

Management of Chronic Achilles Tendon Ruptures



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KEYWORDS

• Chronic • Achilles • Synthetic • Graft • Technique

KEY POINTS

- Traditional chronic Achilles tendon rupture (CATR) repair techniques are often associated with large soft tissue exposures and donor site morbidity.
- Synthetic grafts such as Artelon and acellular collagen matrices can be used in CATR repairs to improve healing.
- A 5-mm strand synthetic graft can be woven through an Achilles tendon in CATR to provide strength and biology.

BACKGROUND

The human body's largest and strongest tendon, the Achilles tendon (AT), joins the gastrocnemius complex to the calcaneus to enable the foot's plantarflexion.¹ The most commonly torn tendon, tears occur mainly in men aged 30 to 40 years during activity, with increasing incidence in the past few decades.^{2,3} Although it is the most commonly torn tendon, acute tears can be difficult to diagnose resulting in 10% to 25% being undiagnosed.⁴ AT tears that do not receive treatment in 4 to 6 weeks are defined as chronic AT ruptures (CATR).⁵

CATR can be challenging to treat due to histologic changes in the tendon and retraction of the proximal end of the tendon. Torn tendons histologically demonstrate thick collagen fibers with highly cellular fibrovascular tissue and thick fibrous scar at the torn ends that must be debrided to improve healing.^{6,7} In addition to the cellular changes, the large retraction distances of the proximal section can pose significant technical difficulty in repair.^{7,8} The grading system used to guide treatment is the Myerson Classification which is graded by the length retraction of the two ends.⁹ For a type 1 defect of 0 to 2 cm, recommended repair is end to end repair. A type 2 defect ranges from 2 cm to 5 cm and can be treated with a VY lengthening with or without tendon

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Abbreviations	
ACM	acellular collagen matrices
AT	Achilles tendon
CATR	chronic Achilles tendon rupture
FHL	flexor hallucis longus

transfer. Type 3 defects are defined as greater than 5 cm of retraction and recommended treatment includes tendon transfer alone or in combination with VY advancement.

Historical surgical techniques for CATR include primary repair, VY advancement, AT turndown, tendon transfers, and allografts. Primary repair is indicated for tendon repairs within 2 cm.^{9,10} End to end repair is ideal due to preservation of native anatomy, potentially faster healing, without the downsides of advancement procedures.¹⁰ Often this method of repair is not feasible due to the gap being greater than 2 cm after debridement of the tendon ends.¹⁰ When available, primary repair demonstrates excellent outcomes for short repairs. However when the patient is placed in extreme plantarflexion, this can increase tendon tension and lead to prolonged recovery time and immobilization postoperatively.¹¹

Advancements in device technology allowed the development of minimally invasive techniques for primary end to end repair of an AT. These techniques offer the potential for increasing the efficiency of surgery while decreasing the soft tissue exposure.^{11–13} However, their indications and techniques are beyond the scope of this paper.

When end to end repair is not feasible, surgeons have turned to VY advancement or gastrocnemius fascial turndown to bridge the gap.^{9,10,14,15} Gastrocnemius VY advancement uses the gastrocnemius aponeurosis for the V sliding down the remaining proximal portion of the Achilles to bridge the gap¹⁶ (Fig. 1). The tendon thickness and anatomy at the repair site remains unaltered in this technique, and surgeons can bridge large gaps, up to 9 cm, with good outcomes reported.^{10,16} Given that the V side of the advancement must be one and a half times the size of the gap, this may limit the length of advancement in some patients.^{10,16} In addition to the anatomic limitations of the advancement, the technique necessitates a large open incision often resulting in large scar formation, decreased calf strength, decreased plantarflexion versus uninjured side, and decreased tendon strength.^{10,15}

Achilles turndown is also used for defects greater than 2 cm and uses gastrocnemius fascia incised and peeled inferior, the tendon split, and the fascia used to bridge the tendon gap.¹⁷ The gastrocnemius fascia, however, is not as strong as native tendon and repair with fascia alone has demonstrated issues with retear and plantarflexion strength.¹⁴ Thus gastrocnemius fascia turndowns are often paired with flexor hallucis longus (FHL) tendon transfers to decrease the incidence of retear, increase plantarflexion strength, and improve rates of return to sport.^{14,18} Concerns with gastrocnemius fascial turndown include decreased calf size, decreased strength, and diminished tendon thickness.^{10,14}

