Open versus percutaneous repair of acute Achilles tendon rupture: a systematic review

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Background
The Achilles tendon is the strongest in the human body. It is most frequently ruptured in the third and fourth decade of age. Most studies have reported that usually ruptures during sports practice.
Objective
To compare open repair (OR) versus percutaneous repair (PR) for treating acute Achilles tendon rupture in a systematic review and evaluate the functional outcomes of each method.
Patients and methods
This systematic review is based on six articles selected from 5507 studies using PubMed, Google Scholar, and Cochrane Library. Articles included showed 329 patients with acute Achilles tendon ruptures. There were 165 patients who had an open surgical repair and 164 patients who had a PR with a mean follow-up of 23 months (range, 20–24 months). Variables of each article were recorded and analyzed with respect to age, sex, follow-up, complications, and final outcomes.
Results
The study revealed that there was a statistically significant difference between both groups regarding operative time to be faster in PR but regarding return to work it was faster in OR. Also, there was statistical significance difference regarding American Foot and Ankle Outcome Score to be higher for OR. Both groups did not significantly differ in re-rupture rate, infection, Achilles tendon Total Rupture Score and wound complications.
Conclusion
OR is a more traditional approach that involves making a larger incision to access the tendon. This allows the surgeon to have a more direct visualization of the tendon and to place the sutures more precisely. However, OR also carries a higher risk of complications, such as wound infection. PR is a newfound method with fewer complications and a better cosmetic appearance.

Keywords:
Achilles tendon, minimally invasive repair, open repair, percutaneous

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Introduction

Achilles tendon injuries mostly occur during sports activities in the third or fourth decade of life [1]. There are too many risk factors for spontaneous Achilles tendon rupture such as intratendinous injection of steroids, steroid therapy, rheumatoid arthritis, fluoroquinolones, and long-term dialysis [2]. The most common injury site is 6 cm above the calcaneal tuberosity because of its poor vascularity [3].

Management of acute Achilles tendon rupture has been controversial for decades and usually depends upon the surgeon and patient preference, between different types and techniques of surgical management and nonsurgical treatment. The surgical management can be open repair (OR) or percutaneous repair (PR) and the nonsurgical management includes cast immobilization or functional bracing [4–6].

The purpose of this study is to compare open versus PR for treating Achilles rupture in a systematic review and evaluate the functional outcomes of each method. The hypothesis of the study was that PR would result in fewer wound complications and a quicker return to work.

Aim

To compare open versus PR for treating Achilles rupture in a systematic review and evaluate the functional outcomes of each method.

Patients and methods

This systematic review was prepared with a careful following of the Cochrane Handbook for Systematic Reviews of Interventions and adhered to The Preferred Reporting Items for Systematic Reviews (PRISMA) guidelines during the design of the study. This study was approved by Ain Shams University ethical committee (MS 610/2022). As this article does not contain any studies involving human subjects, informed consent was not required.

Included studies that met the review had the following inclusion criteria

Population

Patients with acute Achilles tendon rupture. Intervention: OR versus PR.

Types of outcome measures

Primary outcomes: re-rupture rate, complication rate (e.g. infection, scar, sural nerve injury), Achilles tendon rupture score (ATRS), and American Orthopedic Foot and Ankle Society Score (AOFAS). Secondary outcomes: time to return to work, time to return to sport, range of movement of the ankle, and duration of surgery.

Eligibility criteria

Inclusion criteria

Adult patients (age 17–65 years), less than 14 days after injury, functionally complete Achilles tendon rupture, isolated Achilles tendon rupture, able to follow rehabilitation protocol, English literature only, closed rupture, studies included were randomized control trials and clinical trials between 2009 and 2023.

Exclusion criteria

Avulsion from the calcaneus, open rupture, former application of local steroid injection, pregnancy, previous Achilles tendon rupture, and Achilles tendinopathy.

Search methods for identifying studies

The review was based on a literature search on published studies using PubMed, Google Scholar, and Cochrane Library.

Keywords used

'Achilles tendon,' 'open repair,' 'minimally invasive repair,' 'percutaneous.'

The study was based on 'OR' and 'AND' operators during the Literature search as follows: • ('Achilles tendon') AND ('open' OR 'percutaneous' OR 'minimally invasive').

Data extraction

The characteristics of each study were selected as follows: study design, sample size, age, sex, duration of follow-up, and outcomes that were reported consistently across the included studies as regards: re-rupture rate (at any time reported), complication rate, wound infection, deep venous thrombosis, sural nerve lesion, return to sport, ankle range of motion and acute ARTS.

