	18 months	The surgical group favored strength recovery and QoL

			Rise Test, Satisfaction, LSI		
(Olsson et al., 2013)	Randomized controlled study	Sweden.	Complications, FO, QoL	12 months.	No significant difference
(Keating & Will, 2011)	Prospective randomized clinical trial	United Kingdom	Complications, SMFA, ROM, Muscle Function	12 months	no significant long-term function between groups
(Metz et al., 2009)	Randomized controlled study	The Netherlands.	Complications, Calf muscle strength recovery, PFF, ROM, Loss of muscle strength	10 months	No significant difference
(Möller et al., 2001)	Prospective randomized study	Sweden	VAS, Heel-Rise Test, ROM, Functional Index for Lower Leg and Ankle	24 months	Faster recovery with lower re-rupture rates in surgical group

VAS: Visual Analog Scale, ROM: Range of Motion, SMFA: Short Musculoskeletal Function Assessment, ATRS: Achilles Tendon Total Rupture Score, PFF: Plantar flexion force, EQ-5D: EuroQol five-dimension, SF-36: Short Form-36, LSI: Sport and Recreation, Limb Symmetry Index, QoL: Quality of life, FO: Function outcomes, SMFA: Short Musculoskeletal Function Assessment, CMJ: Drop Countermovement Jump

The included studies collectively analyzed 1,149 patients with a broad age range (18–70 years). The results showed that most of the participants were males, where most of the studies reported a higher incidence of rupture among male participants (e.g., 132/136 in Myhrvold et al., 2022 (Myhrvold et al., 2022), and 99/13 in Möller et al., 2001 (Möller et al., 2001)). In addition, the study showed that mean age is reported consistently among the studies, averaging around 40 years. Few studies reported comorbidities, though Olsson et al. (2013) and Metz et al. (2009) identified factors such as BMI and smoking prevalence as potential influencing variables (Metz et al., 2009; Olsson et al., 2013). Comorbidities like hypertension (HTN) and diabetes mellitus (DM) were infrequent, with isolated mentions in the conservative management group (Metz et al., 2009) (Table 2).

Table 2: Patients' characteristics

Study ID	No	Group 1*	Group 2**	Age, Mean (SD), range	Gender (M/F)	Comorbidities
Myhrvold et al., 2022	526	176	178	NA (NA), 18-60	132/136	NA
Maempel et al., 2020	64	33	31	57.6 (NA), 21-59	45/19	NA
Fischer et al., 2021	90	60	30	41 (NA), 21-60	81/9	NA
Manent et al., 2019	34	23	11	41.5 (NA), 18-70	31/3	NA
Lantto et al., 2016	60	32	28	40 (NA), 27-60	55/5	NA
Olsson et al., 2013	100	49	51	39.7 (9.3), 18-65	86/14	BMI: 27.1 (3.5)/25.7(2.8) Kg/m2; Smokers: 4/5
Keating & Will, 2011	80	39	41	40.6 (NA), 21-59	60/20	NA
Metz et al., 2009	83	39	34	40 (NA), 24-63	44/18	DM: 0/2; HTN: 0/2; BMI: 25.7/26.2;Smokers:4/6
Möller et al., 2001	112	59	53	39.1 (8.2), 21-63	99/13	NA

* Surgical patients; ** Conservative / Nonsurgica) patients

Intervention description

Surgical techniques varied, with open surgery

(Kessler technique) and minimally invasive percutaneous methods most frequently employed. Physical therapy initiation and weight-bearing protocols differed slightly between surgical and conservative groups, with most studies advocating early weight-bearing (within 1–2 weeks). Functional bracing was more common in conservative groups, such as in Myhrvold et al. (2022) and Metz et al. (2009), where it was introduced alongside physical therapy (Metz et al., 2009; Myhrvold et al., 2022) (Table 3).

