

## Review

# Neglected Achilles tendon ruptures: literature review

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## Abstract

**Objective:** Review the literature on the current treatment of neglected Achilles tendon ruptures, their results, and potential complications.

**Methods:** Bibliographic review on the state of the art in national and international databases. Articles published in indexed journals between 1991 and 2022 that addressed the treatment of Achilles tendon ruptures with more than four weeks of evolution were selected; however, only articles with less than 22 years of publication (2000-2022) were analyzed.

**Results:** Surgical treatment is well-established in patients with significant functional demands. The various surgical techniques described in the literature and currently used have similar success rates and complications, especially regarding patient satisfaction, functional results, anthropometric measurements, and return to work and sports activities.

**Conclusion:** Several techniques can be used to treat neglected Achilles tendon ruptures. When choosing the most appropriate technique, gap size, patient characteristics, and surgeon experience should be considered.

**Level of evidence I; Type of study; Evaluation of results.**

**Keywords:** Achilles tendon; Rupture; Surgical procedures, operative.

## Introduction

Achilles tendon rupture is the most common tendon injury of the lower limb. This injury is particularly significant due to the tendon's crucial role in transferring, storing, and releasing energy during locomotion<sup>(1)</sup>.

Its prevalence is estimated at 0.2% of the general population and increases in individuals in the fourth decade of life<sup>(2)</sup>. Achilles tendon ruptures have increased in the last decade due to the growing interest in recreational physical activities, especially by patients above this age group<sup>(3)</sup>. Approximately one in four Achilles tendon ruptures will be neglected by patients and physicians at first, either due to the nature of the trauma, minor pain, or maintenance of plantar flexion movement<sup>(4)</sup>.

A delay of more than four weeks between injury and diagnosis is defined as a neglected or chronic Achilles tendon rupture. Neglected injuries result in loss of plantar flexion associated with edema, pain, and limited ankle movement. Surgically, they differ from acute ruptures due to the difficulty

of apposition of the stumps for primary end-to-end suture with plantar flexion of the ankle<sup>(5)</sup>.

These injuries can heal spontaneously due to the abundant fibrous tissue in the gap. However, the functional result is not ideal because, due to the associated contraction of the triceps surae, there is insufficient healing from a functional point of view, which sometimes generates weakness in performing plantar flexion with weight-bearing.

The objective of this study is to review the literature on the current treatment of neglected Achilles tendon ruptures, their results, and potential complications.

## Methods

This systematic review was developed following the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol to ensure transparency, methodological rigor, and reproducibility in the search, selection, and analysis of studies.

Study performed at the Hospital IFOR – Rede D'Or São Luiz, São Bernardo do Campo - SP, Brazil.

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## Sources of information and search strategy

Our study was conducted as a systematic review of scientific articles indexed in the PubMed, Bireme, SciELO, and ScienceDirect databases. The search strategy included the terms: “neglected Achilles tendon rupture,” “chronic Achilles,” “delayed diagnosis Achilles tendon rupture,” and “tendon transfers.”

## Eligibility criteria

The inclusion criteria were studies that addressed skeletally mature patients over 18 years old, studies that demonstrated results of managing supervised chronic Achilles tendon ruptures, and articles that presented at least the abstract in English.

## Exclusion criteria

The exclusion criteria were studies that did not contain the mentioned terms and keywords, articles published before 2000 or after 2022, articles that were not published in indexed journals, studies with less than ten patients in the analysis, studies involving patients with associated injuries, other than Achilles tendon rupture, study involving patients with acute Achilles tendon ruptures, and animal studies.

## The selection process

The selection of studies was performed in three stages: (1) Initial screening based on article titles and abstracts, (2) Evaluation of the full texts to confirm the eligibility criteria, and (3) Detailed analysis of the results obtained in each article to extract the relevant data.

All articles were independently analyzed by two reviewers. In cases of disagreements, a consensus was reached through discussion among all authors of the review.

## Data extraction and synthesis

Extracted data included demographic characteristics of patients, details of the interventions, and clinical and functional outcomes reported.

Data synthesis was performed qualitatively, describing the methods used in the studies and their final outcomes.

## Methodological quality assessment

The methodological quality of the studies was evaluated based on previously defined criteria, ensuring the validity and reliability of the results included in the review.

