Technical Note

A Percutaneous Knotless Technique for Acute Achilles Tendon Ruptures

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Abstract: Achilles tendon ruptures are a common tendon injury, usually occurring in middle-aged men during recreational sporting activities. Both nonoperative and operative management are employed to treat these injuries. Several operative treatments are described in the literature, including percutaneous Achilles repair, mini-open repair, and open repair. Open Achilles repair is associated with higher rates of impaired wound healing and infection, whereas minimally invasive techniques have been reported to have an increased risk of iatrogenic sural nerve injury. More recently, low complication rates, improved cosmetic appearance, reduced operating times, and improved clinical outcomes have been reported for the percutaneous Achilles repair technique. In this Technical Note, we present our preferred technique using the Percutaneous Achilles Repair System (Arthrex, Naples, FL), which has been reported to have minimal wound and nerve complications, and early return to activity.

Achilles tendon ruptures are a common tendon injury, usually occurring in middle-aged men during recreational sporting activities.[1-4] The most common injury mechanism involves pushing off a planted foot with an extended knee. Other injury mechanisms include forced dorsiflexion on a plantarflexed ankle, or falls from height.

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Several operative and nonoperative treatment options are available. Nonoperative treatment usually consists of brief immobilization, followed by early rehabilitation and early weight bearing.[5,6] Operative methods include percutaneous Achilles repair, mini-open repair, and open Achilles repair.[7-14] There is still no consensus on the best method of treating these injuries, nor the best method of repair in operative management of the ruptured Achilles tendon.[15,16] Some studies have reported that nonoperative management is associated with higher rerupture rates compared with operative treatment, with rates of 8.8% versus 3.6%, respectively.[4,17] Nonoperative treatment is generally reserved for lower demand patients and patients with higher surgical risk, whereas operative repair is preferred for treatment in younger, healthier, and more active patients.[18] Open repairs carry with them an increased risk of wound healing problems, whereas minimally invasive techniques are reported to have an increased risk of iatrogenic sural nerve injuries.[19,20] Low complication rates, reduced operating time, improved cosmetic appearance, and favorable clinical outcomes have been reported for newer percutaneous techniques.[11,16]

Minimally invasive techniques have emerged to eliminate wound healing and infection problems associated with open surgery, and sural nerve injuries reported in early percutaneous techniques.[16] Furthermore, improved wound and nerve complications as well as early return to activity have been reported in minimally invasive operative techniques.[21,22] The purpose of this Technical Note is to

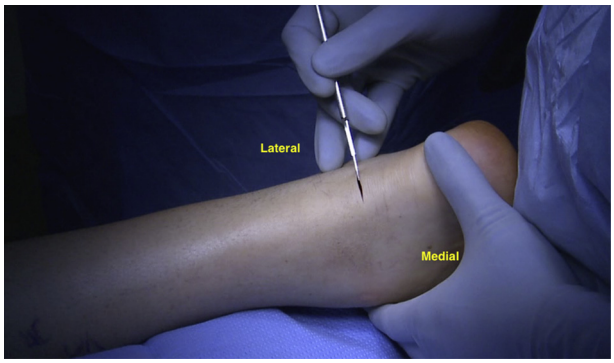

Fig 1. The tendon rupture is palpated, and a 3-cm horizontal incision is made approximately 1 cm proximal to the defect. The patient is in a prone position.

describe our preferred knotless technique for Achilles tendon repair using a Percutaneous Achilles Repair System (PARS) (Arthrex, Naples, FL).

Indications

This technique is indicated for acute Achilles tendon ruptures (less than 3 weeks) in active patients. A trial of conservative therapy consisting of temporary immobilization with early functional rehabilitation may be considered in older more sedentary patients, especially those with significant medical comorbidities that may impact wound healing.