Table 3: Surgical and conservative treatment details

Study ID	Surgical Group				Conservative Group						
	Open, Kessler technique.	Minimally invasive	Percutaneous	Duration	physical therapy	Weight-bearing start	Platelet-Rich Plasma	Functional Bracing	Weight-bearing start	Physical Therapy	Duration
(Myhrvold et al., 2022)	176	172	0	8 weeks	348	2 weeks.	N/A	178	2 weeks.	178	6 weeks
(Maempel et al., 2020)	33	0	0	6 weeks	33	6 weeks	N/A	31	10 weeks	31	10 weeks
(Fischer et al., 2021)	30	30	0	6 weeks	N/A	after 2 weeks	N/A	30	2 weeks	N/A	6 weeks
(Manent et al., 2019)	0	12	11	N/A	23	10 days	N/A	11	10 days	11	40 days
(Iikka Lantto et al., 2016)	32	0	0	6 weeks	32	1 week	N/A	28	1 week	28	6-7 weeks
(Olsson et al., 2013)	49	N/A	0	6 weeks	49	day 1	N/A	51	day 1	51	8 weeks
(Keating & Will, 2011)	39	0	0	6 weeks	39	6 weeks	N/A	41	10 weeks	41	10 weeks
(Metz et al., 2009)	0	31	0	7 weeks	39	After 1 week	N/A	25	After 1 week	34	7 weeks
(Möller et al., 2001)	59	0	0	N/A	59	3 weeks	N/A	53	8 weeks	53	N/A

Outcomes assessment: Across studies, no significant differences were observed in most outcome measures between surgical and conservative treatment groups. Different studies reported similar scores between patients of conservative and surgical groups, considering the scores of ATRS, VAS, and SF-36 (Myhrvold et al., 2022; Olsson et al., 2013). In addition, different studies showed slight variations between groups considering functional assessment; however, surgical groups showed slight advantages in the early stages (Iikka Lantto et al., 2016; Möller et al., 2001). Return-to-sport rates were comparable, with different studies reporting about 70–85% return-to-sport rates across both groups (Keating & Will, 2011; Manent et al., 2019). While some surgical advantages were evident in strength and early functional recovery, the conservative group outcomes converged over time, supporting both approaches as viable treatment options depending on individual patient scenarios (Table 4).

Table 4. Studies outcomes comparison between intervention/conservative groups

Study	Follow-up period/Months	ATRS	VAS	SF-36	Heel-Rise Test	ROM	Qol	FAOS	Sport and Recreation	PAS	EQ - 5D	LSI	CMJ
(Myhrvol et al., 2022)	0	O: 93.9, M: 94.2/ 92.7	NA / NA	NA / NA	NA / NA	NA / NA	NA / NA	NA / NA	NA / NA	NA / NA	NA / NA	NA / NA	NA / NA
	3	O: -43.1, M: -49.8/ -45.9	NA / NA	NA / NA	NA / NA	NA / NA	NA / NA	NA / NA	NA / NA	NA / NA	NA / NA	NA / NA	NA / NA
	6	O: -28.0, M: -31.2/ -28.8	NA / NA	O: -3.78, M: -3.87/ -3.73	69.2/72.7	ID:11.31 ° / 12.19 °, IPF: 47.58 ° / 44.43 °	NA / NA	NA / NA	70%/ 64 % returned to sport	NA / NA	NA / NA	NA / NA	75-80%
	12	O: -16.0, M: -14.7/ -17.0	NA / NA	O: -1.46, M: -1.04/ -1.03	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	85-88%/ 85-88%	NA / NA
(Maempel et	3	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	15.47/ 16.9	NA/NA	NA/NA	NA/NA	NA/NA	85/85	NA/NA
	12	94/95	NA/NA	NA/NA	NA/NA	NA/NA	0.0/1.48	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA
(Fischer et al.,	24	96.9 (6.07)/ 94.9 (6.07)	95.5/ 96.1	55.9/54.3	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA
(Manent et al., 2019)	12-13	P: 84, O: 79/NA	P: 82%, O: 83/100 reporting pain <2	NA/NA	85.2%/ 100% could perform monopodial heel-rise for 3 seconds	IPF: P: 20°, O:15°/ 26°	NA/NA	NA/NA	P: 82%, O: 83%/91% returned to sport	NA/NA	NA/NA	NA/NA	NA/NA
(likka Lantto et	6	NA/NA	NA/NA	PF: 97 (5)//88 (16), PP: 87(15)/ 74 (27)	NA/NA	5°/5°	Higher in Operative group	NA/NA	Activity allowed for both groups	NA/NA	NA/NA	Peak torque 110.3/ 96.5 Nm.	NA/NA
(C	0	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	0.95	NA/NA	NA/NA