## Results

Four hundred and ninety-one articles were found, most dealing with surgical descriptions, case reports, or case series. No large cohort studies or meta-analyses were found. After applying the inclusion and exclusion criteria, 25 articles

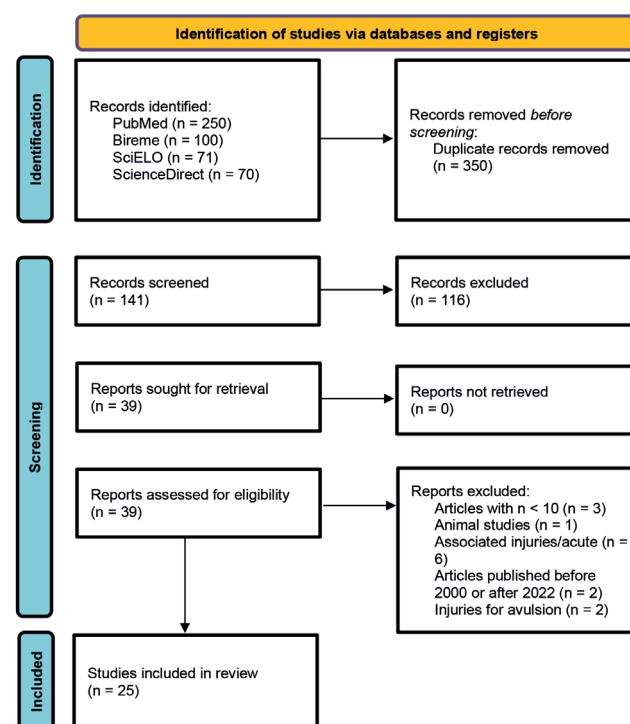
were selected and analyzed. Figure 1 details the process of identifying eligible studies.

The selected studies, the repair method used in each of them, and the complications and results are briefly described in Table 1<sup>(1,6-29)</sup>.

Techniques used to treat neglected Achilles tendon ruptures included direct repairs, allografts, transfers of the flexor hallucis longus, flexor digitorum longus or peroneus brevis tendon, graft with knee flexors, V-Y advancements, minimally invasive techniques, use of Achilles tendon flaps. There was no standardization in the outcomes analyzed in the included studies. The variables analyzed in the studies were calf circumference, muscle contraction strength scales, time to return to work and sports activities, pain scales such as the visual analog scale (VAS), and validated functional scores. The American Orthopaedic Foot and Ankle Society (AOFAS) score was also used to assess injuries in different regions of the foot.

## Discussion

The Achilles tendon is the strongest in the human body, and intrinsic and extrinsic factors can influence its rupture. Genetic predisposition, hypovascularization, and repetitive microtrauma are the main causes described in the literature<sup>(30)</sup>. These injuries are diagnosed based on anamnesis, physical examination, and, more recently, ultrasound and magnetic resonance imaging findings.



