

Knotless Reconstruction of Chronic Achilles Tendon Ruptures With <3-cm Defects: Technique Tip

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Abstract

Chronic Achilles tendon ruptures can result in tendon lengthening and significant functional deficits including gait abnormalities and diminished push-off strength. Surgical intervention is typically required to restore Achilles tension and improve ankle plantarflexion strength. A variety of surgical reconstruction techniques exist depending on the size of the defect and amount of associated tendinosis. For smaller tendon defects 2 to 3 cm in size, primary end-to-end repair using an open incision and multiple locking sutures is an established technique. However, a longer skin incision and increased soft tissue dissection is required, and failure at the suture-tendon interface has been reported that can result in postoperative tendon elongation and persistent weakness. In this report, we describe a novel technique to reconstruct chronic midsubstance Achilles tendon ruptures using a small incision with knotless repair of the tendon secured directly to the calcaneus. This technique minimizes wound healing complications, increases construct fixation strength, and allows for early range of motion and rehabilitation.

Level of Evidence: Level V, Expert Opinion.

Keywords: Achilles rupture, midsubstance, knotless, Krackow, repair, percutaneous

Introduction

Chronic Achilles tendon ruptures due to a delayed diagnosis, missed diagnosis, or inappropriate initial treatment plan can result in weakness, gait impairment, and permanent disability.^{5,12,14,19,22} A subset of patients who choose nonoperative treatment for an acute Achilles midsubstance rupture may develop chronic elongation of the musculotendinous unit with decreased resting tension of the tendon and reduced push-off strength.¹² In order to return to a previous level of physical activity, many patients will pursue surgical reconstruction to restore the normal tendon length and tension. Nonsurgical management with a solid ankle foot orthosis (AFO) is often reserved for low-demand patients or those with significant medical comorbidities.²² A variety of surgical options exist to treat chronic Achilles tendon ruptures depending on patient demographics, chronicity, defect size, tissue quality, and location.^{4,18}

Primary end-to-end repair is often indicated in small defects with less than 2–3 cm of retraction or tears, resulting in an elongated tendon unit with tendinosis. Good results

have been demonstrated with direct primary repair; however, many suture techniques are subject to repair failure and recurrent postoperative tendon lengthening.^{13,23} Causes for failure in the absence of rerupture include failure at the suture knots or at the suture-tendon interface due to poor native tissue quality.^{4,12,22} In addition, sutures may pull through unhealthy tissue and result in a lengthened tendon during the early postoperative period when weightbearing is initiated.

In this report, we describe a novel minimally invasive technique to reconstruct chronic midsubstance Achilles

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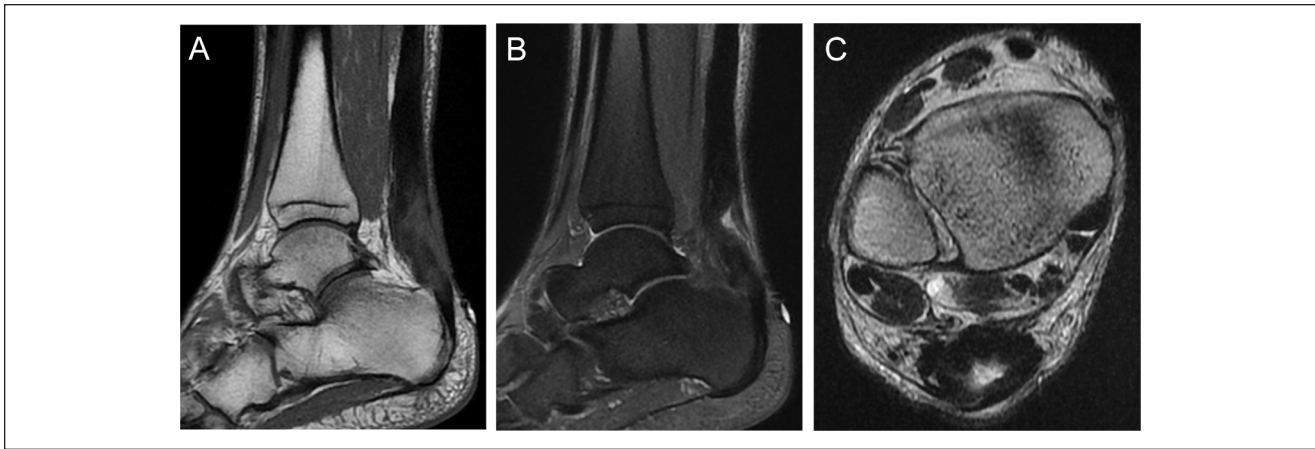