											(0.11)/ 0.95 (0.13)		
	3	43 (20)/ 35 (14)	NA/NA	NA/NA	NA/NA	NA/NA	45 (18)/ 39 (15)	78 (17)/ 77 (13)	34 (22)/ 28 (17)	NA/NA	NA/NA	NA/NA	NA/NA
	6	70 (23)/ 70 (19)	NA/NA	NA/NA	89 (27)/ 81 (24)	NA/NA	63 (20)/ 61 (16)	90 (17)/ 92 (10)	68 (24)/ 69 (19)	3.86 (1.0)/ 3.86 (1.1)	0.88 (0.18)/ 0.86 (0.13)	82 %/ 76%	81 (21)/ 74 (12)
	12	82 (20)/ 80 (23)	NA/NA	NA/NA	93 (17)/ 90 (17)	NA/NA	75 (21)/ 77 (21)	94 (14)/ 94 (11)	83 (20)/ 83 (21)	4.0 (1.1)/ 4 (1.0)	0.91 (0.17)/ 0.90 (0.13)	103%/ 86 %	91 (15)/ 82 (13)
(Keating & Will, 2011)	3	NA/NA	NA/NA	15 (1.0)/ 20 (2.0)	NA/NA	ID: 7.76°/ 6.44 ° IPF: 43.18 °/ 40.38 °	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA
	6	NA/NA	NA/NA	NA/NA	NA/NA	ID: 12.58 °/14.4 9 ° IPF: 49.31 °/ 44.63 °	NA/NA	NA/NA	70 %/64 % return ed to sport	NA/NA	NA/NA	NA/NA	NA/NA
	12	NA/NA	NA/ NA	NA/NA	NA/NA	ID: 13.4 °/ 12.19 ° IPF: 50.86 ° /44.43 °	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA
(Metz et al., 2009)	6-12	NA / NA	NA/ NA	NA/ NA	No significant differe nce	No significant differe nce	NA/ NA	NA/ NA	NA/NA	NA/NA	NA/NA	No significant differe nce	NA/NA
(Möller et al., 2001)	0	NA/NA	NA/ NA	NA / NA	NA / NA	NA/NA	NA/ NA	NA/ NA	NA / NA	NA/ NA	NA/ NA	NA/ NA	NA/NA
	8	NA / NA	89.2 (10.3) / 74.9 (19.1)		NA / NA	NA / NA	NA/ NA	NA/ NA	NA / NA	NA/ NA	NA/ NA	NA/ NA	NA / NA
	6	NA / NA	83.5 (16.4) / 72.3 (19.4)	NA / NA	NA / NA	NA / NA	NA/ NA	NA/ NA	NA / NA	NA/ NA	NA/ NA	NA/ NA	NA / NA
	12	NA / NA	84.2 (13.8) / 75.9 (17.1)	NA / NA	69%/5 4% Regain ed endura	ID: 5.2/4.1	NA/ NA	NA/ NA	54%/5 4% return to norma	NA/ NA	NA/ NA	NA/ NA	NA / NA

					nce compared to the uninjured side.				l activity				

ATRS: Achilles Tendon Total Rupture Score, VAS: Visual Analog Scale, SF-36: Short Form-36, ROM: Range of Motion, FAOS: Foot and Ankle Outcome Score, EQ-5D: EuroQol five-dimension, LSI: Sport and Recreation, CMJ: countermovement jump, NA: Not Available, ID: dorsiflexion, IPF: Injured plantar flexion, O: open surgery, M: Minimally Invasive.

