CHAPTER **20**

EVIDENCE-BASED ANALYSIS FOR FIXATION MATERIALS OF ACHILLES TENDON RUPTURE REPAIRS

Ramy Fahim, DPM
Jared Visser, DPM
Ryan Ellsworth, DPM
Jessica Sciulli, DPM
Wissam Khoury, DPM

INTRODUCTION

Achilles tendon ruptures typically occur in middle-aged men during sports-related activities. This incidence has increased significantly over the past two decades. Epidemiological data from Sweden have reported an incidence curve with two peaks: a larger one with young or middle-aged athletes and another with older males in their seventies. There is also a reported increase in sports activities and participation especially in the 65-years-old and above population over the past 2 decades. Interestingly enough, Arndt et al reported a 57% incidence of 1823 Achilles tendon ruptures to be left-sided, which would likely be attributed to the greater prevalence of right-sided individuals who push-off with their left lower limb.

Mechanisms of injuries for these tendons have been attributed to two main schools of thought, a "degeneration theory" and a "mechanical theory." The degenerative factors include physiologic alterations in the tendon, chronic overlading with microtrauma, pharmacologic treatment, and in association with other systemic diseases. Kannus and Jozsa looked at a histopathological analysis of 397 Achilles tendon ruptures where 97% of the pathological changes were degenerative with 45% hypoxic, 19% mucoid, 6% tendino-lipomatous, and 3% calcifying tendinopathy. On a microscopic level, ruptured Achilles tendons display more type III collagens, which are inherently resistant to tensile strength.

Achilles tendon repair is a topic of great controversy with different considerations. Those include a vast array of factors such as method of suturing technique, incision placement for the repair, epitendinous augmentation, type of suture used, and control of host factors.

Najibi et al reported on the biomechanical properties of different suture materials for tendon repairs in vitro. Three types of braided absorbable suture material and one non-absorbable with different calibers underwent biomechanical testing for maximum load to failure, strain, and stiffness. The number 5 FiberWire displayed the maximum load to failure and strain, while the 0 Ethibond Excel was the lowest. Additionally, the stiffness was lowest for the 2-0 Vicryl but highest for the 5 FiberWire. Therefore, as per the authors, use of FiberWire suture is the standard choice for Achilles tendon ruptures but that certainly does not substitute for a sound technique with proper augmentation for the repair.

TYPES OF REPAIR

Traditional repair of Achilles tendon ruptures is comprised of a number of different suture techniques. An important parameter in this equation is the appreciation of the tensile strength as well as the limitation of the repair in the healing process after performing a repair. In an in vivo study by Yildirim et al with rabbit models, the repairs were conducted using the Kessler technique. This technique revealed that the suture holding capacity of the tendon at the end of the first and third weeks after surgery were within 30% of the control tendon. At the end of the fourth week, the load to failure reached 65% of the control. This process is proposed to take longer in humans. The significance of this is to reiterate the added risk for early range of motion at the third week secondary to suture pullout from the tendon. The optimal period for early motion and weight bearing remains in the fourth week where suture holding capacity was 65% of the control. Mason and Allen reported an initial drop in the tensile strength of the tendon within five days after the repair in their study.

Nystrom and Holumund reported a biphasic separation of the tendon ends after suture of the Achilles tendon where the first separation took place during the first five days while the second one began at about twenty days. The drop of the tensile strength at the first week after repair was attributed to the edematous softening of the tendon ends during the inflammatory phase of healing. Additionally, the involuntary contraction, reinnervation of the muscle fibers, and plastic

deformation of the neocollagen were hypothesized to be the cause of separation of the tendon ends at the end of the third week in the former studies.

Pullout strength of common configurations also constitutes a significant factor in the integrity of the repair. In the 2002 in vitro study by Yildrim et al, it was determined on 48 fresh frozen sheep Achilles tendons that the Bunnel and Krackow locking loop techniques do not differ significantly from one another with regard to pullout strength. The Kessler configuration however, was determined to be 50% weaker. This was previously confirmed by the 1995 study in which Watson et al reported a 1.58 and 1.73 stronger pullout in the Krackow technique as opposed to the Kessler and Bunnell.

Jaakkola et al concentrated on comparing the triple bundle technique to the Krakow locking loop technique. The fresh frozen cadaveric study revealed an overall stronger construct with the triple bundle. In fact, an overall three times stronger load to failure has been reported. The attributing advantages could be related to the abundance of strands crossing over the rupture site. The Triple bundle technique has six as opposed to the four with the Krakow technique. Another factor is the location of the knot in the triple bundle, which happens to be away from the rupture site whereas in the Krakaow technique, it is within the rupture. The notable possible disadvantage is the potential damage and vascular compromise. The authors did concede, however, that no traumatic characteristics were taken into account such as the "mop end" appearance.