**Figure 1.** Eligible studies identification process.

**Table 1.** Methods of repair and results of included studies

Author	Methods	Results	Re-rupture	Complications
Lin et al., 2019 <sup>(1)</sup> (Retrospective study)	V-Y tendon plasty (20)	Mean follow-up of 32.8 months Mean injury-to-surgery was 20.4 weeks Mean operative gap was 5 cm Mean preoperative AOFAS score was 59.25 ± 12.28 and postoperative was 96.55 ± 3.75 Mean preoperative ATRS score was 39.55 ± 14.21 and postoperative was 94.05 ± 4.89 No patient was limited when walking on uneven surfaces and walking quickly up stairs	No	1 superficial infection treated with antibiotics and debridement
Wilcox et al., 2000 <sup>(6)</sup> (Retrospective study)	Flexor hallucis longus (20) – two incisions	Mean AOFAS of 86 90% of patients with AOFAS > 70 No significant difference in the SF-36 compared to USA norms except for physical function (significantly lower scores) Cybex strength testing: gain of 3% of dorsiflexion strength and loss of 7% of plantarflexion strength	No	Small loss of calf circumference
Pintore et al., 2001 <sup>(7)</sup> (Prospective study)	Peroneus brevis tendon (22)	No patient presented poor functional results (all performed single-leg heel rises five times) Reduction of peak torque (newtons per meter), total work (joules), and average power (watts)	Not informed	Loss of calf circumference (not significant) Superficial operative infection in two patients Hypertrophic scar in one patient Deep vein thrombosis in one patient (diabetic)
Jennings and Sefton 2002 <sup>(8)</sup> (Retrospective study)	Polyester tape (16)	Median time of partial weight-bearing: 17 days Median time of full weight-bearing: 5.9 weeks Median times to return to work and driving, and sports Tempo médio para retorno ao trabalho, dirigir e esportes: 7, 8, 6, and 18 weeks, respectively Only two patients had increased dorsiflexion compared with the uninjured leg Mean isometric power of the operated leg (238.7 N) vs. uninjured leg (281 N) (p > 0.05) Mean circumference of the operated leg of 32.1 cm vs. unoperated leg 36.6 (p < 0.05) Reduction of Tegner activity score from 2.7 to 1.8 (p < 0.05)	No	One patient needed further surgery for excision of the tape One patient had persistent numbness in the distribution of the sural nerve Three patients had superficial infections
Suttinark et al., 2009 <sup>(9)</sup> (Retrospective study)	Flexor hallucis longus (12)	Mean follow-up time of 22.5 months Improved mean AOFAS from 54.6 to 92.9	Not informed	Slightly decrease of strength in flexion of the first metatarsophalangeal
Park et al., 2012 <sup>(10)</sup> (Retrospective study)	V-Y advancement, gastrocnemius fascial turn-down flap, flexor hallucis longus tendon transfer, or Achilles tendon allograft (12).	Follow-up of 36.2 months AOFAS: 68.7 (preoperative) to 98 (postoperative) VAS: 6.5 (preoperative) to 0.17 (postoperative) All patients performed 10 single-leg heel rises on the operated leg ROM: was equal to that of the opposite side in nine patients, and dorsiflexion was smaller by < 10° in three patients Seven patients rated as excellent, four as good, and one as fair	No	None
Maffulli et al., 2010 <sup>(11)</sup> (Prospective study)	Peroneus brevis tendon transfer through two paramidline incisions (32)	Mean final ATRS of 92.5 Loss of muscle strength and calf circumference compared to nonoperated side The majority of the patients were satisfied with the results Six patients were classified as excellent, and 24 as good	Not informed	Four patients had superficial infections in at least one operative wound Two patients had a hypertrophic scar in the area of the Achilles tendon

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**Table 1.** Methods of repair and results of included studies

Author	Methods	Results	Re-rupture	Complications
Maffulli and Leadbetter, 2005 <sup>(12)</sup> (Prospective study)	Free gracilis tendon graft	Follow-up of two years 19 patients with no pain and two patients with mild pain (postoperative) 12 patients with no limitation for recreational activities and 9 with limitations 19 patients with restrictions or mild restrictions to footwear and two with moderate restrictions 19 patients were satisfied, and two had minor reservations Overall results: two excellent, 15 good, and four fair Decrease in calf circumference compared to the uninjured leg (mean): 39.2 vs. 40.9	Not informed	Five patients had superficial wound infections
Mao et al., 2015 <sup>(13)</sup> (Retrospective study)	Flexor hallucis longus transfer associated with gastrocnemius fascial turn-down flap and plantaris tendon	Mean AOFAS from 64.4 in the operative to 94.3 in the postoperative ROM evolved closer to the nonoperative side with a mean of 12° (5°–15°) of dorsiflexion and 40.5° (35°–50°) of plantarflexion	Not informed	Not informed
Maffulli et al., 2017 <sup>(14)</sup> (Review article)	Semitendinosus (21) – gap ≥ 6 cm Peroneus brevis tendon (20) Flexor hallucis longus (21)	All patients showed significant improvements in the operative ( $p < 0.001$ ) with no difference between groups Peroneus brevis tendon transfer had a slower return to sports	Not informed	None
Vega et al., 2018 <sup>(15)</sup> (Retrospective study)	Endoscopic flexor hallucis longus transfer (22)	Mean AOFAS score increased from 55 to 91 All patients returned to their daily activities without difficulties, and only one patient reported mild pain No patients reported complaints of great toe flexion strength	No	1 calcaneal bone avulsion
Pendse et al., 2019 <sup>(16)</sup> (Retrospective study)	Flexor hallucis longus with a single incision (17)	Mean follow-up of 27 months Mean AOFAS increased from 57.47 to 96.71 Mean calf girth atrophy was 1.53 cm No significant difference in the range of ankle movement	No	All patients had decreased plantar flexion strength in the great toe One patient had superficial cellulitis successfully managed with oral antibiotic
Abubeih et al., 2018 <sup>(17)</sup> (Prospective study)	Flexor hallucis longus with a single incision (21)	Mean follow-up of 15 months Mean AOFAS increased from $57.4 \pm 10.3$ to $95.3 \pm 4.4$ At the end of the study, 16 patients (76%) were able to lift the heel in unipodal support All patients showed weakness in flexion of the hallux interphalangeal joint, but no functional impairment	No	One patient had superficial cellulitis successfully managed with oral antibiotic
Alhaug et al., 2019 <sup>(18)</sup> (Retrospective study)	Flexor hallucis longus (21)	Median maximal concentric strength was equal, 1300 vs 1336 W, comparing affected with unaffected side Mean heel rise was 5.5 for the affected side and 26.5 for the unaffected leg Mean work energy was 219J for the affected side and 2398J for the unaffected leg Mean ROM was 7.35 cm for the affected side and 13.7 cm for the unaffected leg Mean AOFAS was 87 and the VISA-A was 81	One patient	Five patients had infections, three being deep infections and one patient required plastic surgery Two had prolonged healing Two had claw toes Three had poor sensibility in the sural nerve area