Figure 1. (A) Sagittal T1- and (B) T2-weighted MRI images demonstrating a 2×1×1-cm chronic rupture of the right Achilles tendon 3 months after initial injury. (C) Axial MRI image demonstrates tendinosis and scar tissue within the rupture site.

tendon ruptures using percutaneous proximal sutures in combination with direct fixation of the tendon to the calcaneus in a knotless fashion.^{7,8,16,21} This surgical strategy avoids reliance on suture knots at the site of excised tendinosis and allows for early motion and weightbearing to improve collagen organization and tendon healing with decreased risk of tendon elongation and re-rupture.

History and Physical

A chronic Achilles tendon rupture is typically defined as one left untreated for at least 6 weeks or longer from the time of initial injury.^{12,22} Delayed presentation is often the result of misdiagnosis or inappropriate initial treatment with unprotected early weightbearing. A high index of suspicion is warranted for clinicians as the presentation of a chronic rupture is often vague, with patient complaints of ankle weakness, pain, and difficulty with impact activities. Physical examination may demonstrate gastrocnemius atrophy compared to the contralateral extremity. A Thompson test may be positive, however misleading if the tendon has partially intact fibers or areas of tendinosis. In the prone position with both knees flexed to 90 degrees, there is often increased dorsiflexion of the affected ankle compared to the contralateral side. The palpable gap within the tendon often associated with acute ruptures may not be present if fibrous tissue has filled in the defect. Active plantarflexion may be preserved through the compensatory action of the tibialis posterior, flexor hallucis longus, flexor digitorum longus, and peroneal muscles but is often weaker compared to the contralateral side.

Imaging

A preoperative lateral ankle radiograph may show calcifications in the midsubstance of the Achilles tendon along with

tendon irregularities. Ultrasonography is another imaging modality that can be used to identify abnormal tendon morphology and areas of tendinosis. MRI is recommended for preoperative planning to characterize the location, rupture or defect size, pattern of injury, and degree of tendinosis. Sagittal T1- and T2-weighted sequences will often demonstrate increased signal heterogeneity and tendon thickening in the previous rupture site (Figure 1).

Surgical Indications

Symptomatic patients with pain and/or functional deficits who present with a chronic Achilles tendon rupture more than 6 weeks old with a defect size of 2-3 cm or less may be considered for this procedure. Relative contraindications include a defect size greater than 3 cm, although a V-Y lengthening can be added to the procedure as needed through a separate proximal incision if increased excursion of the proximal tendon is required. For larger tendon defects, Myerson has developed guidelines based on gap size along with associated treatment recommendations.¹⁸ Additional relative contraindications include medical comorbidities precluding the administration of general anesthesia, the inability to safely perform prone positioning, infection, significant smoking history, and severe peripheral vascular disease.

Operative Positioning

Surgery is performed under general anesthesia with a regional block for postoperative pain control. The patient is positioned prone with a thigh tourniquet, chest rolls, knee-pads, and with the arms padded, bent at the elbow and in less than 90 degrees of abduction. The foot of the operative extremity is positioned hanging slightly off the end of the bed with a small bump under the anterior aspect of the ankle

