

Achilles Tendon Salvage



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KEYWORDS

- Achilles tendon • Salvage • Tendon transfer • V-Y advancement
- Gastrocnemius turnaround

KEY POINTS

- In the setting of infection, the cornerstone of Achilles tendon salvage is adequate debridement.
- Different salvage techniques are optimal depending on tendon gap length.
- Achilles tendon repair often faces wound complications, infection, and rerupture due to limited blood supply and soft tissue, necessitating meticulous surgical and wound management.
- Effective management requires early aggressive debridement, infection control, and appropriate reconstruction - primary repair, tendon transfer, or allograft based on tendon loss and soft tissue condition.
- Traumatic lacerations and tendon reruptures present unique challenges that necessitate prompt intervention, meticulous surgical planning, and sometimes complex reconstructions to restore plantar flexion and functional outcomes.

INTRODUCTION

Achilles tendon repair, though often successful, can be associated with complications that challenge even the most experienced orthopedic surgeons. In the case of wound complications, infections, and tendon reruptures the goal shifts from primary repair to salvage procedures aimed at preserving plantar flexion function and strength. Although a distinct entity, traumatic lacerations of the Achilles are often associated surrounding soft tissue damage, and like postoperative complications, also require a multifaceted approach requiring a keen understanding of tendon biology, wound healing, and advanced surgical techniques.

Infections and wound dehiscence are among the most common complications after Achilles tendon surgery. When an infection is suspected or confirmed, managing the delicate balance between debridement and tendon preservation becomes a critical challenge. Moreover, wound complications, especially in patients with poor vascularity, diabetes, or a history of previous surgeries, often necessitate aggressive

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Abbreviations

FDL flexor digitorum longus
FHL flexor hallucis longus

management strategies, including advanced wound care techniques and occasionally flap coverage. Wound complications are among the most common issues following operative Achilles tendon repair, with an estimated incidence ranging from 2.3% to 5.2%.^{1–3} In conjunction with wound issues, infection occurs in an estimated 1% to 2.8% of Achilles tendon operative repairs.⁴ These complications are associated with significant postoperative morbidity, leading to prolonged recovery and possible, permanent functional impairment. The Achilles tendon region presents challenges in wound healing due to its relatively poor blood supply, a thin layer of subcutaneous tissue, and the lack of significant surrounding soft tissue, which impairs the body's natural ability to promote healing.^{5,6} These anatomic factors make the area especially susceptible to infection, dehiscence, and other wound-related issues.

Postoperative Achilles tendon reruptures further complicate the salvage process. Rerupture after Achilles tendon repair remains a significant concern, though recent advances in surgical techniques and postoperative care have significantly reduced the incidence. While more modern functional rehabilitation techniques have decreased rerupture rate after nonoperative treatment, debate remains on the optimal treatment of Achilles tendon ruptures. Rerupture rates following operative repair typically range from 0.6% to 1.6%. There has been conflicting literature on rerupture rate in nonoperative management. Historically, rerupture rates were cited as high as 5% to 10% but more modern meta-analysis of studies that incorporate functional rehab have shown lower rates of rerupture.^{7–9} When comparing open surgical repair and minimally invasive surgery, rerupture rates are generally similar, with both techniques demonstrating rates between 1% and 3%.^{10,11} Multiple factors contribute to the likelihood of rerupture, including patient demographics, comorbidities, surgical technique, and postoperative management. Understanding these factors is essential for optimizing surgical outcomes and minimizing the risk of reinjury following Achilles tendon repair. Whether they occur due to inadequate primary repair, infection, noncompliance with rehabilitation protocols, reruptures require urgent reassessment and potentially more complex reconstructions. As reruptures often result in scarring and altered biomechanics, restoring tendon continuity and function requires meticulous attention to tendon repair techniques, tendon transfers, or allograft.