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**Table 1.** Methods of repair and results of included studies

Author	Methods	Results	Re-rupture	Complications
Bai et al., 2019 <sup>(19)</sup> (Retrospective cohort)	Comparison of free hamstring graft (15) and gastrocnemius turn flap (11)	Three months: higher degree of ankle dorsiflexion in the hamstring graft group ( $p = 0.004$ ), with no significant differences in ankle function  Six months: no significant differences in dorsiflexion and ankle function in both groups  12 months: no significant differences in dorsiflexion, ankle function, and AOFAS score in both groups	No	One patient had a saphenous nerve injury in the hamstring graft group  Two patients had impaired wound healing in the gastrocnemius turn flap group  One patient had deep vein thrombosis in the gastrocnemius turn flap group
Guclu et al., 2016 <sup>(20)</sup> (Comparative retrospective study)	V-Y tendon plasty with fascia turndown (17)  Follow-up of 16 years	Mean time until surgery was seven months  Mean gap was 6 cm  Mean AOFAS score was 64 in the preoperative and 95 in the postoperative  The defect size did not affect the AOFAS score but affected the peak torque  The gap size, time to surgery, and calf atrophy had an adverse effect on the muscle strength, but did not affect the postoperative outcomes	No	Two superficial infections
Koh et al., 2019 <sup>(21)</sup> (Comparative retrospective study)	Flexor hallucis longus (29) vs. turndown flaps augmented with flexor hallucis longus (20)	In one year the VAS score was 0 for both groups  Mean AOFAS score was $90 \pm 11$ for Flexor hallucis longus and $95 \pm 10$ turndown flaps augmented with flexor hallucis longus  SF-36 showed improvement in the functional and physical scores  Turndown flaps augmented with flexor hallucis longus had longer surgical time ( $100 \pm 21$ min) vs. flexor hallucis longus ( $73 \pm 23$ min)	No	Two cases of soft tissue complications (one stitch abscess and one wound dehiscence) in the turndown flaps augmented with flexor hallucis longus group
Lever et al., 2018 <sup>(22)</sup> (Retrospective cohort study)	Transtendinous flexor hallucis longus transfer (20)	Mean follow-up of 73 months  Mean ATRS score was 83 in the postoperative  Mean AOFAS score was 94.3 in the postoperative  Mean SF-12 score was 4.8 in the physical component and 54.3 for the mental component  The great toe strength was 40% weaker than the contralateral side  The ankle plantarflexion strength was 24% weaker than the nonoperative side	No	Six 6 had wound problems, three superficial infections, one wound dehiscence, one slow scar healing, and one scar adhesion
Massoud et al., 2017 <sup>(23)</sup> (Prospective - case series)	Lengthening of the proximal tendon stump (15)	All patients returned to the normal level of daily activities, no pain, tenderness, or stiffness at the ankle  The calf circumference was equal among the 12 patients  Three patients had calf atrophy  Ankle motion was equal to the contralateral side	No	Three superficial infections  One deep infection  Two scar adhesion
Ofili et al., 2016 <sup>(24)</sup> (Retrospective study)	Achilles tendon allograft (14)	Mean follow-up was 16.1 months  Mean time to surgery was 6.9 months  Mean defect size was Média 3.7 cm  Bone graft was used in two cases  All patients were able to perform a single-limb heel rise at 27 weeks  Weight-bearing in normal shoe gear was achieved at a mean of 13.5 weeks	No	One delay union that was treated with calcaneal bone block