Operative Technique

Patient Positioning

The patient is placed prone on a standard operative table after anesthesia is induced on the stretcher where a nonsterile thigh tourniquet is placed on the operative limb (Video 1). All bony prominences are well padded. An examination is performed to evaluate the location of the defect as well as the difference in carrying angle

Fig 2. While grasping the tendon, a 1-inch (2.54-cm) ribbon malleable retractor is used to free the Achilles tendon from the surrounding paratenon, mobilizing the tendon. The paratenon is initially separated from the tendon with a No. 15 blade, and countertension is evenly applied with 2 Kocher clamps. (L, lateral; M, medial.)

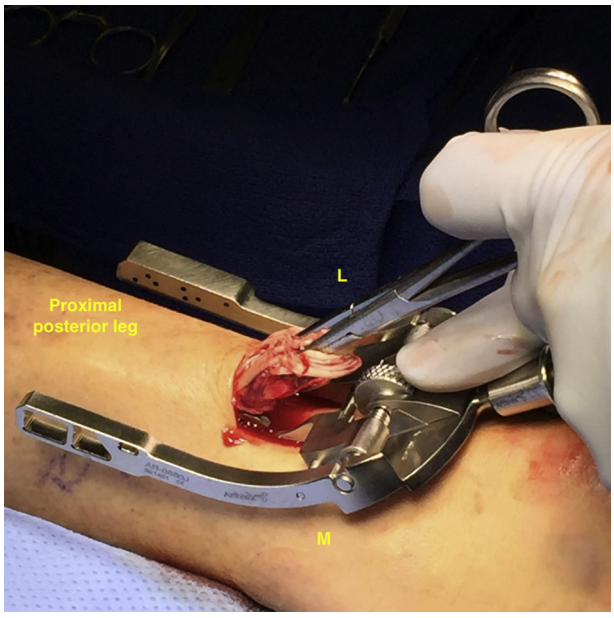

Fig 3. Distal right leg pictured. The Percutaneous Achilles Repair System jig (Arthrex) is placed in the incision and advanced proximally between the tendon and until it is stopped by the gastrocsoleus complex muscle belly. (L, lateral; M, medial.)

of the foot. The operative leg or both legs are prepared and draped in a routine surgical sterile fashion below the knee to allow for intraoperative assessment and proper tensioning of the Achilles rupture repair.

Operative Technique

Exposure. A small horizontal incision (approximately 3 cm) is made approximately 1 cm proximal to the distal end of the palpable defect at the tendon rupture (Fig 1). The sural nerve is defined by blunt dissection laterally and protected while the paratenon is opened horizontally and the proximal portion of the healthy

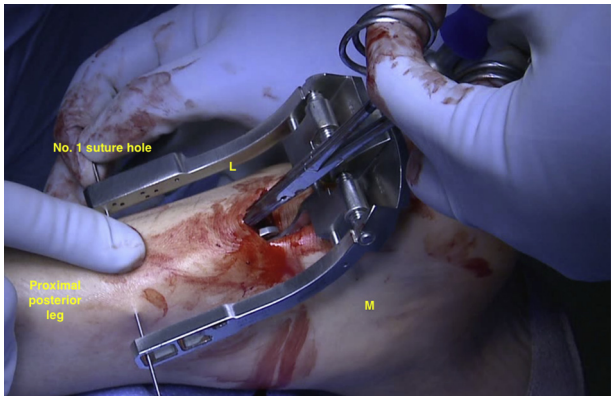

Fig 4. On the right leg, with the percutaneous Achilles repair system jig in place, the sutures are placed percutaneously to capture the proximal end of the tendon. The needle suture passer is first placed through the most proximal No. 1, using a FiberTape (Arthrex) suture. (L, lateral; M, medial.)