Statistical analysis

Data were collected, revised, and entered the Statistical Package for Social Science (IBM SPSS, Chicago, Illinois, USA), version 23. The quantitative data were presented as mean, SDs, and ranges when parametric. Also, qualitative variables were presented as numbers and percentages. The comparison between groups with qualitative data was done by using the χ^2 test. The comparison between two groups with quantitative data and parametric distribution was done by using an independent t test. The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the P value was considered significant as the following: P value more than 0.05: nonsignificant. P value less than 0.05: significant. P value less than 0.01: highly significant.

Statistical considerations

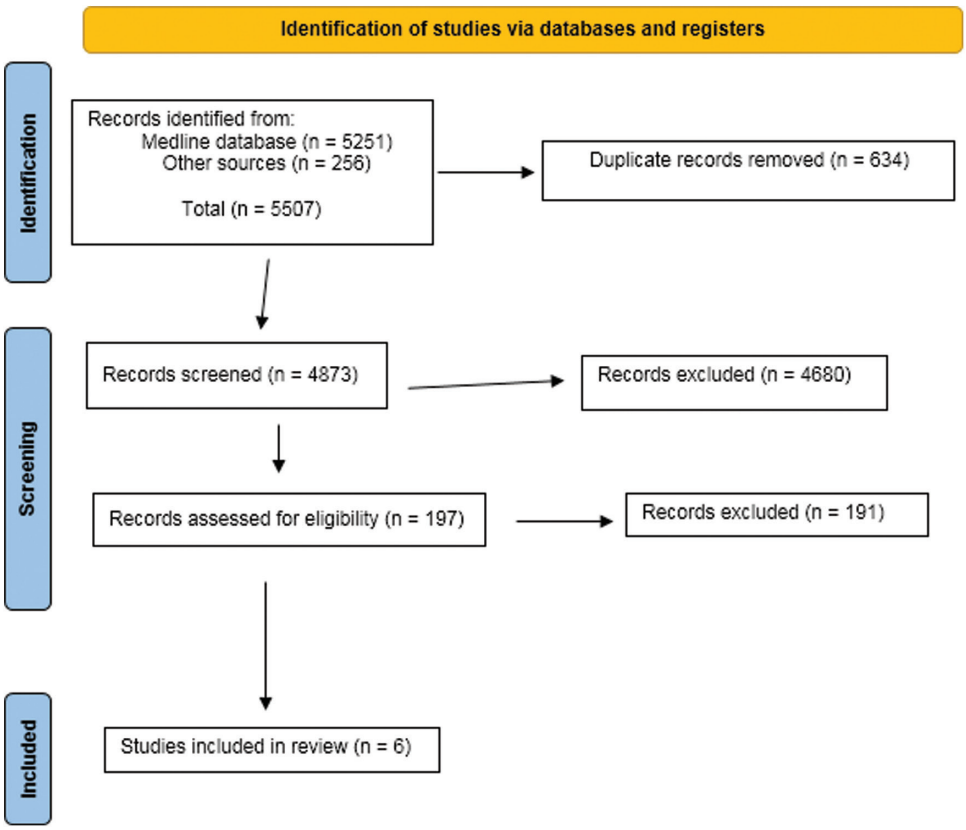
Outcomes from included trials were combined using the systematic review manager software and manually screened for eligibility to be included. PRISMA flowchart was produced based on the search results and the inclusion/exclusion criteria.

This study conducted a literature search on published studies using PubMed, Google Scholar, and Cochrane Library. Searching for the articles through PubMed revealed 5251 articles while the others revealed 256 articles. The Mendeley system was utilized to remove duplicates, resulting in a total of 634 duplicates being removed, leaving behind 4873 unique articles. Out of these, 4680 articles were excluded as they were either case reports or case series. Further exclusion of articles based on title and abstract resulted in 197 remaining articles. One hundred ninety-one articles excluded that were not eligible based on inclusion and exclusion criteria, cost-paid articles and chronic ATR giving a total of six articles for this review as following PRISMA (Fig. 1).

Results

This systematic review was based on six articles with 329 patients having acute Achilles tendon ruptures treated with open and PR. There were 165 patients who had OR and 164 patients who had PR. The summary

Figure 1



Flow diagram showing the protocol of study selection.

of studies characteristics and summary of findings are shown in Table 1. The follow-up duration, age, sex, and characteristics of patients were demonstrated in Table 2.