Traumatic Achilles tendon lacerations, particularly those in the presence of significant soft tissue injury, present their own set of challenges. These cases often involve tissue loss, contamination, and the need for reconstructive strategies. Surgeons must make critical decisions about how to best manage tendon defects, whether through primary tendon repair, augmentation with grafts, or more complex tendon reconstructions. There is limited literature on the epidemiology, presentation, and management of open Achilles tendon lacerations.^{12,13} These injuries typically result from direct trauma to the posterior leg, presenting with an open wound. Diagnosis can often be made through physical examination, particularly if the laceration is large enough to expose the tendon, along with the Thompson test or MRI. Prompt treatment within 24 hours is crucial due to the limited blood supply and the high risk of wound and infection complications in this area. Treatment includes antibiotics, surgical irrigation and debridement, and, when feasible, primary tendon repair. Management strategies for cases where primary tendon repair is not possible—such as when there is a significant tendon gap or inadequate soft tissue coverage—will be discussed later in this article.

This article will delve into the specific challenges and techniques associated with Achilles tendon salvage in the face of postoperative complications, including infection, wound dehiscence, and rerupture and touch on Achilles salvage in the setting of traumatic lacerations.

MANAGEMENT STRATEGIES

The general goals of care for postoperative Achilles wounds and infections include eradicating infection, covering the wound, and restoring functional plantarflexion. Generally agreed upon management of superficial wounds and infections is early debridement and wound management to prevent deep infection. However, deep infection of the tendon requires more aggressive debridement including removal of necrotic tendon and foreign materials and grafts, cultures, and antibiotics which should be culture-driven.^{14,15} Once infection is eradicated, there is no consensus on one better strategy for tendon reconstruction and soft tissue coverage. Furthermore, there are conflicting reports on multistage versus single-stage debridement and tendon reconstruction which is typically patient, case, and surgeon specific.

Liles and colleagues described a treatment algorithm to guide management. In general, wound breakdown with exposed tendon should be debrided, cultures taken, and infection treated with antibiotics.¹⁶ It is crucial that any foreign material be debrided, as this will be a nidus for further infection and wound healing issues. The wound can be primarily closed if able or covered with negative pressure wound device and redebrided as necessary until there is a healthy wound bed and tendon quality can be assessed. At this point, tendon gap management is the same as rerupture management, in that further management depends on size of the tendon gap. Typically, in gaps lesser than 2 cm end-to-end repair can be attempted.¹⁷ When gaps are larger, salvage tendon reconstruction options described include tendon transfer, turn-down rotational flap, advancement flap, or reconstruction with tendon allograft, which can all be used in isolation or more often in combination as seen in Fig. 1.

Tendon Transfers

Tendon transfers are ideal to augment Achilles tendon reconstruction as they are vascularized, less prone to infection, available, and aid in plantarflexion.¹⁸ The most

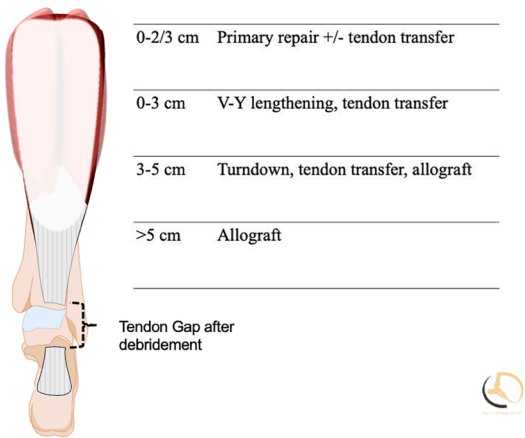


Fig. 1. Management strategies of Achilles tendon salvage based on tendon gap size after debridement.

widely used tendon is the flexor hallucis longus (FHL). This technique was first described in 1991 by Hansen.¹⁹ Since that time, FHL transfer has become the most common salvage technique in Achilles tendon repair.²⁰ The FHL tendon is unique due to its role in plantarflexion, inversion, and toe flexion. Its anatomic course within the posterior compartment allows ease of transfer through the same incision. Moreover, the FHL is activated during the same phase of gait and in line with the triceps surae. By transferring the FHL to the Achilles tendon (typically in a manner that simulates the natural line of pull of the achilles), the plantarflexion strength can be restored to a large degree, helping to regain functional motion in the ankle.²¹

The technique is generally as follows. After the initial standard Achilles exposure, the fascia anterior to the Achilles tendon is incised to expose the FHL muscle belly, taking care to avoid the neurovascular bundle located superiorly and anteriorly. Care should be taken to fully release the fascia to avoid impingement of the FHL. The FHL tendon is identified as it runs behind the talus; traction is applied to confirm its identity by observing flexion of the hallux. The tendon is then transected as distally as possible to protect the medial neurovascular bundle and is retrieved proximally through the posterior incision.