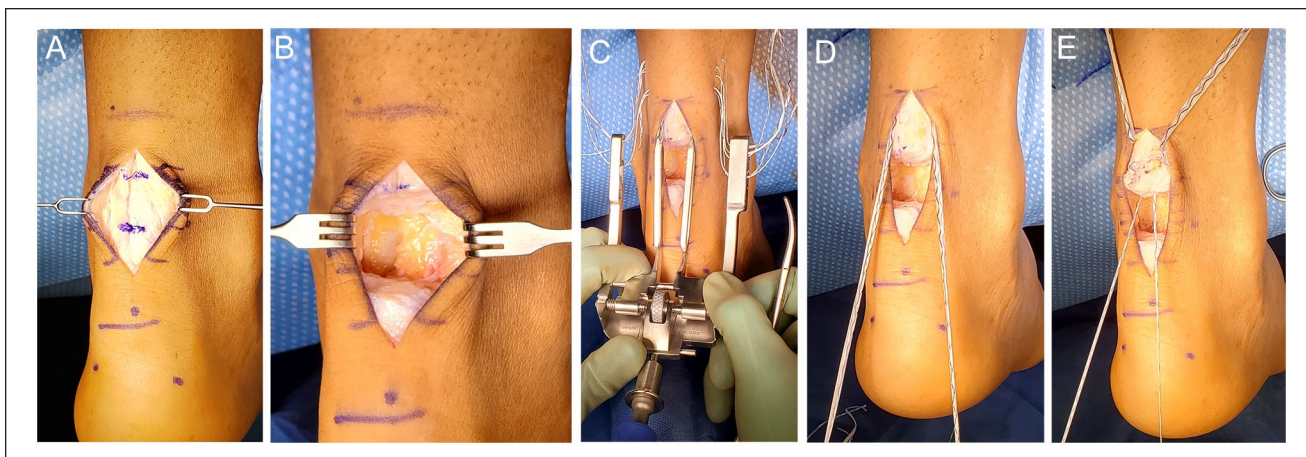


Figure 2. Intraoperative photo of the chronic rupture site and tendinosis (A) before and (B) after sharp resection of all diseased tissue with a remaining 3-cm defect. (C) An external jig is passed along the proximal aspect of the Achilles tendon with percutaneous sutures to achieve fixation without elongating the skin incision. (D) Sutures are pulled out of the wound and passed in order to create 2 nonlocking and 1 locking suture. (E) An additional Krackow locking tape is added to the proximal tendon stump to increase fixation strength.

to adjust the amount of plantarflexion intraoperatively. It is recommended to have the operative extremity elevated with blankets slightly above the level of the contralateral extremity so that it does not interfere with use of the percutaneous jig during surgery. The center of the Achilles should be pointed toward the ceiling in neutral rotation. After sterile prepping and draping, the extremity is exsanguinated, and the tourniquet is inflated.

Surgical Technique

1. A longitudinal skin incision centered over the area of maximal thickness and scar tissue of the Achilles tendon is made with minimal handling and manipulation of the soft tissues. The paratenon is sharply incised and retracted off of the underlying scar tissue for later repair (Figure 2). The tendon is debrided of any scar tissue or adhesions circumferentially in the area of the previous rupture. If the sural nerve is encountered in the operative field, it is gently retracted out of the way. The segment of scar tissue is then marked for planned resection and then sharply transected proximally and distally until normal striated tendon is encountered.
2. An Allis clamp is inserted into the wound and the proximal tendon is secured and pulled distally. A freer elevator or malleable is used along the sides of the tendon proximally to release any potential adhesions that may limit distal excursion. The reusable metal jig (PARS, Arthrex, Inc, Naples, FL) is inserted along the sides of the tendon in the paratenon. Proper jig placement should be smooth and encounter little resistance. The proximal tendon is palpated within the jig to double-check that the tendon is centered.
3. The jig is kept centralized and in neutral rotation to minimize improper suture passing and avoid iatrogenic injury to the medial and lateral neurovascular structures. During suture passing, 1.6-mm needles with nitinol loops are used to pass multiple 1.3-mm sutures (SutureTape) through the jig and tendon.
4. The jig is then carefully pulled distally and out of the wound. The sutures are passed to create 2 nonlocking and 1 locking suture for proximal fixation. Each suture pair is individually checked with distal pull to ensure that fixation in tendon is achieved. A separate suture can be added to the construct in a locking Krackow fashion for further fixation at the end of the proximal stump.
5. Next, 2 separate <1-cm incisions are made along the posterior aspect of the heel just distal to the area of maximal heel convexity. The incisions are spaced approximately 2 cm apart along the sides of the Achilles tendon insertion. A 3.5-mm drill with drill guide are used through each incision and placed flush against the bone. The drill is inserted into the calcaneus oriented distal and toward the midline to create a triangular trajectory. Each drill hole is then tapped to receive a 4.75-mm anchor (Figure 3) (Achilles Midsubstance Speedbridge, Arthrex, Inc). The holes are confirmed on lateral radiograph to be in the correct orientation with adequate depth of the tap to ensure that the final anchors are able to be seated flush with the bone.

