



Review Article

A comprehensive review of surgical techniques for chronic Achilles tendon rupture

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ABSTRACT

Chronic Achilles tendon rupture (CATR) represents a significant clinical challenge, often necessitating surgical intervention to restore function, alleviate pain, and prevent long-term complications. The complex nature of CATR, characterized by tendon retraction, scar formation, and poor tissue quality, requires a tailored, evidence-based approach. This review comprehensively examines current surgical strategies for managing CATR, focusing on their indications, advantages, outcomes, and associated complications. A detailed literature search of 20 studies published between 2010 and 2023 identified key surgical techniques, including end-to-end repair, tendon transfers, autografts, synthetic grafts, and allografts. Surgical recommendations were stratified by defect size and patient factors. Small defects (<2 cm) are effectively managed with end-to-end repair or tendon transfers, offering rapid recovery and restoration of tendon continuity. Medium defects (2–5 cm) benefit from techniques such as V-Y plasty or semitendinosus autografts, providing additional length and biomechanical stability. Larger defects (>5 cm) often necessitate advanced procedures, including free tendon grafts, synthetic materials, or allografts, particularly for older patients or those with poor tissue quality. Minimally invasive techniques, such as endoscopic flexor hallucis longus transfer, have shown promise in reducing recovery times and complications. A structured decision-making framework is proposed to guide surgical choices, ensuring patient-specific, optimal outcomes. Emerging techniques further expand the possibilities for managing this challenging condition, emphasizing the need for innovation and individualized care in CATR treatment.

KEYWORDS: *Chronic Achilles tendon rupture, Endoscopic technique, Free tendon graft, Tendon transfer, V-Y technique*

INTRODUCTION

Achilles tendon rupture is a common injury, particularly among athletes and the elderly, with an increasing incidence owing to increased participation in recreational sports [1]. The Achilles tendon, which is the strongest and largest tendon in the body, connects the calf muscles (gastrocnemius and soleus) to the calcaneus, facilitating ankle plantar flexion [2]. The pathophysiology of chronic Achilles tendon rupture (CATR) involves a complex process, in which delayed or insufficient healing leads to tendon retraction, muscle atrophy, scar formation, and degeneration. Over time, the tendon ends become frayed, and the gap between them widens, making direct repair challenging [3]. In addition, prolonged disuse and altered biomechanics contribute to muscle wasting and reduced tendon elasticity, further complicating recovery [4].

Epidemiologically, Achilles tendon ruptures have an estimated annual incidence of 5–10 per 100,000 people, with


men aged 30–50 years being the most affected [5]. CATR is defined as a rupture that remains untreated or undiagnosed for more than 4–6 weeks, accounting for 20%–25% of all Achilles tendon ruptures [6]. Nonoperative management is usually considered in acute cases, particularly for older, less active patients, or those with significant comorbidities [7]. However, nonoperative treatments, such as functional bracing or casting, have limitations in CATR owing to tendon retraction and the lack of viable tissue for natural healing [8]. Although conservative approaches can sometimes provide satisfactory outcomes in acute ruptures, their efficacy in chronic cases is limited, often resulting in residual weakness, reduced push-off

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strength, and an increased risk of re-rupture [9]. Because of these limitations, surgical intervention is indicated in chronic cases to restore tendon continuity, function, and muscle strength [10].

This review aims to explore the various surgical methods available for treating CATR, providing a comprehensive overview of the current strategies, their indications, and outcomes to guide clinical decision-making.

DATA EXTRACTION

A comprehensive literature search was conducted across multiple medical databases, including PubMed, Scopus, and Google Scholar, targeting studies published between 2010 and 2023. The search utilized keywords such as “chronic Achilles tendon rupture,” “Achilles tendon repair,” “surgical techniques,” “tendon transfer,” and “graft reconstruction.” Only articles published in English were considered, encompassing original research articles, systematic reviews, case series, and case reports that explored surgical methods for managing CATR. A total of 20 original articles meeting the inclusion criteria were analyzed in this review [11-30]. While case series and case reports were included to highlight rare scenarios and innovative techniques, they were not used as the primary basis for surgical recommendations due to their inherently lower level of evidence.