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**Table 1.** Methods of repair and results of included studies

Author	Methods	Results	Re-rupture	Complications
Ozan et al., 2017 <sup>(25)</sup> (Retrospective study)	Lindholm method (8) vs. Vulpius method (7)	Mean follow-up of 19.6 months Mean time to surgery was 42 days Mean defect size was 4 cm Mean calf atrophy was 1.2 cm Mean time to return to daily activities was 3.2 months All patients were able to perform a single-limb heel rise at the end of follow-up	No	No
Ozer et al., 2018 <sup>(26)</sup> (Prospective study)	Flexor hallucis longus (19)	Mean time to surgery was 36 days Mean AOFAS hindfoot score was 93.83 in the postoperative Mean AOFAS hallux score was 86.9 in the postoperative No significant difference was found in the balance performance No significant difference was found in the vertical and forward jump Less ankle dorsiflexion on the operated side was recorded compared with the nonoperated side ( $p = 0.008$ ) Concentric/eccentric muscle strength between the operated and nonoperated side was similar ( $p > 0.05$ )	No	No
Seker et al., 2016 <sup>(27)</sup> (Retrospective study)	Lindholm method (21)	Mean follow-up time of 145.3 months Mean calf circumference on the operated side was 36.2 cm and the nonoperated side was 37.2 cm, not significant ( $p = 0.291$ ) Mean ankle range of motion on the operated side was 19° and the nonoperated side was 18° Mean time to return to daily activities was 11.1 weeks Mean AOFAS score was 98.5, and FADI was 98.9; VAS was 0	No	One superficial infection treated with antibiotics
Yasuda et al., 2016 <sup>(28)</sup> (Retrospective study)	Scar tissue located between the tendon stumps (30)	Mean plantar flexion angle increased ( $p = 0.0049$ ) Mean dorsiflexion angle decreased ( $p = 0.009$ ) Mean calf circumference increased in the postoperative ( $p = 0.0087$ ) All patients were able to perform a single-limb heel rise, except two patients Mean AOFAS score in the postoperative was 98.1 Mean ATRS score in the postoperative was 92.0	No	One delay scar healing
Song et al., 2020 <sup>(29)</sup> (Retrospective – case series)	Semitendinosus allograft (34)	Mean follow-up of 53 months Functional and clinical scores had a significant increase 39.4% returned to previous sports activities All patients were able to stand on tiptoe of the single injured limb Mean AOFAS score in the postoperative was 100, ATRS was 99, VISA-A was 94, and Tegner was 4	No	Four patients complained of mild pain when the weather was colder or after a minimum of 30 min of sitting, walking, or jogging, which were alleviated by ultrasonic or microwave therapy, slight footwear modifications with heel cushions, and stretching

Achilles tendon ruptures not diagnosed in the acute phase, in which conservative treatment fails after four weeks, or chronic ruptures due to degeneration are considered neglected or chronic Achilles tendon ruptures. Clinically, these injuries rarely present palpable gaps due to the formation of local scar tissue<sup>(31)</sup>. However, with close clinical examination, the change in local tissue consistency can determine the rupture site. Other physical examination findings are dependent on the degree of healing. Patients may present a deficit of strength in plantar flexion, with a delay of the heel detachment phase in gait, which generates great discomfort. Patients are unable to stand or walk on tiptoes. Plantar flexion force can only be recovered with surgical treatment during this period.

Ultrasound is the imaging method with the highest availability and good accuracy for diagnosing Achilles tendon ruptures. Magnetic resonance imaging has recently become the gold standard method, but its little availability, especially in public health, and its high cost do not place it as the first choice<sup>(32)</sup>.

