

Review

Tendon allograft for treatment of chronic Achilles tendon rupture: A systematic review



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ABSTRACT

Background: To summarize available evidence and determine if tendon allograft is an effective treatment for chronic Achilles tendon rupture.

Methods: A search was performed in the PubMed, Web of Science, Embase and Cochrane Database from 1960 to April 2017 to identify relevant articles. Predefined inclusion and exclusion criteria were applied to identify all eligible articles.

Results: Total 186 articles were identified through our systematic search. Of these, 9 publications met the inclusion criteria. Five studies were case reports; three were case series; and one were expert opinion. Of a total 35 patients, 34 underwent Achilles tendon allograft repair and 1 peroneus brevis tendon allograft reconstruction. All patients experienced good clinical and functional results, but most reports used non-validated outcome measures.

Conclusions: The evidence suggests that tendon allograft offers favorable outcomes in patients with chronic Achilles tendon rupture. However, randomized controlled trials which use validated functional outcome measures are required to determine effectiveness of this intervention.

Level of evidence: Level V, systematic review of Level IV and V studies.

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1. Introduction

Ruptures of the Achilles tendon are common ankle and foot injuries, which can be misdiagnosed easily by the initial physical examination as 25% of the time [1–4]. Achilles tendon rupture is considered as chronic if it has been delayed in diagnosis or treatment at least for 4–6 weeks [5,6]. And there is a consensus that chronic

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ruptures should be managed operatively. Numerous surgical techniques have been demonstrated. For example, V-Y advancement has been used for treatment of chronic Achilles tendon rupture [7–9]. While transfer augmentations, such as synthetic materials [10–12], free tissue transfer [13–16], tendon autograft [17–24] and tendon allograft [25–34], are indicated to present better surgical results in cases of extensive tendon defects gap. However, there has not been a gold standard of treatment for neglected ruptures of Achilles tendon. Synthetic materials cannot function as biologic grafts and are incapable of remodeling [35,36]. Although autologous tendon and turn-down flap are performed widely to reconstruct the Achilles tendon with chronic rupture, autografts which are insufficient may cause a morbidity at the donor site and require a second incision [33,37]. It appears that tendon allograft might be an optimal surgical management. Allografts are free from these disadvantages discussed above and can shorten operating time as well. Besides, allografts for reconstruction of the anterior cruciate ligament (ACL) and lateral ankle ligament have provided satisfactory clinical results in our previous studies [38–40]. The concerns of using allografts are potential disease transmission, risk of immune response, timely incorporation of the graft at the host recipient site and increased cost [15,41]. Nevertheless, the risk of disease transmission associated with the use of allograft tendons are extremely low [42–45]; and methods for procuring allografts (freeze-drying, fresh freezing) minimize their antigenicity, so that immunologic reaction and rejection is not an issue [46–48]. Earlier studies have shown that allografts may affect postoperative laxity and cause a higher failure rate after anterior cruciate ligament reconstruction due to their slow remodeling [49,50]. However, there is no such conclusion made on the use of allografts for Achilles tendon reconstruction. Overall, the aim of this systematic review is to evaluate the available literature and determine if tendon allograft is a comparable treatment for chronic ruptures of Achilles tendon.

2. Materials and methods

2.1. Search strategy

An electronic literature review was completed using PubMed, Web of Science, Embase and Cochrane Database from 1960 up to April 2017, combining the following search terms: (Achilles AND tendon OR tendo AND allograft AND reconstruct* AND repair*). A secondary search of references from articles selected was also performed, and one relevant article was found.

2.2. Inclusion and exclusion criteria

We included the following:

1. All studies reporting clinical and functional outcomes of patients who had undergone tendon allograft surgery for repair of chronic Achilles tendon ruptures.
2. All patients aged over 18 years.
3. All studies published in English.

Studies were excluded if they

1. Were acute ruptures (less than 14 days);
2. Were tendon autograft treatment;
3. Were animal studies, reviews or letters;

2.3. Outcome measures

We considered all subjective functional outcomes including range of movement, calf circumference, repetitive single-heel

risks, American Orthopedic Foot and Ankle Society Scale score (AOFAS); Achilles tendon rupture score (ATRS), patient returned to work as the primary outcome measures. Complications such as re-ruptures, infections were secondary outcome measures.