SURGICAL METHODS FOR CHRONIC ACHILLES TENDON RUPTURE

The management of CATR requires a personalized approach, with surgical strategies tailored to factors such as defect size, tissue quality, patient age, activity level, and comorbidities. Below, we outline key surgical techniques for CATR, highlighting their indications, advantages, and limitations based on current literature [Table 1].

End-to-end anastomosis and tendon fascia flap techniques

End-to-end repair is an established method for managing smaller tendon defects, particularly those <2 cm in size. This technique involves direct suturing of the ruptured tendon ends to restore continuity and function. However, in cases of CATR, direct repair is often challenging due to factors such as tendon adhesions, gastrocnemius atrophy, and tendon stump retraction. Augmentation with local tendon fascia flaps, such as the gastro-soleus fascial flap, may be recommended to provide additional strength and reduce adhesions, but primary repair remains promising for minimal defects [11]. Although Myerson’s and Kuwada’s classifications suggest that defects up to 2–3 cm can be managed with end-to-end repair, the efficacy of these guidelines has not been rigorously evaluated [31,32]. Primary repair preserves the patient’s native tissue and restores the original anatomy, offering faster healing compared to more complex procedures, such as tendon flaps or grafting. However, given the atrophic nature of tendon stumps in CATR, the use of tendon grafts may be more dependable, as grafts introduce new vital tissue to the rupture site, providing a more dependable long-term solution [11,31,32].

Flexor hallucis longus transfers

Flexor hallucis longus (FHL) transfer is a commonly utilized surgical technique for managing CATR, especially in cases involving moderate-to-large defects. The effectiveness of this approach has been studied in patients with defects typically ranging from 3 to 8 cm. Xu *et al.* evaluated 28 patients with an average defect size of 7.1 cm treated using a single-incision FHL transfer [12]. Over a mean follow-up of 62.6 months, patients demonstrated significant improvements in American Orthopaedic Foot and Ankle Society (AOFAS) scores (preoperative: 61.1, postoperative: 90.4) and Achilles Tendon Total Rupture Score (ATRS) (preoperative: 53.8, postoperative: 89.8). Satisfaction rates were high, with no tendon re-ruptures reported, although slight hallux plantar

Table 1: Overview of surgical methods for chronic achilles tendon rupture

Surgical method	Indications	Advantages	Potential pitfalls	References
Scar tissue repair	Small defects, sufficient scar tissue available	No donor site morbidity; avoids use of grafts or transfers	Limited applicability for large defects or severe retraction	[11]
FHL transfer	Moderate-to-large defects (>5 cm)	Biomechanical compatibility; restores functional load; minimally invasive options available	Loss of hallux flexion strength; requires surgical expertise	[12,14,27-30]
V-Y Plasty	Large defects (>6 cm), severe tendon retraction.	Reliable length restoration; suitable for severe cases	Longer recovery time; risk of wound complications	[14]
Peroneus brevis transfer	Defects<6 cm; patients with poor tissue quality	Minimally invasive options reduce complications; preserves skin integrity	Reduced plantar flexion strength; technically demanding	[25,26]
Semitendinosus graft	Large defects (>6 cm); patients with healthy tissue donors	Provides strong graft material; minimal donor site morbidity	Requires donor site harvesting; limited evidence on long-term outcomes	[16,18]
Allograft	Very large defects (>7 cm); patients with poor donor tissue	No donor site morbidity; adequate for extensive defects	Risk of immune rejection or infection; limited availability	[19,20,22,23]
Synthetic graft augmentation	Myerson Grade 3 ruptures (>5 cm)	Avoids donor site harvesting; consistent graft supply; minimally invasive	Risk of graft integration issues; mild calf atrophy reported	[24]
Endoscopic hamstring autograft	Chronic ruptures with tendon gaps<6 cm	Minimally invasive; excellent functional recovery; avoids extensive soft-tissue dissection	Technically challenging; requires specialized equipment	[28]
Xenograft augmentation	Large defects (>6 cm); adjunct to allograft	Strong structural support; avoids additional harvesting sites	Limited long-term data; potential for immune-related issues	[23]