Tendon transfers are another viable option to bridge the tear in deficits greater than 2 cm, and can be used alone or as supplements to strengthen a repair. The two most common options for reconstruction are the peroneus brevis and FHL tendons. These transfers present an alternative to gastroc advancement procedures, which cause substantial soft tissue disruption.¹⁹

The FHL tendon transfer has several potential benefits, including having the same phasic action as the gastrocsoleus complex, preserving normal ankle muscle balance, and being easy to harvest.^{18,20,21} When tears have been neglected for a significant period of time (more than 3 months), MRI is recommended to assess for fatty



Fig. 1. Clinical photo demonstrating debrided edges of the AT.

infiltration and atrophy of the gastrocnemius-soleus complex.²² In these patients, FHL transfer is recommended for additional plantarflexion strength, as it is the second strongest ankle flexor.²²

Research demonstrates both FHL and peroneus brevis transfers have similar outcomes, with most patients regaining their previous levels of activity and ankle function.^{10,23,24} The downsides of tendon transfers include alteration of the native biomechanics of the foot and ankle, donor site morbidity, and increased risk to neurovascular structures.^{20,21,25–27} Allografts and synthetic grafts offer simpler surgical technique, smaller exposures, and no donor site morbidity, making them attractive alternatives to tendon transfers and gastrocnemius advancement procedures.^{10,20,21,28}

Achilles allograft with or without bone block offer many advantages including a strong scaffold that provides immediate structural support for the repair, shorter operative times than the autologous procedures, and adequate tissue quantity.²⁹ Although no large comparative studies have been performed, single case studies and small cohort studies have demonstrated significant improvements in ankle function with achilles allograft comparable to autologous procedures.^{29–32} The risks of infection from allografts, potential immune response, long integration time, and higher costs decrease the appeal of allografts.

Despite their widespread use, allograft and autograft options have a major disadvantage: they lose strength due to resorption.³³ These grafts can take up to 12 months to mature and restore mechanical strength, which has highlighted the need for a biological implant that can provide structural support during integration.^{33–35} Recent technological advancements have enabled the development of commercially available synthetic grafts. These synthetic grafts can provide immediate rigid strength to

repairs, decrease exposure sizes, and maintain strength throughout the remodeling and healing process.^{34,35}

Acellular collagen matrices (ACM) are collagen scaffolds made from processed collagen, elastin, and growth factors that typically come from human or bovine sources.^{34,36} Commercial versions are commonly woven into sheets or strands. Some examples are TissueMend, GraftJacket, Integra Inforce, BioBrace, and Arthroflex.^{34,37–40} ACM augments offer structural support up to 2 years during the remodeling process, and also function as a framework for cellular and vascular ingrowth.^{34,41} Studies show that ACM significantly increases the strength of the repair after implantation, up to 185% stronger than standard sutures, and also reduces creep compared to standard suture repair.^{34,42}

Besides providing structural support for the healing tendon, collagen-based augmentations may also accelerate recovery and enhance healing. Lee and colleagues conducted a study where 9 chronic AT repairs were augmented with acellular dermal collagen matrix.³⁷ The patients in the Lee study returned to their activities more quickly than patients who had been treated with standard gastrocnemius advancement flaps or primary repair in previous studies.³⁷ Multiple case reports and studies that evaluated tendon tears and collagen matrix augmentations found no cases of retear or tissue irritation, demonstrating that acellular augments not only provide strength, but also cause a minimal inflammatory response at the repair site.^{37,43}

Although immediate strength of a repair is important in early remodeling, tendon healing continues into the weight bearing portion of a patient's rehabilitation process.⁴⁴ While a benefit during early remodeling when the patient is non weight-bearing, a stiff implant could potentially create stress shielding and alter the healing template in a maturing repair as patient progresses through therapy. With early weight-bearing in CATR rehabilitation demonstrating long term functional improvements, a synthetic augment with mechanical properties closely matching native tissue is highly desirable as rehabilitation protocols have demonstrated early weight-bearing and range of motion improves long term function after CATR repair.¹⁰

Artelon, a synthetic augment made of woven poly urethane urea, has strength similar to the anterior talofibular ligament (ATFL) of 170N.⁴⁵ Its hyperelasticity allows loading of affected tissues, which stimulates late remodeling.³⁵ Artelon is an inert implant that maintains its strength well, retaining 50% of its mechanical properties at 3 years with a total integration time of 5 years.⁴⁶ It is commercially available in multiple sizes as either sheets or thick strands (5-mm width).