2.4. Risk of bias and quality assessment

We assessed the risk of bias of studies using the Coleman Methodology Score (CMS) [51]. The CMS assesses methodology of each study using 10 criteria to give a total score between 0 and 100. A score approaching 100 represents the study has an ideal design and largely avoids the influence chance, various biases, or confounding factors.

2.5. Data extraction

We performed data extraction from each included publication. Extracted characteristics of the included studies were as follows: authors details, level of evidence, outcome measures, results and authors' conclusions.

3. Results

From the initial 186 relevant articles identified, 168 publications were excluded based on title and abstract, because they did not meet the inclusion criteria. Subsequently, 10 were excluded: 9 due to duplications; 1 did not report any patient-derived information. In addition, one relevant paper was found within the reference list of a screened article. Consequently, a total of 9 studies were included. A flow chart of the literature is presented in Fig. 1. Five of the studies were case reports; three were case series; and one were expert opinion. They all used tendon allograft operative management. Table 1 details the findings for each of the included studies. We did not identify any published randomized controlled trials (RCTs). According to the Coleman Methodology Score, the quality assessment of studies is outlined in Table 2, and the average CMS was 60 (range 45–75) points.

Two kinds of tendon allograft were reported in the literature. 8 studies used Achilles tendon allograft and 1 study used peroneus brevis tendon allograft. The outcome measure of all articles varied. Two studies [30,31] used the AOFAS; one study [30] used the ATRS; one study [27] used FAOI (Foot and Ankle Outcomes Instrument) Core Scale score and FAOI Shoe Comfort Scale score. However, only ATRS is validated for Achilles tendon rupture [52].

Three studies [25,28,34] reported complications. Five patients (14.3%), who had treated with Achilles tendon allograft and the calcaneal bone block, experienced complications, including delayed union of the calcaneal bone block; delayed healing of the incision; infection; a fragmented calcaneal tuberosity, and interosseus ossification proximal to the insertion; heterotopic bone in the retrocalcaneal bursa adjacent to the bone block allograft. No re-ruptures happened in all cases.

Given the inconsistencies in the reporting outcomes, a meta-analysis was not deemed appropriate. The details of each procedure are described below.

3.1. Management options

3.1.1. Peroneus brevis tendon allograft

Kocabey et al. [31] presented a case report using four stands of peroneus brevis tendon allograft to bridge the defect and indicated that early range of motion and weight bearing can be achieved by this surgical technique. However, non-validated outcome measure and only one subject limit applicability.