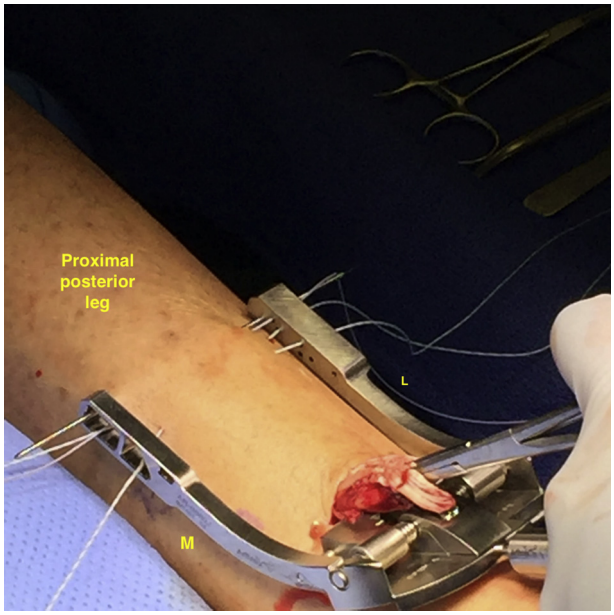

Fig 5. The remaining sutures are passed through the guide system while applying distal traction on the Achilles tendon. (L, lateral; M, medial.)

Achilles tendon is grasped with 2 Kocher clamps (one positioned medially, and one laterally). While grasping the proximal stump of the tendon, a 1-inch (2.54-cm) ribbon malleable retractor is used to free the proximal Achilles tendon from the surrounding paratenon (Fig 2). Separation of the tendon from the paratenon facilitates proximal placement of the PARS jig and excursion of the proximal tendon stump as it is often scarred down after rupture.

Instrumentation. The PARS jig (Arthrex) is placed in the incision and advanced proximally between the tendon and paratenon until it is stopped by the gastrocsoleus complex muscle belly (Fig 3). Advancing the device between the tendon and paratenon aids in avoiding injury to the sural nerve. The device is opened just enough to ensure that the proximal tendon is between the 2 arms of the PARS jig. Digital palpation is used to confirm that the tendon stump is captured. A 1.6-mm guide pin with a Nitinol loop (Arthrex) is placed through the No. 1 hole of the jig to secure the tendon stump to the jig (Fig 4). Another similar 1.6-mm guide pin is then placed in the No. 2 hole, and a blue No. 2 FiberWire (Arthrex) suture is shuttled through the jig (Fig 2). Subsequently, 2 white and green striped, No. 2 FiberWire (Arthrex) sutures with loops on one end are passed through the No. 3 and 4 jig holes leaving looped ends on the opposite sides of the leg. Finally, a white and black striped No. 2 TigerWire (Arthrex) suture is passed

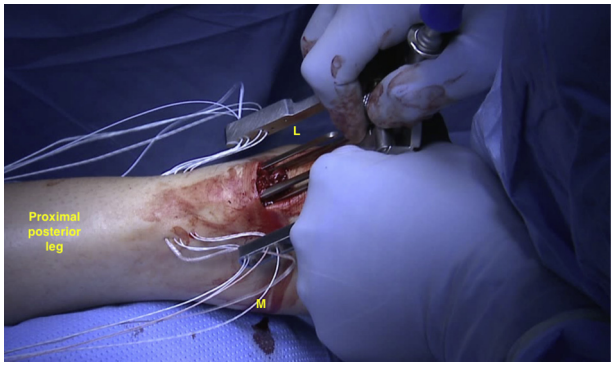

Fig 6. With all sutures in place and appropriately tied, the guide system is removed, pulling the suture bridge construct through the proximal incision. Of note, the sutures are also passed through the paratenon to minimize the risk of injury to the sural nerve. (L, lateral; M, medial.)

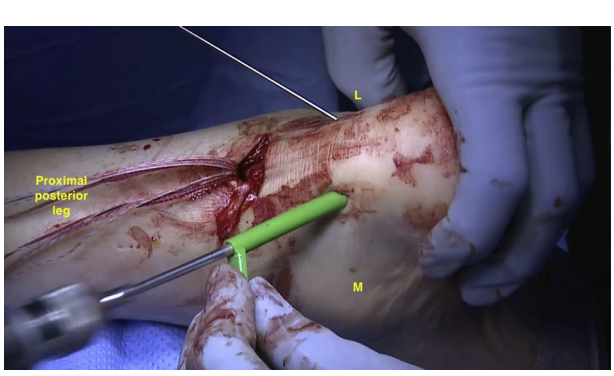

Fig 7. A 3.5-mm drill, with drill guide, is used to make holes at a 45° angle converging toward the midline within these stab incisions for cortical fixation of the proximal tendon sutures. (L, lateral; M, medial.)