The literature on Artelon, while limited, shows successful results in a variety of reconstructive methods. Shaoib and colleagues demonstrated Artelon's use with gastrocnemius VY plasty in 7 CATR patients with deficits greater than 5 cm. Six of the 7 patients were able to single stance heel raise and they reported no retears at 2 years.²⁸ Carvahlo and colleagues demonstrated an FHL transfer with Artelon augmentation in a 13 cm deficit. At 12 month follow-up the patient had a positive single leg heel raise and no complications.⁴⁷

While rehabilitation protocols for CATR repair vary, studies have shown that early range of motion improves functional outcomes without increasing the risk of retear.^{48,49} Most protocols recommend about 2 weeks of early immobilization, followed by early range of motion and weight bearing in a boot, progressing to full weight-bearing by 8 weeks.¹⁰

AUTHOR'S PREFERRED TECHNIQUE

With the advent of the strand-like synthetics that provide strength and biology without donor site morbidity, we prefer the use of a synthetic strand (5 mm in width) graft, used in a similar fashion to the autograft tendon transfer methods with or without FHL

transfer to treat and reinforce CATR with various gaps. This technique is recommended for index procedures in acute, subacute, or chronic tears. This provides for structure spanning the tendon repair site, addition of biologics, and allows for integration long-term. Surgical treatment begins with careful soft tissue dissection, preserving the precrural fascia of the pseudosheath of the Achilles to allow for a layered repair over the reconstructed tendon at the conclusion of the case. This is followed by meticulous soft tissue release of both the proximal and distal ends of the ruptured tendon to allow for full excursion of the tendon after reconstruction (see [Fig. 1](#)).

A preliminary repair is performed using 0 Vicryl suture in a Krackow fashion to allow a surgical assistant to hold the tendon edges in apposition after debridement. Alternatively, the Vicryl can be substituted for a permanent suture if desired. While holding these sutures under tension, a #2 permanent suture is used to maintain this reduction, also in a Krackow fashion ([Figs. 2 and 3](#)). Once tied, the Vicryl sutures are also tied. This suture repair is then reinforced with a synthetic strand graft of 250 mm to 300 mm in length. The graft is passed horizontally through the distal segment, distal to the Krackow sutures, using these as a rip-stop. Then, both limbs are passed vertically on both the medial and lateral sides of the repair site and passed horizontally through the proximal segment, proximal to the Krackow sutures, akin to the Turco and Spinella modification of the Teuffer technique ([Fig. 4](#)).^{26,27}

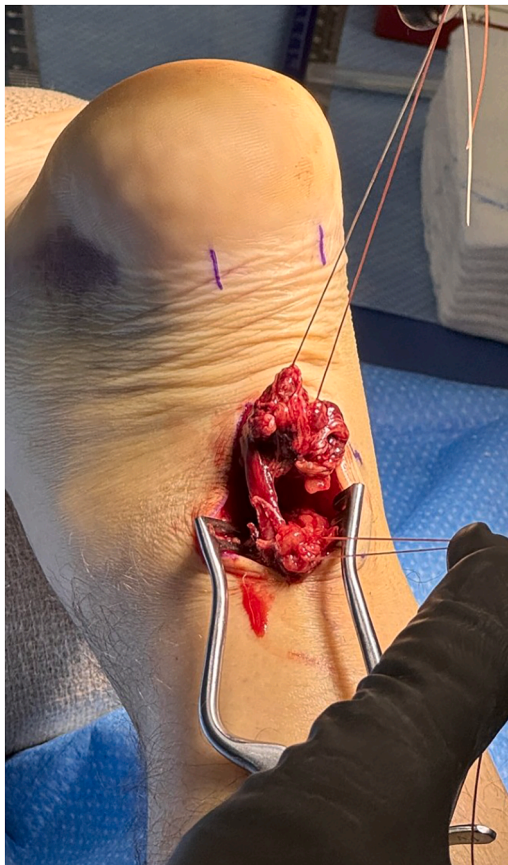


Fig. 2. Demonstrates two ends of the tendon with placement of Vicryl sutures.



Fig. 3. Demonstrates reapproximation of the two tendon ends.