Meta-analysis:

Functional outcomes

Surgical treatment showed a statistically significant but small improvement in functional recovery (ATRS difference of 2.241, 95% CI: 1.004–3.478; $p < 0.001$). While significant, this difference may have limited clinical relevance given that ATRS is measured on a scale of 0–100. (Figure 2). However, for the Visual Analog Scale (VAS), scores did not differ significantly ($p = 0.168$), indicating that pain levels were comparable between the surgical and conservative groups. (Figure 3).

Complications incidence

The incidence of complications was compared between surgical and conservative treatment groups across various studies. For deep vein thrombosis (DVT), the number of cases was relatively low in both groups. Myhrvold et al. (2022) reported 1 case in each group (Myhrvold et al., 2022), while Fischer et al. (2019) reported 1 case in the surgical group and none in the conservative group (Fischer et al., 2021). Other studies, such as Maempel et al. (2020), Lantto et al. (2016), and Möller et al. (2001), observed slightly higher incidences of DVT in the conservative treatment group (Iikka Lantto et al., 2016; Maempel et al., 2020; Möller et al., 2001) (Table 5). However, the meta-analysis revealed no statistically significant difference in DVT incidence between the two groups (pooled estimate: 0.460; 95% CI: 0.163–1.302; $p = 0.144$; $I^2 = 0\%$) (Figure 4).

For infection, the surgical group generally showed a higher number of cases compared to the conservative group. For example, (Olsson et al., 2013) reported 6 cases in the surgical group and none in the conservative group, and (Keating & Will, 2011) reported 3 cases in the surgical group and none in the conservative group. However, some studies reported no infections in either group, such as (Fischer et al., 2021; Maempel et al., 2020) (Table 5). The meta-analysis indicated a trend toward a higher infection risk in the surgical group, though this difference was not statistically significant (pooled estimate: 2.217; 95% CI: 0.763–6.446; $p = 0.144$; $I^2 = 0\%$) (Figure 5).

For re-rupture, the conservative group consistently demonstrated higher rates compared to the surgical group across nearly all studies. Myhrvold et al. (2022) reported 11 cases of re-rupture in the conservative group compared to 1 in the surgical group (Myhrvold et al., 2022). Similarly, Olsson et al. (2013) reported 5 cases in the conservative group and none in the surgical group (Olsson et al., 2013), and Möller et al. (2001) observed 11 cases in the conservative group and 1 in the surgical group (Möller et al., 2001). The meta-analysis showed that surgery significantly reduced re-rupture rates compared to conservative treatment (OR = 0.182, 95% CI: 0.085–0.391; $p < 0.001$), translating to an approximately 82% lower risk of re-rupture. This suggests that surgical intervention may be preferred for physically active individuals who require a stronger and more resilient tendon recovery (Figure 6).

Table 5: Complications' incidence between groups

	DVT	Infection	Re-rupture

	Surgical	Conservative	Surgical	Conservative	Surgical	Conservative
(Myhrvold et al., 2022)	1	1	2	2	1	11
(Maempel et al., 2020)	0	2	0	0	2	4
(Fischer et al., 2021)	1	0	0	0	0	2
(Manent et al., 2019)	0	0	2	0	0	0
(Lantto et al., 2016)	0	0	1	0	1	4
(Olsson et al., 2013)	1	2	6	0	0	5
(Keating & Will, 2011)	0	2	3	0	2	4
(Metz et al., 2009)	0	1	N/A	N/A	0	5
(Möller et al., 2001)	0	1	1	0	1	11