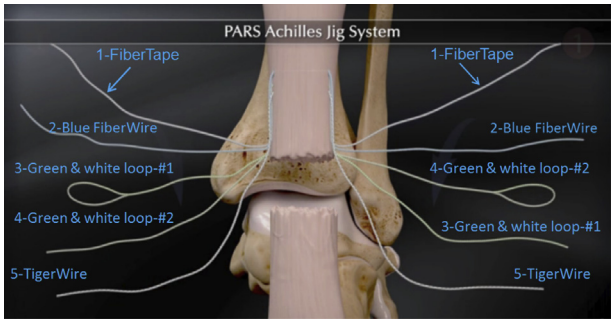

Fig 8. Five sutures placed through the proximal Achilles tendon with the PARS jig. No. 1 suture is a FiberTape suture, which is placed last in the No. 1 hole of the jig. No. 2 suture is a blue FiberWire suture. No. 3 suture is a green and white striped suture with a loop that is pulled through and left on one side. No. 4 suture is a second green and white striped suture with a loop that is pulled through but leaves the loop on the opposite side of the first loop. No. 5 suture is a black and white striped TigerWire suture. All sutures except the FiberTape in the No. 1 hole are No. 2 FiberWire and are placed through the hole for which they are numbered. (PARS, Percutaneous Achilles Repair System.)(Athrex, with permission).

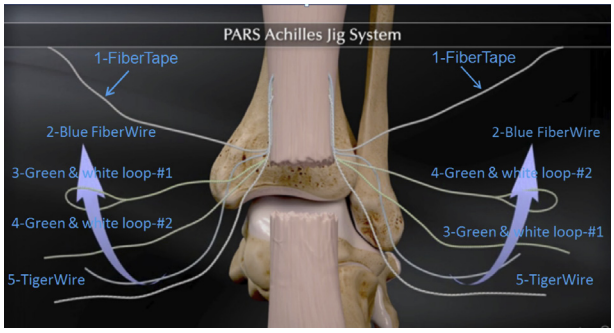

Fig 9. While the PARS jig is still in place, the blue suture is wrapped around the 2 green and white striped sutures with loops on the side of the respective loop and then pulled through the loop. The loop is used to pull the blue suture through the Achilles tendon to the opposite side of the leg. This is followed by doing the same thing and pulling the blue suture on the opposite side across the Achilles tendon effectively locking the suture in the tendon. (PARS, Percutaneous Achilles Repair System.)(Athrex, with permission).

through the No. 5 jig hole (Fig 5). A FiberTape suture (Arthrex) is then placed through the No. 1 hole. The device is then slowly removed from the leg, pulling the suture through the transverse incision site and within the paratenon, avoiding the sural nerve (Fig 6).

Calcaneal Fixation. At this point, attention is turned to the distal portion of the Achilles tendon. Two small stab incisions are made over the calcaneus just proximal to the Achilles insertion (approximately 1.5 cm proximal to the superior aspect of the tuberosity) on the medial and lateral sides of the tendon. A 3.5-mm drill with drill guide (Arthrex) is used to make holes at an angle converging toward the midline within these stab incisions (Fig 7). The tunnels are angled so they do not intersect. A 4.75-mm tap (Arthrex) is then used to prepare the drill holes. At this point, the No. 2 blue suture is passed under the No. 3 and 4 loop sutures on each side of the leg and back through the loop of the white and green striped looped sutures. The No. 2

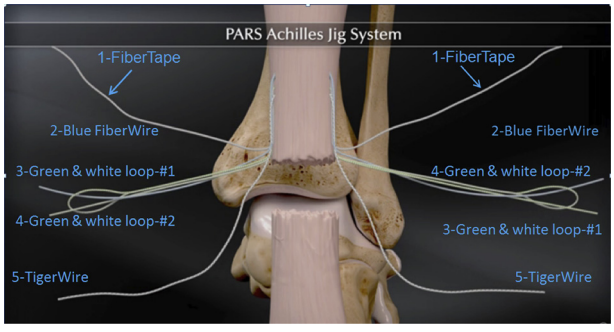

Fig 10. Blue sutures have been wrapped and placed through the loops of the green and white striped sutures on each side of the leg. (PARS, Percutaneous Achilles Repair System.)(Athrex, with permission).