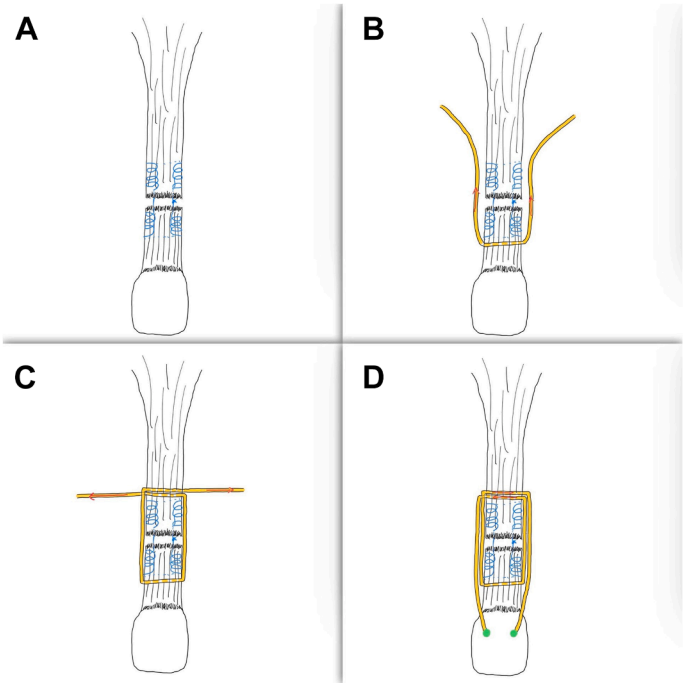


Fig. 4. (A) Demonstrates the preliminary repair using the Krakow technique. (B) Demonstrates the graft placed through the distal end of the AT through a midcoronal split. (C) Demonstrates crossing of the graft strands through the proximal segment. (D) Demonstrates anchoring of the graft strands into the calcaneus.

The long tails are then passed distally, within the pseudo-sheath to percutaneous incisions over the medial and lateral insertions of the AT (**Figs. 5–7**). These tails are then anchored to the calcaneus, bridging the proximal Achilles to the calcaneus, similar to the Midsubstance SpeedBridge technique. The 3.85 mm anchor for Artelon offers strength with optimal sizing and is the recommended size for this technique. A 4.75 mm anchor is used for BioBrace. Anchor placement is at or distal to the Achilles insertion site, one anchor medial, one lateral, drilled orthogonal to the bone to prevent graft damage from more acute angles (like a dead man's anchor). *Both Artelon and BioBrace can be trimmed to size. Artelon is easily shaped with a scalpel both on the back table and intraoperatively. BioBrace is best trimmed with sharp mayo scissors before insertion, and excess can be removed with a scalpel once implanted.*

The longitudinal limbs of the graft at the repair site are sutured to each other using a figure-of-8 fashion with 0 Vicryl, both proximal and distal to the reconstruction site. In cases where a substantial gap exists at the repair site and/or muscle atrophy is present, an FHL transfer can be performed to supplement the repair's strength. This procedure is carried out through the same incision using a blind tunnel and interference screw fixation into the calcaneus. The muscle belly is then positioned against the deep side of the repair site and sutured in place. The procedure concludes with a meticulous layered closure of the soft tissue, and the patient is placed in a bulky splint for 10 to 14 days.

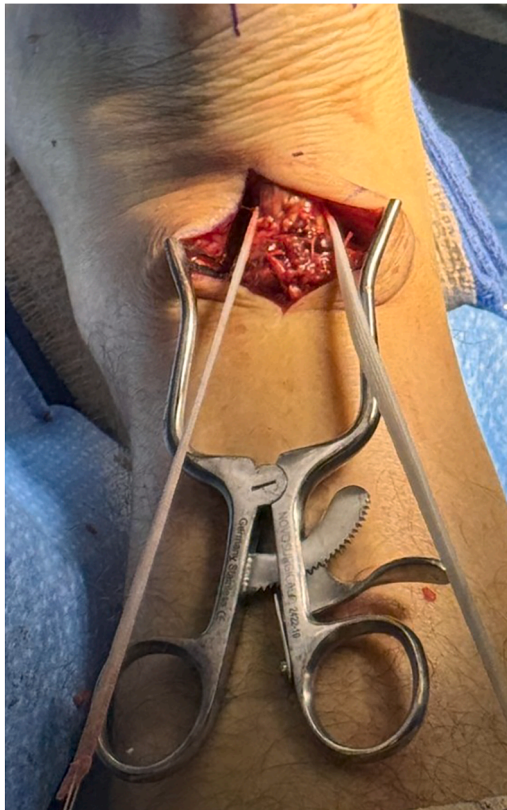


Fig. 5. Demonstrates passage of Artelon through distal aspect of the tendon.