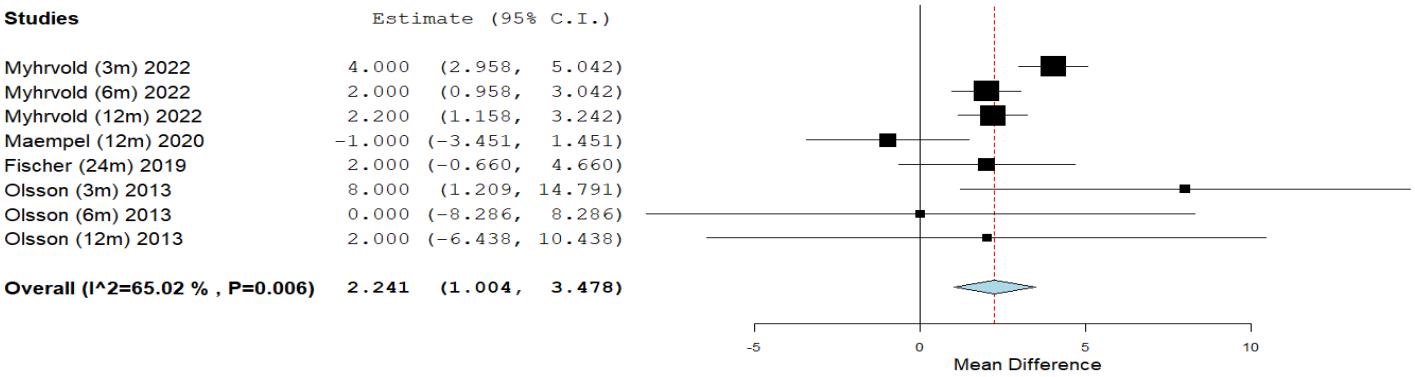

Figure 2: The forest plot of the difference between surgical and conservative techniques considering ATRS scores.

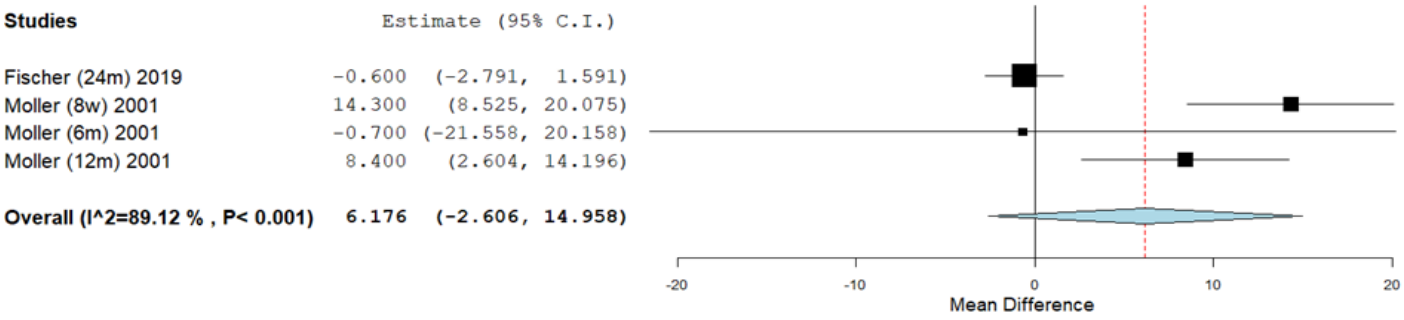

Figure3: The forest plot of the difference between surgical and conservative techniques considering VAS scores