This study demonstrated that PR is superior to OR as regard AOFAS and operative time. But, regarding return to work, it was faster in OR (Tables 3-5). The had 97.2 points regarding AOFAS while 95.97 points were for PR. The average operative time for percutaneous was 35.47 min which was faster than OR taking 61.59 min. Scar length in PR was much smaller than OR (4 cm PR, 14.5 cm OR).

Both groups did not significantly differ in re-rupture rate, infection, ATRS, return to sport and other complications (Tables 6, 7). Re-rupture in OR recorded in four (2.4%) patients while in PR was less (three patients 1.8%) but that was statistically insignificant. Superficial infection scored 4.4%, deep infection was 2.2% in OR but better in PR as it was 1.1% with superficial infection and 0% with deep infection. Regarding ATRS, the OR scored 94.97 points while PR scored 95.25 points which is better. Seventy patients in OR returned to sport while 81 patients in PR returned to sport. ROM for OR regarding dorsiflexion and plantar flexion postoperative was about 15.83 degrees and 39.09 degrees, respectively while in PR it was 16.73 degrees for dorsiflexion and 37.51 degrees for plantar flexion. Regarding complications which were less in PR, deep venous thrombosis was in one patient in OR but more in PR with two patients. One patient had sural nerve injury (0.7%) in OR but more in PR with three (2.2%) patients. Other wound problems like delayed healing and scars were more in OR with seven (5.4%) patients but less in PR with six (4.8%) patients.

Discussion

This is a systematic review comparing the two techniques for treating acute Achilles tendon rupture – open technique versus percutaneous technique. Regardless of the method of choice, the objectives are the same – to restore tendon anatomy, avoid major complications, and achieve the best outcomes for the patient.

The hallmark finding of this study was that patients with acute Achilles tendon rupture experienced better clinical outcomes regarding operative time after using the percutaneous technique compared with the open technique.

There was statistical significance difference regarding time to return to work and AOFAS to be better in

Table 1 Summary of findings

References	Country	Type of study	Findings	Method of repair	Journal
Fischer *et al*. [7]	Germany	Prospective RCT	There was one re-rupture recorded for each group of repair with no significant difference could be found in patients treated by each technique at 24-month follow-up	OR: Krakow end-to-end PR: Dresden instrument	Archives of Orthopedic and Trauma Surgery
Kołodziej *et al* [8]	Poland	Prospective RCT	No Achilles tendon re-rupture or nerve injury occurred in treated patients. There were two cases of wound infections in the open surgery group, and one superficial wound infection occurred in the percutaneous group. The groups were not significantly different in the amount of pain, range of ankle movements or time to return to work and sports	OR: Krakow end-to-end PR: Achillon device	International Orthopedics
Makulavičius *et al*. [9]	Spain	Prospective RCT	No statistically significant difference was observed between groups in ATRS score and time back to work. The percutaneous technique was much faster. Overall 13 complications occurred in both groups (5 and 8 respectively). No deep infection occurred, and no revisions were needed	OR: Crown type repair PR: Bunnell type repair	The Journal of Foot & Ankle Surgery
Wang *et al*. [10] 2020	China	Comparative clinical trials	There were no significant differences between the two groups in the ATRS, AOFAS score. One patient in OR had delayed wound healing, which resolved in 40 days	OR: bundle-to-bundle suture technique PR: modified Bunnell suture technique	BMC Musculoskeletal Disorders
Karabinas *et al*. [11] 2014	Greece	Comparative clinical trials	No significant difference was observed regarding complications. The mean time of patients' return to work was 7 weeks for the open group and 9 weeks for the percutaneous group. As expected, cosmetic appearance was significantly better in the percutaneous repair group. No patient experienced other complications such as re-rupture and infection	OR: Krakow end-to-end PR: Ma and Griffith's technique	European Journal of Orthopaedic Surgery and Traumatology
Aktas and Kocaoglu [12] 2009	Turkey	Prospective RCT	The AOFAS clinical outcome scores were 98.7 in open group, 96.8 in percutaneous group with no significant difference. The surgical outcome concerning infection, scar and other complications was better in percutaneous group	OR: Krakow end-to-end PR: Achillon device	Foot & Ankle International

AOFAS, American Foot and Ankle Outcome Score; ATRS, Achilles tendon Total Rupture Score; OR, open repair; PR, percutaneous repair; RCT, randomized control trial.