An alternative technique involves a midfoot harvest using a second incision at the plantar-medial border of the foot, in line with the first metatarsal. Through this additional exposure, the abductor hallucis, flexor hallucis brevis, along with the medial plantar neurovascular structures, are carefully retracted plantar. Care is taken to ligate the cascade of veins along the plantar medial foot to prevent hematoma formation. The anatomic landmark is the master knot of Henry, where the FHL and flexor digitorum longus (FDL) cross. Here, the FHL can be predictably identified dorsal to the FDL and marked using a right-angle clamp. The tendon is then transected proximal to this knot, and the graft is retrieved through the posterior incision. Before transferring the FHL tendon posteriorly, meticulous dissection is required to release the multiple tendinous bands between the FHL and FDL just proximal to the Knot of Henry, ensuring independent mobilization of the FHL and facilitating a tension-free transfer. In some cases, the FHL stump can be tenodesed to the FDL tendon at the Knot of Henry to minimize strength loss.

Comparatively, the posterior harvest (single incision) yields an average tendon length of approximately 5.16 cm, minimizing additional incisions and reducing the risk of neurovascular injury. The midfoot harvest (double incision) provides a longer graft—averaging about 8.09 cm—but involves increased surgical exposure and a higher potential for neurovascular injury. Despite the longer graft provided by the midfoot technique, studies have not conclusively shown that the additional length offers a definitive clinical advantage in Achilles tendon reconstruction. For most cases, the authors will use a posterior harvest. However, in the setting of a large soft tissue defect that prevents reapproximating the native Achilles tendon, they will harvest the FHL at the knot of Henry.

For posterior harvest tendon fixation, a bone tunnel is placed in the calcaneus, positioned 1 cm anterior to the Achilles insertion and angled slightly anterior. The tunnel is carefully placed as posteriorly as possible to preserve the mechanical advantage of the FHL. Tunnel size is dependent on size of the tendon, typically between 5 and 6 mm for a distance of 25 to 30 mm. The tendon is prepared by removing the paratenon, after which a whip-stitched suture is passed through the bone tunnel and out the plantar aspect of the skin. The ankle is maximally plantarflexed and the tendon is pulled to maximal tension and fixed with a tenodesis screw that correlates to the tunnel width. Finally, the FHL can be sutured to the undersurface of the Achilles tendon if needed for additional fixation.

For transfers that involve a midfoot harvest, typically a drill hole is placed in the medial calcaneal border and drilled half way across the width of the calcaneus. A separate tunnel is made about 1 cm anterior to the Achilles insertion connecting the

previous tunnel at a 90° angle. The tendon can then be sutured back on itself and fixed with a tenodesis screw in the medial entrance tunnel of the calcaneus (Fig. 2A–D).

Overall, FHL transfer for Achilles tendon reconstruction is an effective technique that requires a balance between the benefits of additional tendon length and the risks of increased surgical exposure, such as potential neurovascular injury and wound complications. Most common complications include medial and lateral plantar nerve injuries, and loss of hallux plantar strength which is usually not functionally significant.

Alternatives to FHL transfer include FDL and peroneus brevis transfers. Peroneus brevis transfer was first described in 1974 by Teuffer.²² The peroneus brevis tendon originates from the distal two-thirds of the fibula and inserts on the base of the fifth metatarsal. The proximal attachment of the peroneus brevis to the fibula is relatively close to the fibular head, making it accessible and available for harvesting without significant functional loss in foot eversion. Although it lacks the same power as the Achilles tendon in pure plantarflexion, it can effectively generate enough force when rerouted to act in a manner similar to the natural Achilles tendon during ambulation, particularly in situations where the patient does not require maximal plantarflexion strength for activities like sprinting or jumping. One long-term follow-up study demonstrated adequate functional results after peroneal brevis transfer.²³