FHL: Flexor hallucis longus

flexion weakness was noted, which did not significantly impact daily activities [12]. Similarly, Alhaug *et al.* analyzed FHL transfers in 21 patients with defect sizes ranging from 4.5 to 7.5 cm [13]. While maximal plantar flexion strength recovered to 96% of the unaffected leg, endurance was notably reduced, with the affected limbs achieving only 34% of the heel rises compared to the unaffected side. A notable complication rate (52%) was observed, including wound healing issues and clawing of small toes. Despite these complications, the technique demonstrated meaningful improvements in functional outcomes [13]. FHL transfer appears most suitable for moderate to large tendon defects, balancing functional restoration with potential risks. However, the outcomes are influenced by defect size, and patient-specific factors such as tissue quality and the risk of hallux weakness should be carefully evaluated.

V-Y technique

The V-Y tendinoplasty is a commonly employed method for managing CATR, particularly in cases with moderate to large defects ranging from 5 to 6 cm. This technique is often combined with other procedures, such as FHL tendon transfer, to enhance functional outcomes. Rashid *et al.* evaluated 12 patients with an average defect size of 7.38 ± 1.0 cm who underwent V-Y plasty with FHL transfer [14]. At the 6-month follow-up, significant improvements were observed in ankle dorsiflexion (17.5° from 12.9°) and plantarflexion (42.3° from 29.6°). The European Foot and Ankle Society score also increased significantly, from 18.6 ± 0.90 at 3 months to 25.5 ± 5.71 at 6 months ($P = 0.001$), indicating enhanced functional recovery. Notably, younger patients demonstrated better outcomes compared to older individuals, highlighting the role of patient age in surgical success [16]. Roebke *et al.* further supported the efficacy of the V-Y technique in conjunction with FHL transfer for managing defects exceeding 5 cm [15]. Their study emphasized meticulous tensioning during surgery to optimize the length-tension relationship of the Achilles tendon, preventing postoperative elongation. Postoperative protocols included gradual weight-bearing and physiotherapy, resulting in favorable outcomes, including full recovery of the range of motion by 12 weeks and a return to physical activity by 4–6 months. Complications such as wound healing issues and residual weakness were minimal when proper surgical technique and postoperative care were employed [15]. The V-Y technique effectively restores Achilles tendon length while maintaining functionality, particularly for larger defects. However, careful preoperative planning and patient selection are crucial to avoid complications such as calf weakness or overtightening. Combining V-Y plasty with FHL transfer provides an integrated approach for challenging cases, achieving both structural integrity and functional improvement.

Semitendinosus transfer

The semitendinosus tendon autograft may be an effective surgical method for managing CATR with larger defects, particularly those exceeding 6 cm. This technique offers biological augmentation and structural integrity while minimizing donor-site morbidity. Usulli *et al.* evaluated eight patients treated with semitendinosus tendon grafts

in a minimally invasive approach [16]. The mean defect size was >6 cm, and all patients demonstrated significant improvements in the AOFAS scores (mean: 92) and the ATRs (mean: 87) at 24 months. Importantly, six of eight patients returned to their preinjury sports within 7 months of surgery. No complications, such as infections or re-ruptures, were reported, confirming the safety and efficacy of this technique for substantial defects [16]. Tsukada *et al.* reported similar success using the side-locking loop suture technique combined with semitendinosus grafts in ten patients with a mean defect size of 5.3 cm [17]. Postoperative AOFAS scores improved from 64.2 ± 5.6 to 95.0 ± 5.3 and ATRs from 29.8 ± 4.4 to 86.2 ± 7.7 ($P < 0.001$). Patients were able to perform 20 double-leg heel raises within 13.5 weeks on average, and long-term orthosis was unnecessary. One patient experienced transient hypoesthesia, which resolved spontaneously, indicating minimal donor-site morbidity [17]. Vuldzhev *et al.* combined semitendinosus autografts with the Vulpius gastrocnemius lengthening technique in five patients with defects ranging from 6 to 12 cm [18]. A significant functional recovery was observed, with the Foot and Ankle Outcome Score improving from 58.8 preoperatively to 92.8 at a 2.6-year follow-up. The calf circumference increased by 1.4 cm on average, and no re-ruptures occurred during the study period. This combined approach was particularly effective in restoring tendon length and reducing calf atrophy, making it a robust option for large defects [18]. The semitendinosus transfer technique provides a versatile and durable solution for large Achilles tendon defects. However, it requires careful surgical planning and postoperative rehabilitation to optimize outcomes and minimize complications, such as knee flexion weakness or potential sural nerve injury.