Table 2 Distribution of included cases in each study, age, sex, and follow-up duration

References	No.	Groups no.	Age±SD	Sex (M/F)	Mean follow up/months
Fischer *et al*. [7]	60	OR 22	39.60±7.30	26/4	24
		PR 24	39.30±7.90	28/2	
Kołodziej *et al* [8]	47	OR 25	47.10±13.3	24/1	24
		PR 22	44.80±9.20	21/1	
Makulavičius *et al*. [9]	87	OR 44	37.82±10.1	39/5	27
		PR 43	35.93±9.50	38/5	
Wang *et al*. [10]	61	OR 31	41.46±1.20	28/3	23.17
		PR 30	40.06±1.80	28/2	
Karabinas *et al*. [11]	34	OR 15	40.00±5.50	13/2	22
		PR 19	42.00±8.30	15/4	
Aktas and Kocaoglu [12]	40	OR 20	40.60±7.90	17/3	22.5
		PR 20	39.20±7.50	18/2	

F, female; M, male; OR, open repair; PR, percutaneous repair.

OR. On the contrary, re-rupture, infection, ATRS and return to sport were statistically insignificant between open and percutaneous techniques.

The meta-analysis held by Gatz *et al*. [13] empathized the study results regarding re-rupture which were equal among both groups without a significant difference as 24 of 1009 patients in the open group while 23 of 1097 patients in the percutaneous group (P=0.75). The open group reported a lower rate of sural nerve palsy (P=0.001). In the percutaneous group, a shorter surgery duration (P<0.0001) has been evidenced, a lower rate of postoperative wound necrosis (0.006) and a reduced risk of developing scar tissue adhesions (P<0.0001) were noted.

Results in this study were in line with meta-analysis of Yang *et al*. [14] regarding the duration of surgery as it was 24–54.55 min in the percutaneous group and

Table 3 The comparison between open repair group and percutenous repair group shows high statistical significance regarding operative time

References	No.	Operative time (min)			
		No.	OR (mean±SD)	No.	PR (mean±SD)
Makulavičius *et al*. [9]	87	44	61.59±13.80	43	35.47±11.30
Total	87	44	61.59±13.80	43	35.47±11.30
P value			<0.001 (HS)·		

Percutaneous repair (PR) was a much faster procedure than open repair (OR).
Highly significant (HS) using independent *t* test.

Table 4 The comparison between open repair group and percutaneous repair group regarding (American Foot and Ankle Outcome Score) indicates a high statistical significance difference being higher in open repair group

References	No.	AOFAS			
		No.	OR (mean±SD)	No.	PR (mean±SD)
Fischer *et al*. [7]	60	30	96.90	30	96.50
Wang *et al*. [10]	61	31	95.40±3.60	30	95.38±3.40
Karabinas *et al*. [11]	34	15	98.00±2.30	19	95.00±4.00
Aktas and Kocaoglu [12]	40	20	98.50±2.10	20	97.00±5.70
Total	195	96	97.20±1.37	99	95.97±0.94
P value			<0.001 (HS)·		

AOFAS, American Foot and Ankle Outcome Score.
Highly significant using independent *t* test.

Table 5 A statistical significance between the two groups regarding time to return to work (*P*=0.042): the open group returned to work in 7.3 weeks, while the percutaneous group returned after 8.2 weeks

References	Year	No.	Time to return to work (weeks)			
			No.	OR (mean±SD)	No.	PR (mean±SD)
Kołodziej *et al* [8]	2012	47	25	5.50±2.70	22	4.80±2.20
Makulavičius *et al*. [9]	2019	87	44	9.60±5.60	43	10.80±10.0
Karabinas *et al*. [11]	2013	34	15	7.00	19	9.00
Total		168	84	7.37±2.07	84	8.20±3.08
P value				0.042 (S)∞		

∞Significant using independent *t* test.

Table 6 The comparison between open repair group and percutaneous repair group regarding re-rupture, both types were very close regarding this complication without statistically significant difference

References	No.	Re-rupture			
		No.	OR [*n* (%)]	No.	PR [*n* (%)]
Fischer *et al*. [7]	60	30	1 (3.3)	30	1 (3.3)
Kołodziej *et al* [8]	47	25	0	22	0
Makulavičius *et al*. [9]	87	44	3 (6.8)	43	2 (4.7)
Wang *et al*. [10]	61	31	0	30	0
Karabinas *et al*. [11]	34	15	0	19	0
Aktas and Kocaoglu [12]	40	20	0	20	0
Total	329	165	4 (2.4)	164	3 (1.8)
P value			0.708 (NS)		

Nonsignificant using the χ^2 test.