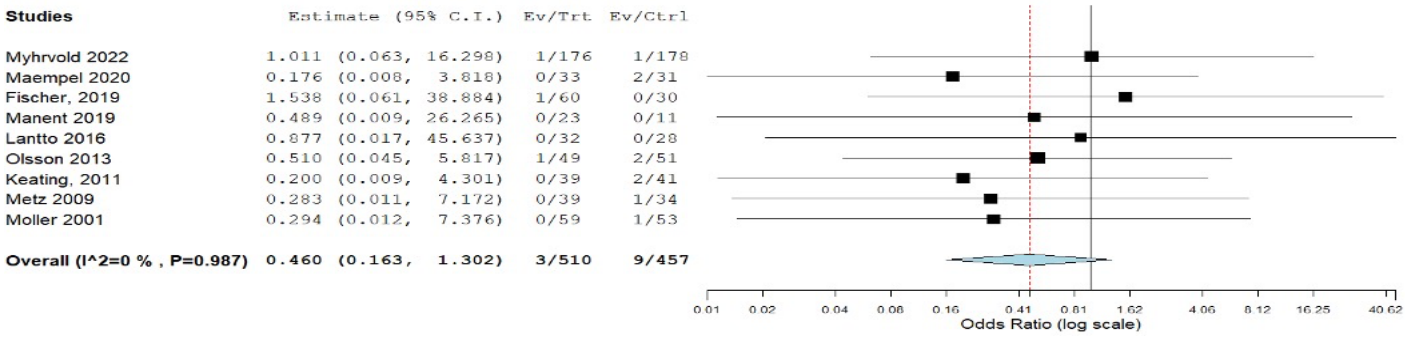

Figure 4: The forest plot of the difference between surgical and conservative techniques considering DVT prevalence

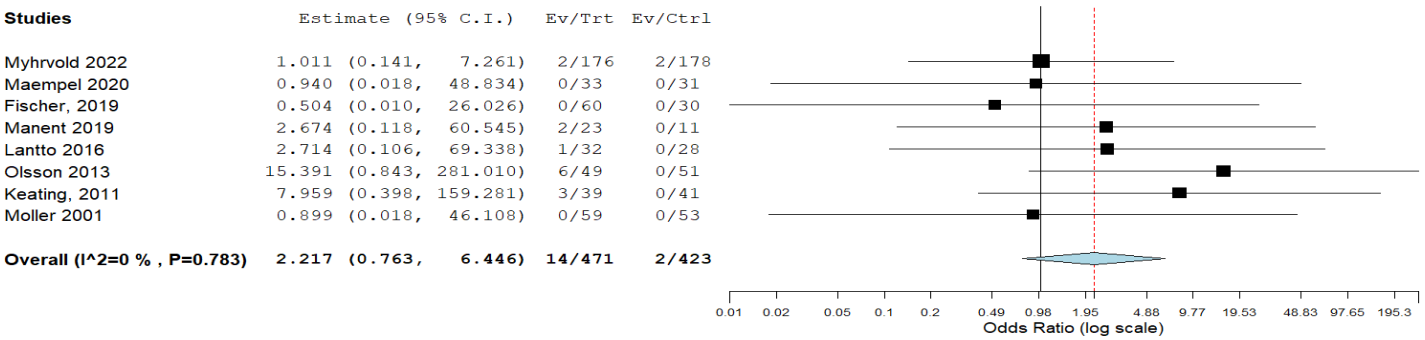

Figure 5: The forest plot of the difference between surgical and conservative techniques considering infection prevalence.

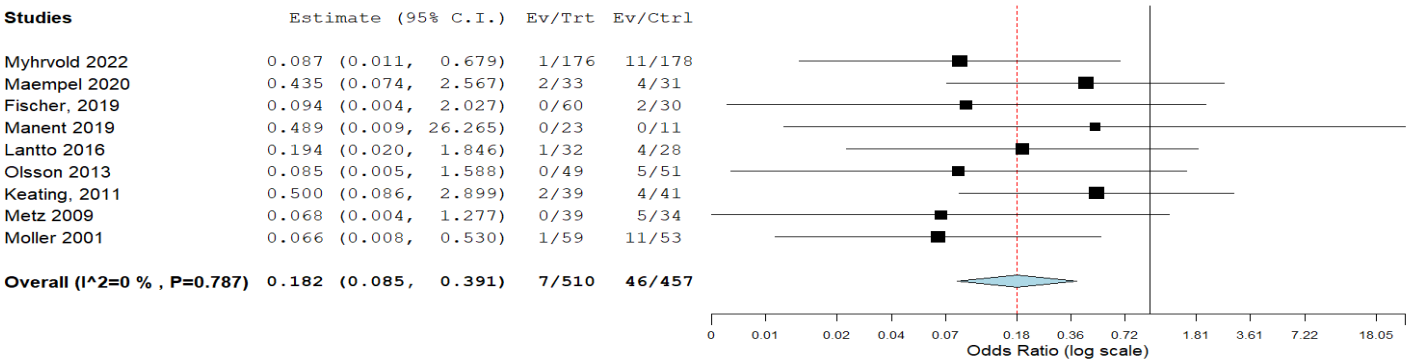

Figure 6: The forest plot of the difference between surgical and conservative techniques considering re-rupture incidence

Assessment of Risk of Bias

According to the current assessment of the risk of bias, most studies showed a low level of bias risk across different domains 20-25. However, only two studies reported a high risk of bias mainly because of incomplete outcome data reporting 17,18, and one study reported a low to moderate risk of bias because of unclear attrition bias 18 (Table 6).