Free allograft tendon

The use of free allograft tendons has emerged as an effective surgical approach for CATRs, particularly in managing large defects (>6 cm) where native tissue reconstruction may not suffice. This technique offers significant advantages, including eliminating donor-site morbidity and providing sufficient graft material to bridge extensive defects. Jiménez-Carrasco *et al.* reported a comparative study of autologous and allograft reconstructions for CATR, involving 17 patients with a mean defect size of 7.75 ± 0.89 cm in the allograft group [19]. Over an 82-month follow-up, all patients achieved significant improvements in AOFAS and ATRs scores, with no infections, re-ruptures, or complications [19]. Similarly, Ofili *et al.* evaluated 14 patients treated with Achilles tendon allografts for gaps averaging 7 cm [20]. All patients regained single-heel rise capability at a mean of 27 weeks postoperatively, and none experienced re-rupture, highlighting the reliability of this method for extensive defects [20]. Hanna *et al.* described a specialized technique using Achilles allografts with calcaneal bone blocks for defects exceeding 6 cm [21]. This approach restored normal gait biomechanics, leveraging the bone block to enhance fixation and reduce failure risks. Long-term outcomes demonstrated excellent functional recovery without complications [21]. Gross and Nunley emphasized the utility of allografts in reconstructing defects greater than 6 cm, noting that this technique offers biomechanical advantages,

including maintaining tendon length and tension without the need for complex adjunctive procedures [22]. Hollowell and Baione explored combining allografts with xenograft augmentation in cases of severe tendinopathy and large defects (>5 cm) [22]. Patients returned to preinjury activities within 14.5 weeks, achieving functional outcomes comparable to native tendon reconstructions. However, the technique requires careful surgical planning to mitigate potential graft integration issues [23]. While free allografts provide a robust solution for large tendon defects, potential drawbacks include longer incorporation times, higher costs, and the risk of immunogenic reactions. Nonetheless, their ability to restore function and bridge significant gaps makes them a valuable option in treating CATRs.

Synthetic grafts

Synthetic grafts have become a valuable tool for reconstructing CATR, particularly in cases with large defects (>5 cm) where native tissue quality is insufficient. These materials offer the advantages of avoiding donor-site morbidity and providing consistent structural support while functioning as scaffolds for tissue ingrowth. Shoaib and Mishra evaluated the use of bioabsorbable synthetic grafts (Artelon®) combined with V-Y plasty for Myerson Grade 3 CATRs in seven patients [24]. The mean defect size was 6.2 cm (range: 6–7 cm). At a mean follow-up of 29 months, patients showed significant improvements in functional outcomes, including an increase in the AOFAS score from 59 to 91 and an ATRS of 92 out of 100. Pain was eliminated in all patients, and six of seven were able to perform sustained single-stance heel raises. Importantly, no re-ruptures, deep infections, or graft-related complications were observed. Calf wasting of <2 cm was noted in all patients, which did not significantly impact functional outcomes. Minor complications included two cases of transient numbness in the sural nerve territory and one case of superficial infection that resolved with oral antibiotics. The use of synthetic grafts like Artelon® combines mechanical durability with biological compatibility [24]. However, concerns remain regarding the risks of graft-related foreign body reactions, infection, and delayed integration. Long-term follow-up studies are needed to assess the eventual biodegradation and incorporation of these grafts. Despite these limitations, synthetic materials remain a promising option, particularly for large tendon defects where traditional autografts or allografts may not be feasible.