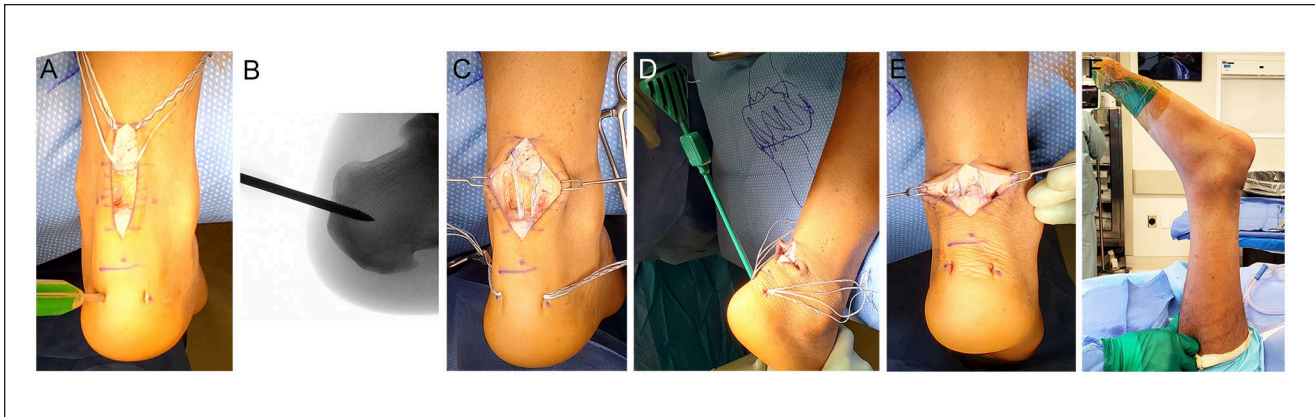


Figure 3. (A) Two small incisions are made along the insertion of the Achilles tendon followed by insertion of a 3.5-mm drill and 4.75-mm tap angled distal and inward to create a triangular orientation. (B) Drill hole orientation and tap depth is verified on lateral radiograph. (C) Sutures are then passed through the central aspect of the distal Achilles tendon using a suture passer and out of the distal anchor incisions. (D) The sutures are cycled 10 times to remove creep and then 2 knotless anchors are inserted into the calcaneus with the ankle in maximum plantarflexion. (E) Final tendon repair showing tendon-to-tendon knotless repair of the previous Achilles tendon defect and (F) restoration of appropriate resting tension of the Achilles on clinical examination.

6. A suture passer is used separately through each of the heel incisions and is passed through the center of the distal Achilles tendon stump and out the proximal incision to retrieve the proximal sutures. Suture passage through the center of the distal tendon is confirmed with visual inspection. Each pair of sutures is then cycled with distal pull 10 times to remove any residual creep in the construct.
7. The ankle is then maximally plantarflexed to bring the 2 ends of the tendon together under direct apposition. The rupture site is visualized to confirm no residual gap or excessive overlap of the tendon ends. Each pair of sutures is passed through the eyelet of the anchors and the anchors are then inserted flush with bone to create a final knotless construct. Resting tension of the Achilles tendon is checked and the remaining suture tails are cut flush with the posterior calcaneus using sharp curved scissors.
8. The wound is then thoroughly irrigated and an absorbable epitendinous suture can be added as needed to tuck in any frayed tendon edges. The paratenon is carefully repaired followed by layered closure of the subcutaneous tissues with vertical mattress nylon sutures for skin.

Postoperative Protocol

The patient is initially made nonweightbearing for 2 weeks in a tall controlled ankle motion (CAM) boot with a total of three 1-cm heel lifts to keep the ankle in a plantarflexed position. Patients take aspirin 81 mg twice daily for deep vein thrombosis prophylaxis for a total of 4 weeks after surgery. Skin sutures are removed at 2 weeks, but if there is

any concern about wound healing, sutures are maintained for another 1-2 weeks. Patients are progressed to weight-bearing as tolerated in a tall CAM boot starting at 2 weeks postoperation along with active ankle plantarflexion range of motion exercises. Progressively increasing weightbearing is continued from weeks 2 to 6, with 1 heel lift being removed every 3-4 days beginning at week 4. From 6 to 10 weeks postoperation, patients are transitioned out of the CAM boot to a regular athletic shoe with initiation of physical therapy avoiding any impact activities. Ankle dorsiflexion past neutral is not allowed until at least 10 weeks after surgery to prevent elongation of the tendon as it remodels. From 10 to 14 weeks postoperation, patients are gradually returned to all baseline physical activities without restrictions.