The treatment of neglected Achilles tendon ruptures remains controversial since several surgical techniques have been described, and even conservative treatment can be indicated, especially in smoking patients with diabetes mellitus and in those with soft tissue complications.

Conservative treatment involves serial immobilizations with a gradual reduction of equinus at each visit. However, this approach is associated with prolonged immobilization and poorer functional outcomes, as fibrosis at the injury site can lead to shortening of the triceps surae, potentially causing functional impairment of ankle plantar flexion in the affected limb.

Surgical treatment has as its primary objective the restoration of function and strength of the triceps surae by restoring the adequate length-tension ratio. Primary anastomosis is the preferred approach in acute ruptures when stump apposition is feasible. This technique optimally restores tendon length before the injury, allowing for maximum isokinetic strength recovery.

Neglected ruptures are complicated by shortening and contracture of the gastrocnemius-soleus complex. Due to the difficulty in achieving stump apposition and performing a primary suture, various techniques have been developed to overcome these difficulties.

In this context, managing neglected Achilles tendon rupture has become challenging due to the diversity of available techniques and the lack of standardization in the analyzed outcomes. When choosing the most appropriate technique, gap size, patient characteristics, and surgeon experience should be considered.

Among the most used tendon transfer techniques, flexor hallucis longus transfer stands out for its proximity to the Achilles tendon, its similar force vector, and the vascular support provided to the rupture area. However, complications such as calf atrophy and loss of strength in the hallux flexion limit its use in some cases<sup>(13,16)</sup>. The nine studies that analyzed

this technique<sup>(6,9,13,16-18,21,22,26)</sup> reported a mean postoperative AOFAS score of 92.53 (86–96.71). Major complications reported included calf atrophy, loss of strength in the first metatarsophalangeal joint, superficial infections, and problems with surgical wounds. Reconstruction with flexor hallucis longus performed endoscopically was described in a study<sup>(15)</sup>, presenting satisfactory results, such as a return to daily activities in all patients evaluated.

Another well-established technique to repair these ruptures is the transfer of one of the peroneus muscles. The most used and best described in the literature is the peroneus brevis tendon transfer. The most used technique consists of two incisions, one on the fifth metatarsal base, to identify the short fibular tendon and one posterior, medial to the Achilles tendon<sup>(7)</sup>, having been described in a study with five patients, who obtained improvement in plantar flexion, with minimal loss of range of motion and ability to return to pre-injury activity levels, with only one episode of occasional edema.

Pintore et al.<sup>(7)</sup> conducted a study on the transfer of the peroneus brevis tendon in 22 patients with neglected Achilles ruptures with a mean age of 41.3 years and 27 patients with acute Achilles ruptures with a mean age of 43.6 years. Patients were operated on by a single surgeon and evaluated postoperatively at six weeks and six months for satisfaction, complications, plantar flexion muscle strength, and calf circumference. They concluded that patients have good satisfaction after surgery but with loss of muscle strength and calf circumference and an increased incidence of complications when compared to the group of acute ruptures, such as superficial surgical wound infection in two patients, in addition to hypertrophic scarring and deep vein thrombosis in one patient each.

In our review, we also included the studies by Maffulli et al.<sup>(11,14)</sup> addressing peroneus brevis tendon transfer, in which good results are evidenced, such as a mean final Achilles tendon total rupture score of 92.5, and 30 of 32 patients with excellent or good results<sup>(11)</sup>. The complications described were superficial infection of at least one of the operative wounds and hypertrophic scar in the area of the operative wound of the Achilles tendon<sup>(11)</sup>.

Subsequently, when comparing the technique above with semitendinosus graft and flexor hallucis longus transfer, the authors observed that patients submitted to peroneus brevis transfer had a slower return to sport<sup>(14)</sup>.

For gaps greater than 6.0 cm, the semitendinosus graft transfer technique was used by Maffulli et al.<sup>(33)</sup>, demonstrating efficacy similar to established techniques, such as flexor hallucis longus and peroneus brevis transfer.

In this context, studies advocating tendon stretching over transfer techniques argue that the difficulty in apposition and primary suture of the stumps is primarily due to the shortening of the triceps surae; the tendon stretching techniques that were developed fit. Such techniques do not require synthetic materials, such as the advancement of tendon flaps and V-Y

advancements, and have been valued for their reduced cost, presenting comparable functional results.