45.9–68.8 min in the open group. Compared with open surgery, PR showed a significant reduction in the duration of surgery (*P*=0.001).

This study was supported also by the meta-analysis held by Attia *et al.* [15]. The mean re-rupture rate was 2.5% (0–6.8%) for OR versus 1.5% (0–4.6%) for PR, with a nonsignificant statistical difference (*P*=0.50). No cases of sural nerve injuries were reported in the OR group. The mean sural nerve injury rate was 3.4% (0–7.3%) in the percutaneous group, which was statistically significant (*P*=0.02).

Table 7 Comparison between open repair group and percutaneous repair group regarding complications

References	Year	Wound problems (delayed healing/necrosis)					Sural nerve injury					Deep venous thrombosis				
		No.	No.	OR [*n* (%)]	No.	PR [*n* (%)]	No.	No.	OR [*n* (%)]	No.	PR [*n* (%)]	No.	No.	OR [*n* (%)]	No.	PR [*n* (%)]
Fischer *et al*. [7]	2020	60	30	5 (16.7)	30	3 (10)			–			60	30	0	30	1 (3.3)
Kołodziej *et al*. [8]	2012	47	25	1 (4.0)	22	1 (4.5)	47	25	0	22	0			–		
Makulavičius *et al*. [9]	2019	87	44	0	43	2 (4.7)	87	44	0	43	3 (7.0)	87	44	0	43	1 (2.3)
Wang *et al*. [10]	2020	61	31	1 (3.2)	30	0	61	31	0	30	0			–		
Karabinas *et al*. [11]	2013			–			34	15	1 (6.7)	19	0			–		
Aktas and Kocaoglu [12]	2009			–			40	20	0	20	0	40	20	1 (5.0)	20	0
Total		255	130	7 (5.4)	125	6 (4.8)	269	135	1 (0.7)	134	3 (2.2)	187	94	1 (1.1)	93	2 (2.2)
P value				0.832 (NS)					0.310 (NS)					0.554 (NS)		

There was no significant difference between the two groups in terms of wound problems, deep venous thrombosis, and sural nerve injury, although the percutaneous repair group had slightly more patients with this injury, with a *P* value of 0.310.
Non-significant using the χ^2 test.

Moreover, the results met the meta-analysis of eight studies by Grassi *et al.* [16] as it showed a significant decrease in complications (*P*=0.00001) regarding PR. In the meta-analysis held by Yang *et al.* [14], no significant difference was seen regarding the rate of re-rupture. The sural nerve injury rate in the percutaneous group was significantly higher (*P*=0.006). However, the deep infection rate in the open group was higher (*P*=0.04).

The results were supported by a meta-analysis conducted by Buono *et al.* [17] regarding scar length as they reported that twelve studies fulfilled our inclusion criteria. Of a total of 781 patients, 375 underwent OR and 406 percutaneous surgeries. Different procedures were performed for open and PR. The average size of the scar was 12 cm (from 9.5 to 14.5 cm) long for patients undergoing OR and 3.4 cm (range from 2.9 to 4.0 cm) long for those in whom percutaneous surgery had been undertaken (*P*<0.0532).

Finally, results in Grassi *et al.* [16] showed that no differences between groups were found with respect to sural nerve injury, return to pre-injury activity level, and time to return to work. Also, the mean postoperative AOFAS score was 94.8 and 95.7 for OR and PR, respectively, with a nonsignificant difference (mean difference; *P*=0.14) by the meta-analysis held by Attia *et al.* [15].

However, there are certain limitations to the present analysis, which are as follows: the limited number of included studies, individual studies had variations in exclusion/inclusion criteria and surgical skills varied between studies and surgeons. Points of strength in this review were that it was based only on randomized controlled trials and clinical trials. Also, the review reflected most postoperative complications regarding both methods.

Conclusion

OR is a more traditional approach that involves making a larger incision to access the tendon. This allows the surgeon to have more direct visualization of the tendon and to place the sutures more precisely. However, OR also carries a higher risk of complications, such as wound infection. PR is a newer technique that involves making several small incisions to pass sutures through the tendon.

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Conflicts of interest

The authors declare that they have no conflict of interest.

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