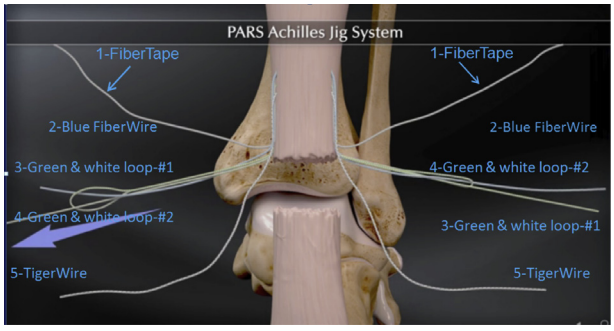

Fig 11. Loop of the green and white striped suture loop No. 2 pulls the blue suture through the Achilles tendon from right to left in the picture. (PARS, Percutaneous Achilles Repair System.)(Athrex, with permission).

suture is then pulled through the Achilles tendon to the other side by pulling on the nonlooped side of the white and green No. 3 and 4 looped sutures. The No. 2 suture is then pulled and locked in place leaving 2 transverse sutures (No. 1 and 5) and the one locked No. 2 suture with the proximal Achilles tendon. Figures 8 to 13 summarize preparation of the suture construct. Each construct is individually tested to be sure that it captures the tendon and will not pull out. A Banana SutureLasso (Arthrex) is passed through the distal Achilles tendon stump to retrieve the proximal FiberWire and FiberTape strands (Fig 14). The strands are then passed through the distal Achilles stump while a small Kocher clamp holds tension on the distal stump. The strands are secured into the calcaneus on the medial and lateral sides with a 4.75-mm SwiveLock (Arthrex) on each side, whereas the foot is held in full plantar flexion (Fig 15). When fastening these strands, careful attention is paid to the contralateral foot to ensure that appropriate tension is applied. In our experience, a carrying angle that is slightly more plantarflexed by approximately 5° to 10° when compared with the contralateral side works best.[23,24]

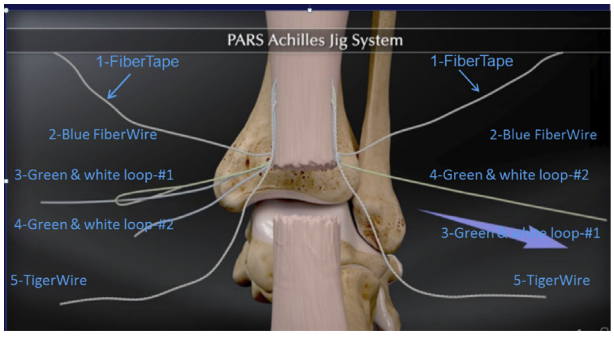

Fig 12. Loop of the green and white striped suture loop No. 1 pulls the blue suture through the Achilles tendon from left to right in the picture. (PARS, Percutaneous Achilles Repair System.)(Athrex, with permission).

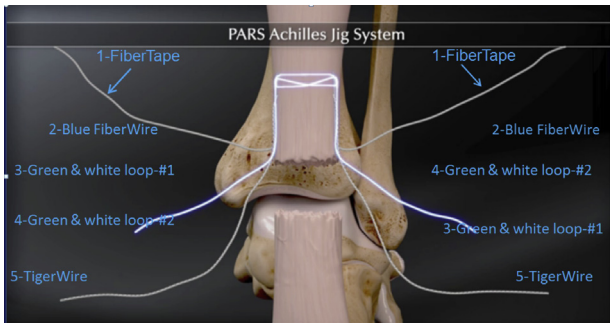

Fig 13. Remaining 3 sutures include 1 FiberTape from the No. 1 hole, 1 blue locked suture from the No. 2 hole, and 1 TigerWire suture from the No. 5 hole. The PARS jig now pulls these futures from outside the leg to inside the paratenon and out the original transverse incision at the rupture site where the sutures are carefully removed from the inner PARS jig. (PARS, Percutaneous Achilles Repair System.)(Athrex, with permission).