The gastrocnemius aponeurosis or fascial flaps can also be used for reconstruction. In this procedure, the dissected flap of the proximal stump is advanced distally and sutured to the terminal stump. Seker et al.<sup>(27)</sup>, using the Lindholm technique with 21 patients, found favorable functional results without sacrificing other healthy tissues and with only one superficial infection.

Using the same technique, Ozan et al.<sup>(25)</sup> demonstrated that all patients could perform single-leg heel rises at the end of the follow-up, although they presented a mean calf atrophy of 1.2 cm.

Park and Sung<sup>(10)</sup> performed a study in which they used multiple techniques, but with a total number of only 12 patients (V-Y advancements in one patient, V-Y advancements with flexor hallucis longus tendon transfer in one patient, gastrocnemius fascial turn-down flap in three patients, gastrocnemius fascial turn-down flap simultaneously performed with flexor hallucis longus tendon transfer for three patients, and V-Y advancements simultaneously performed with flexor hallucis longus tendon transfer and Achilles tendon allograft in two patients). The results were similar, but the patients were carefully selected according to the defect size. In their study, patients with defects < 5 cm performed V-Y advancements alone, and patients with defects greater than 10 cm performed surgery with allograft. Patients with intermediate defects were randomly allocated to the other techniques.

Allografts can also be used for Achilles tendon repair. In a study, Ofili et al.<sup>(24)</sup> found that 100% of the 14 patients submitted to frozen Achilles tendon allograft could perform a single-heel rise. One delayed consolidation was noted and treated with immobilization in a weight-bearing cast.

Techniques involving various sutures for direct end-to-end repair have already been described. Yasuda et al.<sup>(28)</sup> performed Krackow sutures in 30 patients and obtained good results with substantial improvement in the mean AOFAS score (mean of 98.1). In addition, 93% of patients performed single-heel rises without difficulty. There was, however, a case of delayed wound healing.


The outcome of the treatment of Achilles tendon ruptures is mainly related to (a) strength of the triceps surae, (b) residual pain, (c) time to return to activities, and (d) patient satisfaction.

In this context, this review found similar functional, objective, and subjective results for the techniques analyzed in the study, but not enough evidence was found to indicate one technique over another.

Our review highlights that the therapeutic decision must be individualized, considering factors such as the extent of the rupture, clinical characteristics of the patient, and available resources. Despite the differences between the methods, all techniques analyzed showed a significant improvement in functional outcomes, including the strength of the triceps surae, return to work and sports activities, and higher satisfaction compared to conservative treatment. This scenario reinforces the importance of personalizing the treatment to achieve the best possible results in each case.

## Conclusion

The techniques described in the literature presented similar results regarding functional, objective, and subjective aspects; no superiority of one technique in relation to another that justifies its absolute indication was found. However, surgical treatment has superior results to conservative treatment, especially in patients with high functional demand. The most appropriate surgical technique should be based on gap size, patient characteristics, and surgeon experience.

**Authors' contributions:** Each author contributed individually and significantly to the development of this article: RPL \*(<https://orcid.org/0009-0002-4246-5538>) Conduziu a pesquisa bibliográfica, coletou os dados, participou do processo de revisão, revisou as referências selecionadas e aprovou a versão final; RRM \*(<https://orcid.org/0000-0002-2563-2085>) Concebeu e planejou as atividades que levaram ao estudo, redigiu o artigo, interpretou resultados do estudo, participou do processo de revisão e aprovou a versão final; FACS \*(<https://orcid.org/0000-0001-6410-3867>) Interpretou os resultados do estudo, participou do processo de revisão e aprovou a versão final; JPGS \*(<https://orcid.org/0000-0002-1086-9872>) Coletou os dados, participou do processo de revisão e aprovou a versão final; EBON \*(<https://orcid.org/0000-0002-3931-845X>) Coletou os dados, participou do processo de revisão e aprovou a versão final; MRQ \*(<https://orcid.org/0000-0003-3270-4195>) Coletou os dados, participou do processo de revisão e aprovou a versão final. All authors read and approved the final manuscript. \*ORCID (Open Researcher and Contributor ID) .

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