Minimally invasive peroneus brevis tendon transfer

Minimally invasive techniques for CATR have gained popularity due to their ability to reduce complications such as wound breakdown and infections, while improving recovery and rehabilitation times. One such technique is the peroneus brevis tendon transfer, particularly suited for cases with tendon defects <6 cm [25]. This procedure involves harvesting the peroneus brevis tendon and transferring it to the calcaneum via a minimally invasive two- or three-incision approach, ensuring reduced skin exposure and maintaining skin integrity over the rupture site. Studies by Maffulli *et al.* demonstrated significant improvements in patient outcomes following this technique [26]. In a cohort of 17 patients, the ATRS improved significantly from a mean of 58 preoperatively to 91

postoperatively at a mean follow-up of 4.6 years. Functional recovery was notable, with most patients returning to daily activities and recreational sports. Calf circumference and plantar flexion strength, while slightly reduced compared to the contralateral side, were not clinically significant, allowing patients to achieve satisfactory recovery and heel-raise functionality [26]. This approach minimizes surgical risks such as sural nerve injury and postoperative complications. However, it requires meticulous surgical technique to ensure proper alignment and fixation. Although the procedure shows promise for managing chronic ruptures, it is critical to consider individual patient factors such as defective size, tissue quality, and activity level when selecting this method [25,26].

Endoscopic-assisted techniques

Endoscopic techniques for CATR have significantly advanced, offering less invasive solutions that minimize soft-tissue damage, reduce complications, and accelerate recovery. These methods leverage arthroscopy to facilitate precise visualization and intervention while maintaining structural integrity and minimizing wound complications.

A prominent endoscopic technique involves the transfer of the FHL tendon, particularly for gaps exceeding 2 cm. Vega *et al.* described the effectiveness of an all-endoscopic FHL transfer in 22 patients with an average tendon gap of 6.3 cm [27]. The AOFAS scores improved significantly, from 55 preoperatively to 91 postoperatively, with no complications or deficits in great toe flexion. The study emphasized the technical precision required to achieve favorable outcomes, making it suitable for experienced surgeons. Li *et al.* highlighted the use of hamstring tendon autografts in endoscopic reconstruction, demonstrating significant improvements in AOFAS and VISA-A scores postoperatively [28]. No re-ruptures or major complications were observed, supporting the safety and efficacy of this minimally invasive approach. Husebye *et al.* underscored the role of FHL transfer for large tendon gaps, achieving improved functionality with reduced soft-tissue complications [29]. However, the technique's complexity requires substantial surgical expertise. Baumfeld *et al.* detailed the outcomes of endoscopic FHL transfers, reporting significant gains in ATRS and functional recovery [30]. The study noted the importance of avoiding neurovascular injury and ensuring adequate fixation. The cumulative evidence indicates that endoscopic techniques provide excellent outcomes in terms of functionality and recovery. While these approaches demand technical precision and careful patient selection, their minimally invasive nature makes them particularly advantageous for patients at risk of complications or those seeking faster rehabilitation.

We have performed a comparative analysis of various surgical techniques for CATR, emphasizing their success and complication rates, follow-up durations, and specific indications [Table 2]. Techniques such as endoscopic FHL transfer and hamstring autografts demonstrated high success rates (92%–95%) with minimal complications, making them ideal for moderate to large defects. Minimally invasive methods like peroneus brevis transfer offered excellent outcomes for smaller defects with reduced surgical risks.

Table 2: Comparative summary of studies for surgical techniques in chronic achilles tendon rupture

Study author/year	Sample Size	Surgical technique	Indications	Success rate (%)	Complication rate (%)	Follow-up duration (months)	References
Xu <i>et al.</i> , 2023	22	Endoscopic FHL transfer	Defects >6 cm	95	5	30.5	[12]
Maffulli <i>et al.</i> , 2015	17	Minimally invasive peroneus brevis	Defects <6 cm	91	0	55	[26]
Vega <i>et al.</i> , 2018	22	Endoscopic hamstring autograft	Chronic ruptures with gaps <6 cm	92	0	15	[27]
Hollawell and Baione, 2015	4	Allograft + Xenograft combination	Defects >6 cm	100	0	37	[23]
Shoab and Mishra, 2017	7	Synthetic graft augmentation	Myerson grade 3 ruptures (>5 cm)	86	14	29	[24]
Baumfeld <i>et al.</i> , 2017	6	Endoscopic FHL transfer	Defects 2–6 cm proximal to insertion	100	0	5	[30]
Hanna <i>et al.</i> , 2014	18	Allograft with bone block fixation	Severe gaps (>6 cm)	94	6	24	[21]
Gross and Nunley, 2017	14	Interpositional allograft	Defects >6 cm	93	7	27	[22]
Maffulli <i>et al.</i> , 2010	32	Less-invasive peroneus brevis repair	Gaps <6 cm	92.50	0	48	[25]
Husebye <i>et al.</i> , 2018	6	Endoscopic FHL transfer	Chronic ruptures with retraction	83	0	12	[29]

FHL: Flexor hallucis longus

Conversely, allografts and synthetic grafts were effective for extensive defects, albeit with slightly higher complication rates. These findings underscore the need for tailored, evidence-based surgical decisions.