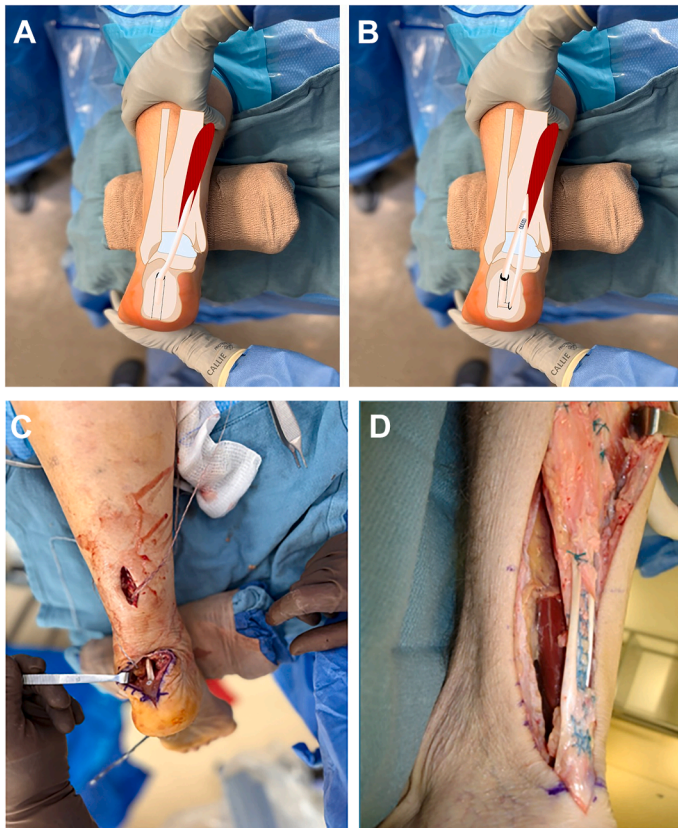


Fig. 2. (A–D) Graphic and clinical photos of FHL transfers—(A & C) demonstrates single incision technique versus (B & D) 2 incision techniques.

FDL transfer for Achilles tendon reconstruction, first described by Mann in 1991, serves as an alternative to the more commonly used FHL transfer. Although the FDL works in tandem with the gastrocnemius during gait, its relative weakness and potential for reduced toe flexion have raised concerns about its ability to fully compensate for a deficient Achilles tendon. Nonetheless, despite limited studies, reported outcomes indicate favorable pain relief, functional restoration, and ambulation, making FDL transfer a viable option when FHL transfer is contraindicated.

V-Y Advancement and Gastrocnemius Turndown

V-Y advancement is helpful in tendon gaps up to about 3 cm. This technique was first described in 1975 by Abraham and Pankovich in which a V-shaped incision is made proximally in the gastrocnemius fascia and distally the tendon is stretched to fill in the tendon gap (Fig. 3).²⁴ The proximal incision is then repaired to create a Y repair. V-Y advancements can be done in isolation and in combination with tendon transfers for larger tendon gaps.

An inverted-V incision is created through the tendinous portion of the gastrocnemius-soleus-Achilles complex at the myotendinous junction, carefully preserving the underlying muscle fibers to maintain vascularity. The apex of the V is positioned at the midline of the most proximal portion of the junction, while its limbs extend medially and laterally, exiting at the respective borders of the tendon. To achieve adequate lengthening, particularly for defects greater than 5 cm, the limbs of the V should be at least twice the length of the rupture gap. A common mistake is underestimating this length, which can result in insufficient tendon advancement and excessive tension on the repair.²⁵

Once the tendon is sufficiently lengthened, the repair is performed using a heavy braided nonabsorbable suture and a locking Krackow technique with at least 5 locking loops placed in a running fashion along both the medial and lateral aspects of the tendon. Each loop captures approximately one-third to one-half of the tendon width, ensuring a strong and secure construct. The suture is passed through the tendon substance and mirrored on the opposite side, forming a continuous, reinforced repair.