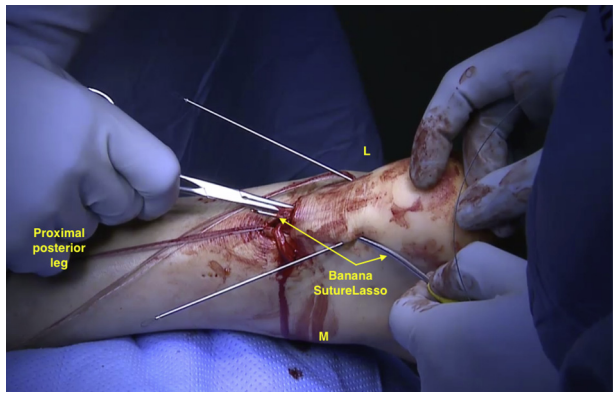

Fig 14. A Banana SutureLasso (Arthrex) is passed through the distal Achilles tendon stump to retrieve the proximal FiberWire and FiberTape strands. The strands are then passed through the distal Achilles stump while a small Kocher clamp holds tension on the distal stump. (L, lateral; M, medial.)

Closure and Dressing. A 3-0 Monocryl (Ethicon, Somerville, NJ) absorbable running epitenon stitch is placed. The wound is irrigated and closed in layers with 3-0 and 4-0 Monocryl sutures and Steri-Strips (3M Health Care, St. Paul, MN). A postoperative dressing is applied along with a plaster short leg splint in plantar flexion with slight tension on the Achilles tendon repair. The abbreviated steps of the operative technique can be found in Table 1. The pearls/pitfalls and advantages/disadvantages of this technique are listed in Tables 2 and 3, respectively.

Rehabilitation

An experienced physical therapist is paramount in rehabilitation after repair of acute Achilles tendon ruptures. In the immediate postoperative period, the patient is made non–weight bearing and the splint remains in place for 10 to 14 days. At that point, the patient is transitioned to a walking boot with 4 felt heel wedges (Hapad, Bethel Park, PA) measuring 7/16″ each in maximum thickness and allowed to start active plantar flexion and dorsiflexion up to 5° to 10° short of neutral. The patient can begin partial weight bearing, removing 1 heel wedge per week and progressing to full weight bearing by 4 to 6 weeks postop. Formal physical therapy begins at 2 weeks with a focus on active plantar flexion and gradual dorsiflexion up to 5° short of the contralateral side. At week 7, the patient is weaned from the boot into a shoe (with wedges if necessary for comfort) over 2 weeks. As motion and strength improve, the patient starts functional physical therapy with sports progression. In weeks 12 to 16, the athletes are limited in activities as the risk of rerupture persists up to 4 months. At week 16, athletes may resume controlled practice with pain as a guide. Athletes may be able to return to full preinjury level of activity between 4.5 and 12 months postoperatively. A summary of the rehabilitation protocol is given in Table 4.

Discussion

Numerous techniques for the treatment of acute Achilles tendon ruptures have been published that include open, mini-open, and percutaneous repairs.[8,12,14,25,26] Repairs have historically been performed with an open, longitudinal lateral or midline incision approach and end-to-end suture repair or graft reconstruction of the