Discussion

Although the preferred treatment strategy for acute Achilles tendon ruptures remains largely debated, the surgical treatment for chronic Achilles tendon ruptures is considered less controversial.^{6,12,22} A chronic rupture causes decreased efficiency of the gastrocnemius-soleus complex and impairment in ankle plantarflexion power. Appropriate healing of an acute rupture depends on the connective tissue reestablishing the normal resting length-tension relationship. A missed or delayed diagnosis or lack of appropriate protected weightbearing early on can result in retraction of the proximal stump, disorganized connective tissue response, and shortening of the tendon.¹⁴ Patients with chronic Achilles tendon ruptures with pain and weakness generally require surgical repair in order to return to their baseline activity level.^{1,20}

Small tendon defects are often managed with an end-to-end repair after scar resection, tendon mobilization, and apposition with locking Krackow sutures. Myerson proposed a treatment algorithm based on the size of tendon gap, which has been established and replicated in the literature.¹⁸ For defects slightly larger than 2 cm, Yasuda et al²³ extended the indications for primary repair by resecting 2 to 3 cm of scar tissue and directly repairing the tendon stumps in defects up to 5 cm. The repair was performed with non-absorbable Krackow sutures through each tendon stump with interposed scar tissue. However, studies have demonstrated that recurrent Achilles tendon elongation can occur with these direct suture techniques.^{11,17}

Postoperative tendon lengthening has been reported in biomechanical studies evaluating various suture techniques used both in open and percutaneous surgical strategies.⁹ A variety of suture techniques exist, with no consensus on suture type and material; however, most surgeons will perform an open repair with braided, nonabsorbable suture that extends above and below the site of the rupture in a locking and looped fashion. Huffard et al performed a biomechanical study comparing a percutaneous, 3-strand, parallel repair technique (Achillon, Integra LifeSciences, Plainsboro, NJ) in a nonlocking fashion that was found to have greater strength compared to the Krackow technique.¹⁰ Demetracopoulos et al³ reviewed the PARS locking technique in an open repair and found a higher resistance to tendon gapping along with cyclic load to failure compared to the Achillon nonlocking technique. To simulate the surgical environment through percutaneous methods, Clanton et al² also performed a biomechanical analysis comparing open vs minimally invasive suture techniques. Failure at the suture-tendon interface was responsible for the tendon lengthening for all techniques. Regardless of the suture technique, the majority of tendon elongation occurred in the first 10 cycles of load, with minimal lengthening occurring thereafter. Therefore, it is recommended to cycle the sutures at least 10 times to remove most of the stretch or creep that the sutures exhibit postoperatively.

Hsu et al⁹ demonstrated in a single-center comparative study of the PARS technique to open repair and found a higher return to baseline activities in the percutaneous group at 5 months. McWilliam and Mackay¹⁶ described a modification to the PARS technique with a locking and nonlocking suture construct with distal fixation into the calcaneus in a knotless fashion. The authors found that 34 patients returned to baseline activities at an average 18.2 weeks (range 9-26 weeks) with this modified technique. Given the increased strength of direct tendon-to-bone fixation, surgeons can use an early range-of-motion and weight-bearing protocol.^{15,21}

The minimally invasive knotless repair technique described in the present report combines decreased soft tissue dissection with increased construct strength with direct

fixation of tendon into bone. The present technique does not place excessive suture material in the area of tendon healing, does not rely on the subject strength of suture knots, and bypasses the areas of resected tendinosis and abnormal tissue with direct capture of more normal proximal and distal tendon tissue.¹⁶ These surgical advantages allow for early ankle motion and weightbearing, which has been shown to improve collagen organization, tendon circulation and mechanical characteristics, and overall tendon healing.^{12,14,19,22} This technique has become the authors' preferred surgical treatment for chronic Achilles tendon ruptures, with gaps ranging from 2 to 3 cm. In an ongoing case series of 12 patients treated using this reconstruction technique, we have had no cases of wound breakdown, superficial or deep infection, nerve injury, rerupture, or tendon elongation. Patients were all able to participate in early range of motion and weightbearing beginning 2-3 weeks postoperation with an average return to athletic activities by 4.5 months after surgery.

Ethical Approval

Ethical approval was not sought for the present technique tip article as no patient-identifying information was used in the creation of this manuscript. Written, informed consent was obtained by the patient whose intraoperative clinical photographs are used in the Figures section of this report.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Andrew R. Hsu, MD, reports personal fees from Arthrex, Inc, outside the submitted work. ICMJE forms for all authors are available online.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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