With the suture in place, traction is applied to the proximal tendon stump in a distally directed manner, allowing the myotendinous junction to gradually slide and lengthen. This process requires steady, controlled force, sometimes aided by a weight placed over the end of the surgical table. Excessive force must be avoided to prevent tendon detachment and potential devascularization. Gentle longitudinal teasing of the muscle fibers helps facilitate further elongation until the tendon ends can be approximated with ankle resting tension matching the unaffected side. Once the necessary length is achieved, the V incision is closed in an inverted-Y configuration, with the new

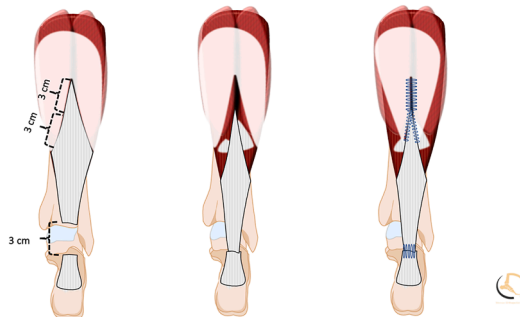


Fig. 3. Illustration of V-Y advancement.

longitudinal limb representing the additional tendon length gained through the procedure. This final step preserves tendon integrity while ensuring sufficient elongation to bridge the defect.²⁶

Similar to V-Y advancement, a gastrocnemius turndown is often used in combination with a tendon transfer in large tendon gaps for additional augmentation. In this technique, a proximal portion of gastrocnemius fascia is dissected from the underlying gastrocnemius muscle belly and turned distally over the tendon gap defect. The procedure begins by identifying the gastrocnemius aponeurosis, typically just proximal to the myotendinous junction. A longitudinal incision is made in the midline of the aponeurosis, extending proximally to create a broad, rectangular flap. The width of the flap should be approximately one-third to one-half of the total tendon width to ensure adequate coverage while preserving enough residual tendons for strength and function. Care is taken to maintain the integrity of the underlying muscle fibers to preserve vascular supply. Once the flap is created, it is carefully mobilized and advanced distally over the defect, with the free edge positioned at or just beyond the distal stump of the Achilles tendon. To enhance the structural integrity of the repair, the flap is typically woven into the distal tendon stump using heavy nonabsorbable suture in a locking Krackow or Bunnell technique. Some variations of this technique incorporate a side-to-side repair, in which the edges of the turn-down flap are sutured to the adjacent remaining tendon to further reinforce the construct.²⁷

Tensioning of the repair is crucial to ensure that the reconstructed tendon provides sufficient function without excessive laxity. The ankle should be positioned in resting plantar flexion, mirroring the physiologic tension of the contralateral limb. A firm but controlled suture construct helps maintain the length and integrity of the turn-down flap while allowing for tendon healing under appropriate load.

As with other techniques, most data on outcomes from V-Y advancements and gastrocnemius turn-down advancements comes from small retrospective case series, of which most have favorable outcomes with few tendon reruptures.^{24,26,28–30} There is no specific data on strength outcomes (Fig. 4A, B).

Allograft

Achilles tendon allograft with a bone block graft is a viable option for reconstructing tendon gaps greater than 5 to 6 cm, particularly in cases where primary repair or autograft reconstruction is not feasible. This technique is advantageous as it allows for the preservation of surrounding anatomic structures, reducing surgical trauma and minimizing donor-site morbidity associated with autograft harvest, such as from tendon transfers. Additionally, allografts provide a readily available, size-matched alternative that can facilitate reconstruction in complex cases. Studies have shown that Achilles

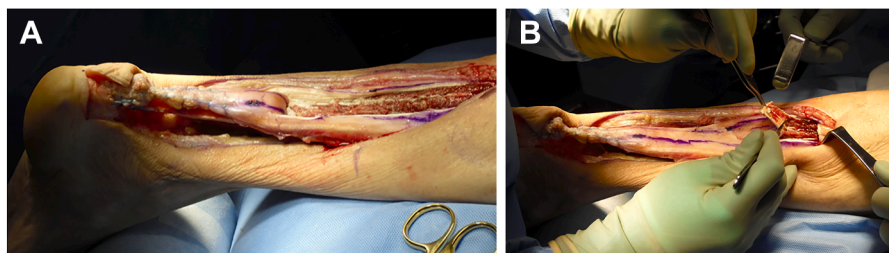


Fig. 4. (A, B) Intraoperative photos of gastric turndown. The first photo demonstrates creation of the flap, and the second photo demonstrates after flap is mobilized and repaired over the tendon gap.