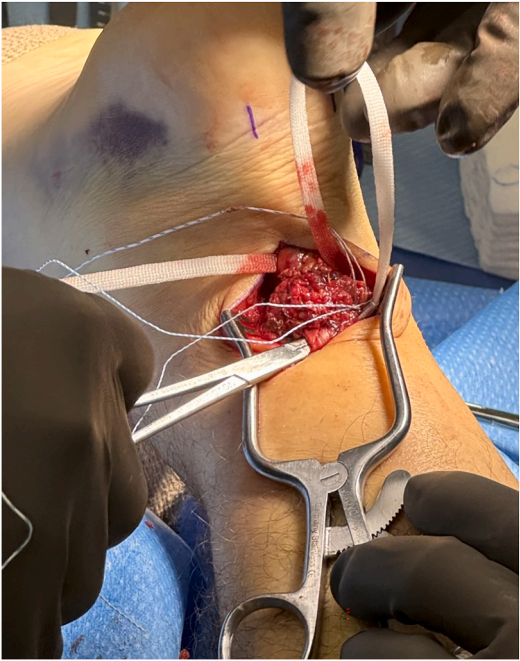


Fig. 6. Demonstrates passage of one limb of Artelon through the proximal tendon.

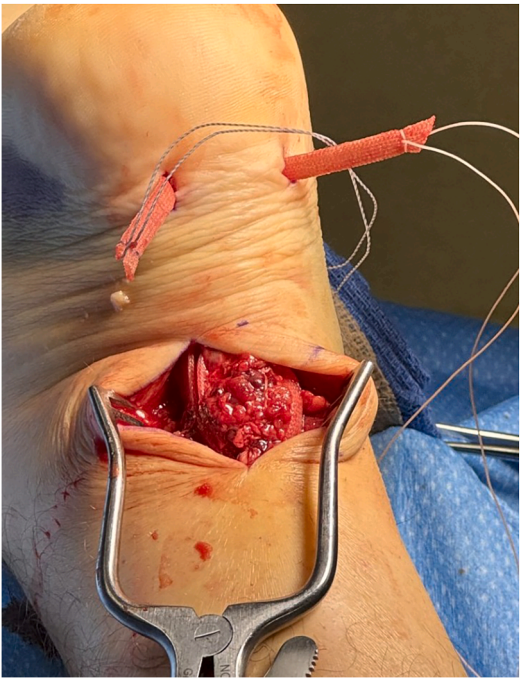


Fig. 7. Demonstrates both limbs of Artelon before anchoring.

Early functional rehabilitation is pivotal for AT repair outcomes. There are multiple early functional rehabilitation protocols.^{48,49} Our patients are kept nonweight-bearing for the first 6 weeks after reconstruction, the first 10 to 14 days in a splint, followed by the remainder in a control ankle motion (CAM) boot using an Achilles wedge. Functional rehabilitation is started after 3 weeks, augmented with blood flow restriction therapy.⁵⁰ Weight-bearing is initiated after 6 weeks, weaning the wedge in the CAM boot as active dorsiflexion allows. At 10 weeks, the patient is weaned out of the boot and into regular shoe gear with limitations to low-impact activities. High impact activities are resumed once the patient is able to perform multiple single limb heel raises and multiple single limb hops.⁵¹ Due to the chronic nature of CATR, total recovery time is estimated to take 9 to 12 months.

SUMMARY

CATR is a challenging disease to treat due to histologic changes and tendon retraction. Traditional techniques involve large soft tissue exposures and donor site morbidity. New synthetic grafts may be used to reduce the soft tissue morbidity of repairs and facilitate earlier mobilization.

CLINICS CARE POINTS

- Traditional chronic Achilles tendon rupture (CATR) repair techniques are associated with large soft tissue exposures, and donor site morbidity.
- Synthetic grafts may offer a tool to reduce the morbidity associated with traditional techniques, and improve healing to CATR repairs.
- A 5 mm synthetic graft augment can be used in a variety of ways to strengthen the repair of CATR with or without flexor hallucis longus transfer.
- Early functional rehabilitation is key to improving functional outcomes after CATR repair.

DECLARATION OF AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of the work, the author Jake Powell D.O. utilized Google Gemini to improve grammar and improve readability of the paper. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

DISCLOSURE

Dr W. Crawford is a consultant for Ossio, Mirus, Medartis, GLW, and Biopoly. The other author has nothing to disclose.

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