DISCUSSION

CATR presents significant challenges due to the diverse patient profiles and varying defect characteristics [1-3]. The surgical management of acute Achilles tendon rupture focuses on immediate restoration of tendon continuity to promote natural healing, whereas chronic rupture requires a more individualized and complex approach, addressing tendon retraction, scar formation, and tissue degeneration, often necessitating grafts, transfers, or augmentation techniques [33,34]. Effective management requires a personalized, evidence-based approach that integrates emerging surgical innovations with traditional techniques [35,36]. Minimally invasive approaches have gained popularity for reducing complications such as wound breakdown, scarring, and infection [16,25,26]. Techniques like endoscopic FHL transfer and peroneus brevis tendon transfer provide excellent functional outcomes, particularly for moderate defects, while maintaining a reduced risk profile compared to traditional open methods [27,28]. The biomechanical compatibility of FHL with the Achilles tendon ensures effective load transfer and preservation of the natural line of pull, making it a preferred method for moderate-to-large defects [12,13]. However, donor site morbidity, including reduced big toe flexion strength, remains a concern, though this rarely impacts daily activities significantly.

Autografts, including FHL and peroneus brevis, remain critical for reconstructing medium-to-large defects, offering robust mechanical properties and minimizing donor-site morbidity [12,13,26]. Augmentation further enhances these techniques, with systematic reviews and meta-analyses demonstrating superior functional outcomes, such as improved AOFAS scores [35]. Despite their advantages, these procedures demand substantial surgical expertise, and complications such as wound healing issues or tendon elongation can impact

outcomes [36]. Allograft tendons are particularly advantageous in cases of extensive tendon gaps, offering a solution without donor-site morbidity, and are often favored for gaps exceeding 6 cm [20-23]. While autografts provide robust mechanical strength and biological integration, allografts eliminate the need for additional operative sites and result in shorter surgical times, though concerns regarding integration and long-term durability remain [19].

Traditional open techniques, such as V-Y plasty, are indispensable for managing extensive defects and retracted tendons [18]. These methods provide structural integrity but are associated with longer recovery times and higher complication risks. Combining V-Y plasty with tendon transfers, such as FHL or semitendinosus autografts, enhances outcomes in challenging cases, as it restores tendon length and ensures functional recovery [14,15,18]. Studies consistently highlight the importance of precise tensioning during surgery to prevent complications like postoperative elongation or calf weakness [35,36].

Innovative techniques incorporating synthetic grafts and biological augmentation have broadened the scope of treatment for large defects and poor-quality tissue [24,36]. These approaches may be particularly useful for patients with comorbidities or complex anatomical challenges. Synthetic grafts, for example, serve as scaffolds for tissue ingrowth while providing immediate structural support, though concerns regarding integration and long-term durability persist [24]. Biological augmentation, combined with minimally invasive procedures, minimizes soft-tissue dissection and improves healing, making it a promising avenue for future treatment strategies [36-38].

Endoscopic techniques for CATR repair offer several advantages over traditional open methods [39,40]. These methods minimize soft-tissue dissection, reduce the risk of wound complications, and enhance cosmetic outcomes [41,42]. Endoscopic FHL tendon transfer and hamstring autograft techniques are associated with improved functional recovery, shorter rehabilitation periods, and superior outcomes in terms

of strength and mobility, particularly for moderate-to-large defects [27-30]. In addition, these approaches provide precise visualization of anatomical structures, enabling accurate graft placement and tensioning, which are critical for successful outcomes. However, endoscopic procedures may be technically demanding and require specialized equipment and surgeon expertise. Complications such as incomplete graft harvest, neurovascular injury, or inadequate tensioning can arise, especially in less experienced hands [39-42]. Despite these challenges, studies consistently demonstrate the efficacy and safety of endoscopic techniques, suggesting their potential as a standard approach for CATR in appropriately selected patients. Future research and standardization of training protocols may further enhance their adoption and outcomes.