tendon allografts with bone blocks can yield long-term functional outcomes comparable to autologous grafts, with satisfactory strength and stability restoration.^{31,32} However, there are some notable disadvantages, including the potential for an immune response leading to graft rejection or resorption, higher costs associated with allograft procurement and processing, and the risk of delayed incorporation of the calcaneal bone block, which may prolong the overall healing process. Furthermore, there is a small but inherent risk of disease transmission, despite stringent screening and sterilization protocols. Careful patient selection and postoperative rehabilitation are essential to optimize graft integration and functional recovery.

Large Soft Tissue Defects

Multidisciplinary collaboration with plastic surgery may be necessary after the process of debridement, or in cases of traumatic lacerations, where there is substantial soft tissue loss when the loss is so significant that primary closure of the wound becomes impossible. In these complex cases, a comprehensive approach to soft tissue reconstruction is required, and this often involves following a well-established reconstructive ladder that includes several techniques. These techniques range from perforator flaps and sural flaps to more advanced procedures, such as free flaps.^{33–35} Each case must be carefully evaluated to determine the most appropriate method of reconstruction. It is important to note that the management of soft tissue loss and its repair falls outside the scope of this article, as it requires detailed, individualized attention. Therefore, the decision-making process should be based on the unique circumstances of each patient, considering factors like overall health, age, and the extent of the injury, and should be carried out in collaboration with a qualified plastic surgeon who can assess and implement the most effective reconstructive approach for optimal recovery.

CASE EXAMPLES

Postoperative Wound and Infection

A 38-year-old patient sustained an Achilles tendon injury while running and underwent open Achilles tendon repair at an outside hospital. Approximately 5 to 6 weeks postoperatively, he developed a draining wound at the proximal end of the incision and required debridement. During the procedure, it was discovered that he had a deep infection with necrotic tendon tissue and a rerupture. The necrotic tendon was excised, leaving a reported 9 cm tendon gap along with placement of a spacer.

After completing a course of intravenous antibiotics, the patient returned to the operating room 5 weeks later for a FHL tendon transfer and allograft with a bone block. Unfortunately, he later developed wound dehiscence, exposing the tendon allograft. Repeat debridement was performed, and a wound vac was applied to aid healing. The patient was eventually transferred to our care due to concerns that flap coverage might be necessary after multiple debridements, growth of *Candida* and *Enterobacter* and prolonged treatment with antibiotic and antifungal treatment. Physical examination demonstrated exposed tendon allograft (**Fig. 5A, B**). In cases of postoperative infection and nonhealing wounds, it is crucial to ensure that all foreign material is completely debrided. After discussing the options with the patient, we elected to proceed with repeat debridement, removing the tendon allograft and any remaining foreign suture material. It was acknowledged that the FHL tendon would serve as the primary plantar flexor moving forward. In addition to an aggressive debridement of all foreign material, we placed an incisional wound vac to aid in healing along with immobilization in a postoperative Robert-Jones Splint and cast for 4 weeks. Antibiotics were discontinued for 2 weeks prior to the debridement and repeat cultures were negative for any growth.



Fig. 5. (A–D) Clinical images of wounds. Panel (A) is patient's wound after multiple debridements at an outside hospital with exposed tendon allograft. Panel (B) is 1 week after radical debridement with removal of allograft. Images (C) and (D) are at final follow-up 5 months postoperatively.

Following a 2 week course of oral antibiotics and consultation with infectious disease, the patient observed it was the best it had ever looked.

The patient's wounds were healed well (Fig. 5C, D) with notable residual atrophy of the involved calf. They were offered a peroneal tendon transfer to improve plantarflexion strength. However, they opted to continue with nonoperative management and physical therapy. This case underscores the importance of complete, radical debridement of all foreign material and multidisciplinary management, especially when dealing with multiple nonhealing wounds.