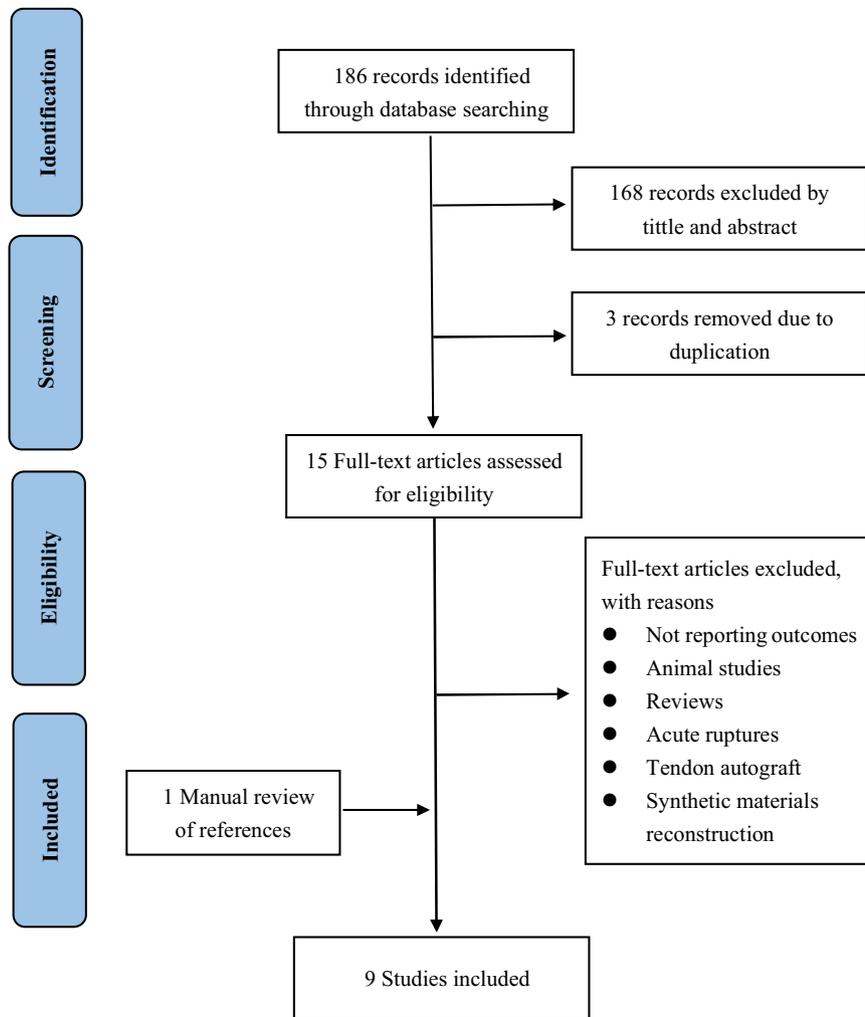


Fig. 1. Flowchart of literature selection.

3.1.2. Achilles tendon allograft

Nellas et al. [33] reported a case using an Achilles tendon allograft to replace an Achilles tendon defect first in 1996, and the other two studies [29,32] utilized the same surgical management in 2006 and 2013, respectively. These results all turned out good, but generalizability of this technique was limited because each of these studies was case report and did not use validated outcome measures.

Park and Sung [30] performed Achilles tendon allograft and flexor hallucis longus tendon transfer in 2 patients. The authors stated that FHL improved not only strength, but allograft healing due to the proximity of the muscle with its increased blood supply. The results were satisfactory. Small numbers limit its impact.

Hanna et al. [28] presented a surgical option: an Achilles tendon allograft with calcaneal bone block. The results were encouraging, but not statistically significant. Further research involves a larger number of patients with longer follow-up would be necessary.

In one series [25], 14 patients with neglected ruptures treated with an Achilles tendon allograft. This series showed promising results with a good follow-up, but few conclusions can be established due to the small patient number and non-validated outcome convention.

In another series, Hollawell and Baione [27] published that 4 patients were successfully treated with an Achilles tendon interposition allograft and simultaneous augmentation with a xenograft. Although this study reported positive results, it was

limited by having small sample size and not using a validated outcome measure.

In the other one series, Deese et al. [34] performed operations on 5 patients who were chronic ruptures and 3 patients who were chronic tendinosis, all with Achilles tendon allograft attached a calcaneal bone block. The results were good, but three complications were reported. However, the author did not demonstrate that these complications happened to what kind of patients. In order to make a firm statistical conclusion, higher-level and longer-term studies are required.

4. Discussion

This systematic review aimed to provide an overview of the current evidence regarding tendon allograft for chronic rupture of Achilles tendon. And the most valuable finding is that this effective technique can provide satisfactory clinical results.

The majority of literatures utilizing tendon allografts have focused on reconstruction of anterior cruciate ligament and the patellar tendon, which started in the late 1980s [36,53–58]. By contrast, its use for chronic Achilles tendon rupture is limited. In most of the patients, the quality of the remaining tendon was good and defect gap was small, therefore, performing V–Y advancement or gastrocnemius fascial turn-down flaps can fix the deficit. Further, autografts offer the advantage of tissue compatibility, which have been widely utilized for reconstruction of Achilles

Table 1
The included studies' repair methods and outcomes^a.