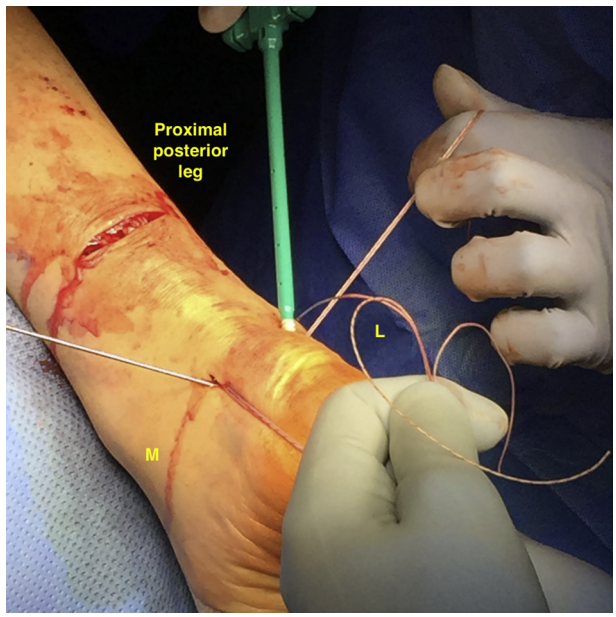

Fig 15. The strands are secured into the calcaneus on the medial and lateral sides with two 4.75-mm SwiveLocks (Arthrex) while the foot is held in plantar flexion. Tensioning the Achilles in 5° to 10° more than the normal carrying angle avoids undertensioning and allows for the typical elongation that occurs during active rehabilitation. (L, lateral; M, medial.)

Table 1. Abbreviated Operative Outline

Basic Operative Plan
• Examination under anesthesia to locate the rupture
• Horizontal incision 1 cm proximal to the palpable defect of the Achilles tendon rupture
• Separation of the Achilles tendon from the paratenon using a transverse (or horizontal) incision and a ribbon malleable retractor
• Placement of the Percutaneous Achilles Repair System (PARS) jig in the incision and advancing it proximally until it is stopped by its hob at the handle
• Use of a 1.6-mm guide pin with the Nitinol loop through the No. 1 hole of the jig to secure the tendon
• Use of a 1.6-mm guide pin with the Nitinol loop through the No. 2 hole of the jig and placement of a blue No. 2 FiberWire through the No. 2 hole of the jig
• Subsequent white and green striped, looped No. 2 FiberWire passage through the No. 3 and 4 holes of the jig using the guide pin with the loop
• Passage of a white and black striped No. 2 TigerWire through the No. 5 hole on the jig
• Next place a FiberTape in the No. 1 hole using the pin left there to hold the tendon
• The jig is carefully removed
• The blue No. 2 suture is passed under the No. 3 and 4 sutures and back through the loop of the white and green looped suture
• Pulling the No. 2 suture through the Achilles tendon to the opposite side by pulling the nonlooped side of the No. 3 and 4 sutures (white and green)
• Pulling and locking the No. 2 suture
• Two stab incisions, 1.5 cm apart over the Achilles insertion on the calcaneus
• Two 3.5-mm drill holes on the calcaneus
• Using a SutureLasso through distal Achilles stump, retrieve the proximal FiberWire sutures
• Fixing the sutures to the calcaneus with two 4.75-mm SwiveLocks
• A 3-0 Monocryl absorbable running epitenon stitch is placed
• Irrigation and closure

tendon.[10,13] Because of the large incision required, these techniques carry a risk of complications including deep and superficial infection, sural nerve injury, impaired wound healing, and development of postoperative tendon adhesions.[9,16] There have been new developments in percutaneous and mini-open repairs with the aim of minimizing the risk of complications.[7,16,27] We present a percutaneous knotless technique with distal suture bridge fixation.