Table 6: Risk of bias assessment

Authors/Year	Selection Bias	Performance Bias	Detection Bias	Attrition Bias	Reporting Bias	Other Bias	Overall RoB
(Myhrvold et al., 2022)	L	N/A	N/A	L	L	NONE	Low
(Maempel et al., 2020)	L	N/A	N/A	L	L	NONE	Low
(Fischer et al., 2021)	L	N/A	N/A	H	L	NONE	High
(Manent et al., 2019)	L	N/A	N/A	L	L	NONE	Low
(Lantto et al., 2016)	L	N/A	N/A	L	L	NONE	Low
(Olsson et al., 2013)	L	N/A	N/A	H	L	NONE	High
(Keating & Will, 2011)	L	N/A	N/A	L	L	NONE	Low
(Metz et al., 2009)	L	N/A	N/A	U	L	NONE	Low to Moderate
(Möller et al., 2001)	L	N/A	N/A	L	L	NONE	Low

Discussion

The current systematic review and meta-analysis

provide different insights into the comparison between surgical and conservative management of Achilles tendon ruptures depending on randomized controlled trials that were conducted in different settings. The results mainly showed that surgical management provides early recovery. However, associated with a higher risk of complications, there is no significant difference in outcomes between the two strategies considering functional outcomes, pain, or quality of life.

Re-rupture Rates and Complications

The surgical group demonstrated a significantly lower risk of re-rupture compared to the conservative group, a finding consistent across most studies. For example, two studies showed an observed reduction in rates of rupture among patients with surgical management than conservative management (Myhrvold et al., 2022; Olsson et al., 2013). These results were also confirmed by the results of the meta-analysis, which showed that surgical management was associated with a significantly lower incidence of rupture than conservative management. These findings were also reported by some previous systematic reviews, including the study by Soroceanu et al., which showed significantly lower re-rupture risk among patients who underwent surgical intervention (Soroceanu et al., 2012). However, other systematic reviews showed no difference in the prevalence of re-rupture between surgical and conservative management (Acevedo et al., 2024; Deng et al., 2023). This reduced risk of re-rupture among patients who underwent surgical management is associated with the mechanical stability provided by the surgery that mainly facilitates the mobilization at earlier stages and prevention of tendon re-rupture (Mao & Wu, 2020; Schellnegger et al., 2024).

Nevertheless, the use of minimally invasive techniques, such as percutaneous repair, may mitigate this risk (Carmont et al., 2011; Lee et al., 2024). Additionally, the surgical group was associated with a higher—though the difference was insignificant statistically—rate of infections. For instance, Olsson et al. (2013) and Keating et al. (2011) revealed the development of more infections in surgically treated patients, with surgery being prone to wound-related complications such as invasive procedures.

Deep Vein Thrombosis (DVT) Risk

In addition, The DVT rate difference was insignificantly detected in either of the groups. This result is in agreement with a significant amount of literature that produced no evidence of variation in the risk of DVT between surgical and non-operative treatments (She et al., 2021; Svedman et al., 2020). Proper administration of anticoagulants might also be regarded as being responsible for this best result.

Functional Outcomes and Patient-Reported Measures

Some of the patient-reported outcomes, such as the Achilles Tendon Rupture Score (ATRS) and Visual Analog Scale (VAS) for pain, showed no significant disparities between groups in the long run. However, While the ATRS difference was statistically significant (2.241; 95% CI: 1.004–3.478; $p< 0.001$), it falls below commonly accepted thresholds for clinical significance (≥5 points difference). Thus, the functional benefit of surgery may not be substantial in real-world settings. In earlier reviews and works, similar to the reality of small but significant benefits in the functional results have been reported as a result of surgical intervention (Sankova et al., 2024; Westin et al., 2018).