Author	Deficit (cm)	Repair method	Outcome measures Function & re-rupture & complications
Kocabey et al. [31]	6.8	Peroneus brevis tendon allograft	16 full-range standing heel raises at the involved side versus 24 at the noninvolved side (33% deficit); the maximum calf circumference was 31 versus 34 cm at the noninvolved side (9% deficit); recreational doubles tennis 1–2 times per week without symptoms; AOFAS 100 (pre-op 55) at 24 months postoperative.
Cienfuegos et al. [29]	12	Achilles tendon allograft	Walk without limitations and perform a bilateral heel rise at 3 months postoperative. Return to normal activity at 1 year postoperative.
Lepow and Green [32]	10	Achilles tendon allograft	Bilateral heel rise but not an isolated heel rise on the injured side at 10 weeks postoperative. No restrictions on activity at 8 months postoperative. Pre-injury functional capacity at 1-year follow-up.
Nellas et al. [33]	4.5	Achilles tendon allograft	Work 13-h days with no swelling or limitation in ambulation; an additional 6% increase in peak torque at 60° or a total of 13% deficit in comparison with the uninjured side (isokinetic testing) at 2.5 years postoperative.
Park and Sung [30]	12	Achilles tendon allograft + FHL transfer (2-incision)	AOFAS 100 (pre-op 50); ATRS 100
	16	Achilles tendon allograft + FHL transfer (1-incision)	No re-ruptures and complications. AOFAS 100 (pre-op 70); ATRS 92
Hanna et al. [28] (6 patients)	Range 3–6	Achilles tendon allograft + a calcaneal block	A single heel raise; an intact Thompson test; normal range of motion; no rejection of donor tissue. Complications included 1 infection. No re-ruptures
Deese et al. [34] (5 patients)	7.6 (range 5.5–10)	Achilles tendon allograft + a calcaneal block	None of the patients reported pain at their last clinical follow-up. One patient fell 4 weeks postoperatively and had increased pain, a fragmented calcaneal tuberosity, and interosseus ossification proximal to the insertion. One patient delayed healing of 3 cm in the midportion of the incision. One patient was radiographic evidence of heterotopic bone in the retrocalcaneal bursa adjacent to the bone block allograft at 4 months postoperatively. No re-ruptures
Ofili et al. [25] (14 patients)	7.0 ± 3 (range 4–15)	Achilles tendon allograft, a calcaneal block was used in 2 patients (14%).	A single heel rise at a mean of 27 ± 11 (range 12–37) weeks postoperatively. Weight-bearing in normal shoe gear at a mean of 13.5 ± 3 (range 12–17) weeks. Complications included 1 delayed union (7%) of the calcaneal bone block. No re-ruptures.
Hollawell et al. [27] (4 patients)	4.75 ± 1.05 (range 3.5–6)	Achilles tendon allograft and simultaneous augmentation with a xenograft	Return to work with preinjury levels of activity at a mean of 14.3 ± 0.79 weeks. The mean FAOI core scale score was 97 ± 1, and the mean normative score was 53 ± 1. The mean FAOI shoe comfort score was 100 ± 0, and the mean normative score was 59 ± 0. No re-ruptures and complications.

^a AOFAS, American Orthopaedic Foot & Ankle Society; ATRS, Achilles tendon rupture score.

Table 2
Coleman Methodology Scores for selected studies.

Methodology criterion (min–max)	Kocabey et al. [31]	Cienfuegos et al. [29]	Lepow and Green [32]	Nellas et al. [33]	Park and Sung [30]	Hanna et al. [28]	Deese et al. [34]	Ofili et al. [25]	Hollawell and Baione [27]
Part A									
1. Study size (0–10)	0	0	0	0	0	0	0	0	0
2. Follow-up (0–5)	2	2	2	5	5	2	0	2	5
3. N procedures (0–10)	10	10	10	10	0	10	0	10	10
4. Type of study (0–15)	0	0	0	0	0	0	0	0	0
5. Diagnostic certainty (0–5)	5	5	5	0	5	5	0	15	0
6. Description of surgical technique (0–5)	5	5	5	3	3	5	5	5	5
7. Rehabilitation and compliance (0–10)	10	5	10	10	10	10	10	10	0
Part B									
1. Outcome criteria (0–10)	7	7	7	7	8	5	7	7	7
2. Outcome assessment (0–15)	11	8	8	8	11	12	8	11	11
3. Selection process (0–15)	15	15	15	15	15	15	15	15	15
Total Coleman Methodology Score (0–100)	65	57	62	58	57	67	45	75	53

tendon ruptures accordingly. However, these biological grafts cannot avoid weakening the donor tissue and may cause functional disability, especially in athletes. Thus, if a patient is an active athlete who has a strong wish to continue competitive sports including sudden turning or jumping, allografts turn out to be the best substitute for Achilles tendon. Besides, allografts can shorten much more surgical time than autografts, which decreases occurrence of wound infection relatively.