A biomechanical study by Clanton et al.[7] on Achilles tendon repair showed comparable ultimate failure strengths of mini-invasive percutaneous repairs versus open repairs. However, susceptibility to early repair elongation was associated with a minimally invasive percutaneous repair technique.[7] One important finding in this study was that minimally invasive tendon repair techniques most commonly failed at the suture-tendon interface, a finding that has been reproduced in other tendon repair studies.[28,29] In the technique described above, distal bony fixation is achieved with the use of suture anchors reducing the number of suture-tendon interfaces, and theoretically, the chance of failure. Despite differences in biomechanical data, no method of Achilles tendon rupture repair has clearly been shown to be clinically superior.[9,16]

Table 2. Pearls and Pitfalls of Acute Achilles Tendon Rupture Repair With a Percutaneous Knotless Repair

Pearls	Pitfalls
Be familiar with the instrumentation	Incision too distal from the rupture
Palpate the Achilles tendon and locate the rupture before incision	Not placing the Percutaneous Achilles Repair System jig proximal enough resulting in poor tendon capture with the sutures
Incision 1 cm proximal to the rupture	Sutures entangling poor suture management
Separate the Achilles tendon from the paratenon to enhance healing and protect the sural nerve	Undertensioning the repair using SwiveLocks
Passing and pulling the sutures in the right order to avoid entangling	Not inserting SwiveLocks completely into calcaneal tunnels
Immobilizing the ankle joint in a stirrup and posterior slab 1-2 wk postoperatively	

There are limitations to the above-mentioned technique. First, incision placement is key. If the incision is placed too proximally, the epitenon suture cannot be placed and it is difficult to ensure apposition of the tendon ends. Likewise, if the incision is placed too distally, it may be difficult to capture the proximal tendon stump with the PARS jig. Second, if the tendon is particularly degenerated or of poor quality, it is difficult to capture the proximal stump with only one locked suture in this 6-core-strand technique. In this case, the incision can be elongated in an s-shape longitudinally, or an additional horizontal incision can be made proximally. In the latter case, we recommend having at least a 4-cm skin bridge. The proximal stump is then brought of the wound and a 6-core Mason-Allen construct[7] or a Krackow construct can be performed open. The surgeon can then choose to continue with calcaneal fixation or convert to a traditional open

Table 3. Advantages and Disadvantages of the Percutaneous Achilles Repair System Technique

Advantages	Disadvantages
Several sutures are used for good purchase of the tendon	Many sutures may entangle
The tendon rupture can be visualized	The surgeon has to be familiar with the instrumentation
Good fixation to bone on the calcaneus with SwiveLocks	
Avoid wound healing problems associated with the open repair technique	
Avoid nerve injury problems associated with other percutaneous techniques	

Table 4. Achilles Tendon Rupture Postoperative Rehabilitation Summary

Postoperative Rehabilitation Protocol	
Time	Therapy
Weeks 1-2	Non–weight bearing in a postoperative splint
Week 3	Walking boot with 4 heel wedges, start 4-wk weight-bearing progression, removal of 1 wedge per week, allowed to start active plantar flexion and dorsiflexion up to 5° to 10° short of neutral. Formal PT can start at this time for range of motion
Week 7	Wean from boot to shoe with 2 wedges, remove 1 wedge per week
Week 8	Start functional PT with sports progression
Weeks 12-16	Limit activities in athletes to practice. Risk of rerupture persists up to 4 mo
Week 16	Start controlled practice with pain as guide
Months 4.5-12	Athletes able to return to the full preinjury level of activity as symptoms allow

PT, physical therapy.

repair. Third, in a small subset of patients, the swivel lock anchors can become painful. We recommend ensuring that the swivel lock is advanced beneath the calcaneal cortex to avoid soft tissue irritation. And finally, appropriate tensioning is important to ensure a good outcome. Undertensioning the repair should be avoided because an elongated healed tendon will not be able to provide the power an athlete needs for propulsion.

We recommend our method of modified suture bridge repair and emphasize a period of short postoperative immobilization followed by protected mobilization to avoid the risk of elongation and rerupture. The technique presented aims to minimize wound complications with the small transverse incision, which also theoretically reduces the risk of injury to the sural nerve compared with traditional longitudinal incisions. The percutaneous technique also facilitates decreased overall operative time. In the senior author's (T.O.C.) experience, a typical case may require as little as 30 minutes. Overall, we believe that this technique allows for patients to recover quickly and return to activities sooner than traditional Achilles repair techniques. However, further clinical and biomechanical studies are needed to substantiate this claim.

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