Early functional recovery, including strength recovery and range of motion (ROM), appeared to favor the surgical group in the short term. Studies such as Möller et al. (2001) and Lantto et al. (2016) highlighted the surgical group's superior outcomes in strength assessments and heel-rise tests (Iikka Lantto et al., 2016; Möller et al., 2001). However, conservative treatment outcomes converged with surgical outcomes over time, supporting its viability as a non-invasive approach. These findings are supported by earlier research which demonstrated no long-term differences in functional outcomes

between the two approaches (Abduljawad et al., 2024; Nilsson et al., 2021).

Return to Sport and Quality of Life

Return-to-sport rates were comparable between groups, with most studies, such as Manent et al. (2019) and Keating et al. (2011), reporting rates between 70% and 85% (Keating & Will, 2011; Manent et al., 2019). These findings suggest that both treatment modalities are effective in restoring pre-injury activity levels. Quality-of-life measures, including SF-36 and EQ-5D, also demonstrated no significant differences between groups, consistent with prior research by Hua A et al. (Hua et al., 2018).

Considerations for High-Demand vs. Low-Demand Patients

The choice between surgical and conservative treatment should be tailored to the patient's activity level. Athletes and high-demand individuals may benefit from surgical intervention due to faster recovery and lower re-rupture rates, which are crucial for their return to peak performance. Previous studies in the literature suggest that elite athletes often undergo surgery to optimize tendon strength and function (Mansfield et al., 2022; Marrone et al., 2024).

Conversely, low-demand and non-athlete patients may prefer conservative management, as it avoids surgical risks while still providing comparable long-term outcomes. Recent research, including Myhrvold et al. (2022) and Metz et al. (2009), supports the use of early functional rehabilitation protocols in conservative treatment to achieve similar outcomes. This emphasizes the importance of individualized treatment planning based on the patient’s lifestyle and functional goals.

Clinical Implications and Future Directions

While surgical treatment offers clear advantages in reducing re-rupture rates and achieving faster functional recovery, it is associated with a higher risk of infection and scar-related complications. On the other hand, conservative management avoids surgical risks but carries a slightly higher risk of re-rupture, particularly in high-demand patients. These findings underscore the importance of tailoring treatment strategies to individual patient needs, considering factors such as activity levels, comorbidities, and preferences.

Future research should focus on refining conservative protocols, particularly the role of early functional rehabilitation. Additionally, adjunctive therapies such as platelet-rich plasma (PRP) or tendon scaffolds could enhance tendon healing, warranting further investigation in randomized trials. Finally, a cost-effectiveness analysis could inform healthcare decision-making.

Strengths and Limitations

This study synthesized data from high-quality randomized trials conducted across multiple countries, providing robust and generalizable evidence. However, heterogeneity in follow-up durations, surgical techniques, and rehabilitation protocols may limit the direct comparability of findings. Furthermore, the underreporting of comorbidities in some studies, such as BMI and smoking prevalence, may have introduced residual confounding.

Conclusion

Both surgical and conservative management remain viable options for Achilles tendon rupture. Surgical repair significantly reduces re-rupture risk and promotes faster functional recovery but carries a higher risk of wound complications. Conservative treatment offers comparable long-term outcomes while avoiding surgery-associated risks. The decision should be tailored to the patient’s activity level, surgical risk profile, and treatment preferences, emphasizing shared decision-making between clinicians and patients.

Author Contributions

All authors significantly contributed to the work reported, including conception, study design, execution, data acquisition, analysis, and

interpretation. They actively participated in drafting, revising, or critically reviewing the manuscript, provided final approval of the version to be published, agreed on the journal submission, and accepted accountability for all aspects of the work.

Data Availability Statement

The authors will transparently provide the primary data underpinning the findings or conclusions of this article, without any unjustified reluctance. If need from editorial team.

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Conflicts of Interest

The authors declare no potential conflicts of interest related to the research, writing, or publication of this work.

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