Comparative analyses highlight the tailored application of techniques based on patient-specific factors, such as age, activity level, defect size, and tissue quality [35-37]. Younger and active patients benefit significantly from tendon transfers, free grafts, and minimally invasive techniques due to their high functional demands and better recovery potential. In contrast, older or less active patients may achieve satisfactory outcomes with allografts or conservative management, as these methods minimize surgical morbidity while addressing functional requirements [35-37]. However, techniques like FHL transfer and minimally invasive procedures can also be adapted for older populations, provided that preoperative planning and postoperative rehabilitation are optimized [23,38]. Our study has tried to develop a decision-making framework for surgically treating CATR, considering critical factors

such as defect size, tissue quality, patient age, activity level, and comorbidities. This framework recommends tailored surgical methods, from end-to-end repairs for small defects to allografts and synthetic grafts for extensive gaps, ensuring optimal, patient-specific outcomes [Table 3].

Despite these advancements, achieving consensus on the optimal surgical approach for CATR remains challenging due to variability in patient profiles, surgeon expertise, and resource availability. Randomized controlled trials and long-term outcome studies are needed to validate emerging techniques and refine treatment guidelines. Future research should focus on standardizing protocols and exploring innovative methods to address the unmet needs of diverse patient populations.

CONCLUSION

Management of CATR requires a comprehensive, patient-centered approach that leverages both established and novel techniques. Small defects are best treated with end-to-end repairs or local tendon transfers, while medium defects benefit from V-Y plasty or semitendinosus autografts. For larger defects, free grafts, synthetic materials, and biological augmentation provide robust solutions. A structured decision-making framework, combined with ongoing advancements in surgical techniques, offers the potential for improved patient outcomes and satisfaction across a wide spectrum of cases.

Data availability statement

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Table 3: Decision-making for treatment of chronic achilles tendon rupture

Factor	Assessment	Recommended surgical methods	Key considerations
Defect size (cm)	Small (<2)	End-to-end repair, local scar tissue repair	Avoids grafts; limited to minimal retraction or tissue loss
	Moderate (2-5)	V-Y plasty, FHL transfer, semitendinosus graft	Provides sufficient length restoration; requires moderate surgical expertise
	Large (>5)	Allograft, synthetic graft, combined techniques	Suitable for extensive defects; synthetic options reduce donor site morbidity
Tissue quality	Healthy, viable tendon ends	Autografts, tendon transfers	Autografts provide durable solutions; ideal for healthy donor tissue availability
	Poor or degenerated tissue	Allograft, synthetic graft augmentation	Allografts avoid donor site risks; synthetic grafts offer consistent structural support
Patient age (years)	Younger patients (<50)	FHL transfer, hamstring autograft	Focuses on strength restoration for active lifestyles
	Older patients (>50)	Allograft, minimally invasive techniques	Minimally invasive methods reduce surgical morbidity; prioritize safe recovery
Activity level	High-demand (athletes, labor-intensive jobs)	FHL transfer, peroneus brevis transfer	Restores high functional capacity; ensures load-bearing strength
	Low-demand (sedentary, elderly)	Allograft, conservative options	Focus on functional recovery and minimizing surgical risks
Comorbidities	Few or no comorbidities	Autografts, tendon transfers	Prioritize durable, function-restoring techniques
	Multiple comorbidities (e.g., diabetes, smoking)	Minimally invasive techniques, synthetic grafts	Reduces wound healing complications; minimizes surgical trauma
Gap chronicity (weeks)	Recent rupture (<6)	End-to-end repair, scar tissue repair	Early interventions yield better outcomes; less complex techniques may suffice
	Chronic rupture (>6)	Allograft, V-Y plasty, synthetic augmentation	Addresses retracted ends and degenerative changes effectively
Surgeon expertise	Experienced in advanced techniques	Endoscopic FHL transfer, hamstring autograft	Optimal for technically demanding methods requiring precision
	Limited expertise	Open procedures, allograft	Reliable and less technically challenging methods ensure predictable outcomes

FHL: Flexor hallucis longus

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Conflicts of interest

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