Experimental studies have shown the mechanical strength of allograft tendon is comparable to that of the autograft [59]. Besides, in the Park study [30], which was the only study in this review that performed various methods for reconstruction, the mean ATRS score of allograft and autograft postoperatively was 96 and 92.3, respectively. Although the score of allograft was higher, we cannot make direct conclusions because the number of patients in the study was small.

Eight papers [25,27–30,32–34] in this review utilized Achilles tendon allograft because the tendon have a long and broad aponeurosis for secure proximal suturing to a wide area [60]. In addition, the shape and thickness of the Achilles tendon are the same with those of the original tissue. While one article used peroneus brevis tendon allograft because biomechanical study [61] suggests that peroneus brevis tendon use in 3- or 4-strand configurations show potential greater strength. However, the multiple-strand technique cannot be performed with an Achilles tendon allograft due to its limited length and its inability to be used in the loop configuration [31]. Long-term histologic and time zero biomechanical studies are required to see if there is a better tendon allograft alternative.

Except those two kinds of graft, semitendinosus tendon graft has gained popularity for tendon reconstruction. Semitendinosus tendon allograft is widely used in lateral ankle ligament reconstruction [40,62–64]. And there is literature supporting the effectiveness of autologous semitendinosus tendon for reconstruction of Achilles tendon [17,65–69]. To date, there is no literature reporting the reconstruction of Achilles tendon using semitendinosus tendon allograft for chronic Achilles tendon rupture. However, from our experience, it is notable that the strong and long tendon of semitendinosus is capable of being folded a few times to increase its diameter, so that the modified semitendinosus tendon obtains the comparable strength to the undamaged Achilles tendon. Especially in some cases, tendon ends are greatly atrophic and retracted, and leave large gap to bridge. Under this circumstance, the local semitendinosus tendon is considerably insufficient to provide such a strong graft, which highlights the advantage of allografts: they are abundant. Additional research, therefore, is warranted to see if this technique is a new and beneficial treatment for chronic Achilles tendon rupture.

As we said before, allografts are not without drawback, such as a slower reincorporation and remodeling rate comparing with autografts, and the potential risk of disease transmission. Nevertheless, there are no such complaints reported from patients in the selected articles. All studies of this review presented promising results. Three studies [25,28,34], however, reported five complications with treatment of Achilles tendon allograft attached a calcaneal block. As mentioned previously, one is infection, and another is delayed healing of the incision, which are the same as complications associated with autograft transfer [13,19,70]. However, the other three complications are some problems with the calcaneal bone block. Generally, if tendon stump is not insufficient, the calcaneal block is used with standard screw fixation. Therefore, further studies would help to determine if this option can increase the risk of complications.

Besides, another two studies [27,30] operated dual techniques with the addition of the flexor hallucis longus tendon and xenograft respectively, which make it hard to conclude which technique is superior because there is no available evidence currently that dual interventions provide better results. Further, two papers [29,30] demonstrated that subjects with a defect gap larger than 10 cm, the use of an allograft will be the optimal procedure because autografts are considered to be insufficient in this situation. However, a greater detail in results and larger number is needed to draw a meaningful conclusion of this theory. Although, to our knowledge, no evidence-based guidelines have been published for indication of tendon allograft transfer. An allograft is recommended when the surgeons think obviating donor site morbidity and saving surgical time is necessary for the patient.

There are some limitations to this systematic review. All identified studies lack control groups. And the length of follow-up widely varied among studies. In three studies [29,32,34], the follow-up time only lasted about 12 months. Also, the outcome

measures among the selected articles lack uniformity, and eight publications (88.8%) used non-validated outcome convention. Besides, the number of patients in these studies was low, as this surgical intervention for neglected ruptures of Achilles tendon had not gained much attention. Lastly, the duration from the rupture to the day of surgical management was different as well. All these factors confound the results.

5. Conclusion

The focus of this review was on tendon allograft as an intervention for chronic Achilles tendon rupture. And this review has highlighted that tendon allograft can be a desirable surgical reconstruction method for chronic Achilles tendon rupture with a low rate of complications. However, randomized controlled trails are demanded to improve the evidence base and validated outcome measures are required to ascertain the comparison of this procedure.

Conflict of interest

The authors declare that they have no conflict of interest.

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