Rupture in an Athlete

A young adult professional athlete sustained a traumatic Achilles laceration that was debrided and repaired primarily within 24 hours at an outside institution. The patient reported early on weakness and at his follow-up exam at 8 weeks the patient had continued weakness in plantarflexion and unable to return to sport. On examination,



Fig. 6. (A–F) Panel (A) demonstrates clinical photo of well-healed prior surgical incisions at presentation. Panel (B) demonstrates single MRI sagittal T2 sequence with evidence of incongruity of the achilles tendon. Panels (C–E) are intraoperative photos demonstrating the tendon gap after debridement and subsequent repair; panel (D) shows the graft. Panel (F) is the healing surgical incision 3 weeks postoperative.

there was a palpable defect and MRI demonstrated several centimeter defects in the mid-Achilles (Fig. 6A, B). After discussion of options, the patient underwent repeat debridement with removal of all foreign sutures and materials. There was no evidence of infection. The tendon edges were debrided to viable tissue and able to be primarily repaired end to end with suture tape which was reinforced with a secondary repair using a synthetic polyurethane graft (Artelon) was woven to improve strength of the repair (Fig. 6A–F). This case highlights that primary end to end repair should be the goal in the revision setting, but this should not be at the sacrifice of adequate debridement. Secondary repair with tendon transfer, allograft, or synthetic graft is helpful for additional strength of the repair in the settings of clean/uninfected repair. In the case of young patients or professional athletes, synthetic augmentation can be used when there is concern about donor site morbidity and resultant weakness from tendon transfer.

Traumatic Laceration with Soft Tissue Defect

A young adult male presented after lawn mower accident to the lower extremity with complete Achilles tendon laceration at the insertion. It was debrided within 24 hours of



Fig. 7. (A–G) Panels (A–C) are intraoperative photos after initial debridement demonstrating large soft tissue defect. Panels (D, E) are intraoperative photo during second debridement and Achilles tendon repair demonstrating 3 cm tendon gap in neutral and 2 cm tendon gap in max plantarflexion. Panels (F, G) are clinical photos 10 weeks postoperative from Achilles repair, free gracilis flap, and skin grafting.

presentation and noted to have significant contamination and a 3.5 cm tendon gap. Wound vac was applied, and the patient returned to the operating room 2 days later for repeat debridement and repair. Repair consisted of central turn down of the Achilles and suture repair through a bone tunnel in the calcaneus. There was a 10 × 15 cm soft tissue defect over the repair that was covered with a free gracilis flap and skin graft through multiple separate debridements with plastic surgery (Fig. 7A–E). At follow-up, the flap had healed with intact plantarflexion (Fig. 7F, G). In the case of traumatic lacerations, prompt debridement within 24 hours is paramount to prevent infection and further wound breakdown. Achilles repair can occur at a separate operation especially in cases of significant contamination. Plastic surgery should be engaged early to evaluate soft tissue coverage options to mitigate risk of infection and reinforces the importance of multidisciplinary management for these complex injuries.

SUMMARY

Achilles tendon salvage presents a variety of surgical options, each requiring careful consideration of patient-specific factors and the extent of tendon compromise. The cornerstone of successful salvage remains thorough debridement to ensure healthy tendon edges, as this sets the foundation for optimal healing. Whether addressing complications such as infections, wound breakdown, rerupture, or traumatic lacerations, the choice of reconstruction technique ultimately hinges on the resultant tendon gap and the surgeon's expertise. By tailoring the approach to the individual case, the goal remains restoring function, strength, and durability to the achilles tendon, allowing patients to regain mobility and quality of life.

CLINICS CARE POINTS

- Early aggressive debridement is critical to control infection and preserve viable tissue.
- Prompt infection management improves healing and reduces rerupture risk.
- Reconstruction strategy should match defect size and soft-tissue quality.
- Primary repair is preferred with tendon continuity can be restored.
- Tendon transfer or allograft reconstruction is appropriate for larger defects or compromised soft tissue.

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