Canete and Deiparine reported on16 patients with acute and chronic tendoAchilles ruptures that were treated with the triple-bundle technique, in addition to early weight bearing. In their postoperative course, the authors advocated the use of an Ankle-Foot-Orthosis on postoperative day one and weight bearing as tolerated on postoperative day two. At the three-month mark, 94% of the patients reported excellent results with the remaining results being fair. No evidence of re-rupture was noted. This study further affirmed the strength of the triple-bundle suturing technique in withstanding the forces of early weight bearing and range of motion.

Labib et al in 2009 further modified the Krackow technique based on the works and recommendations of the pervious works by Jaakkola et al to place the sutures away from the rupture site in the Achilles tendon ruptures. This "gift box" modification was then tested against the traditional Krackow technique in a cadaveric study. The strands were inserted up the axis of the tendon and emerged at the proximal and distal points of the suture area, where they were tied. This modification allowed for an increase of strands crossing the rupture site from two to four. The overall strength was a two-fold increase for the giftbox modification. This modification carries significant weight in comparison to the triple bundle as it minimizes soft tissue and vascular compromise.

EPITENDINOUS SUTURING

Augmentation for the strength of Achilles tendon repairs allow for earlier active rehabilitation with less risk of adhesion formation and re-ruptures. These allow faster and stronger healing. Lee et al have previously established a significant increase in tendon strength and stiffness, while decreasing elongation with the incorporation of epitendinous suturing in their repair. Sirotakova and Elliot reported over 70% good to excellent results with combined epitendinous suturing when followed by a combined active and passive mobilization protocol. Chou et al in 2008 reported a

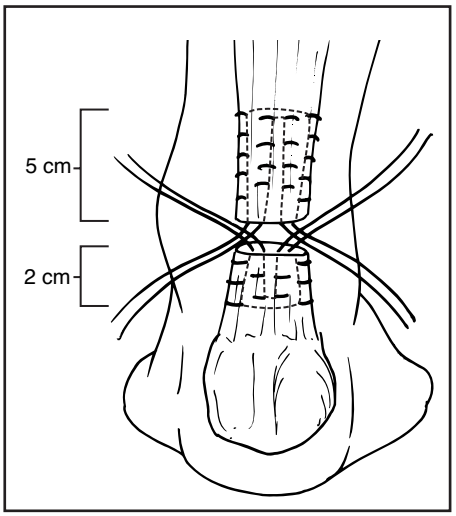

Figure 1. Krackow suture technique.

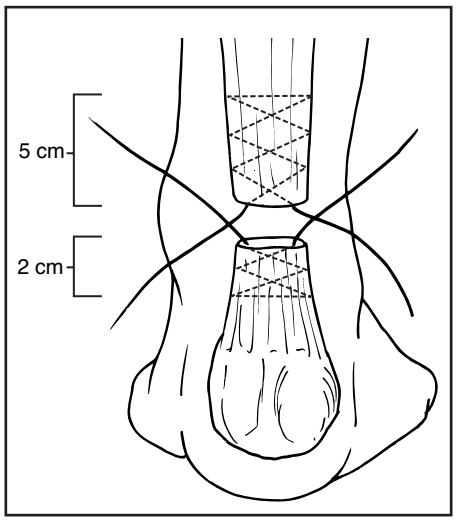

Figure 2. Bunnell suture technique.

comparison of the simple running and cross-stitch epitenon sutures. The continuous running stitch was physically a simple baseball stitch but the cross-stitch had a transverse entry point with an interlocking component. Overall, there was a 53% greater mean failure load with the cross-stitch technique versus the simple-running. This was attributed to further increase in suture entry points from the rupture site, transverse passes, and multiple crossing patterns with equal distribution. Additionally, the cross stitch was noted to avoid impairment for gliding, which ultimately decreases risk for adhesion formation.

Lee et al in 2008 noted an overall stronger resistance to gapping after primary repair of rupture with epitendinous suturing. In fact, they reported a 91% increase in resistance with the cross-stitch technique and a 47% increase with the figure-of-eight stitch. There was also a reported 68% increase in stiffness with the cross-stitch construct, thereby affirming the benefits of augmentation to the tendon repair as previously reported.

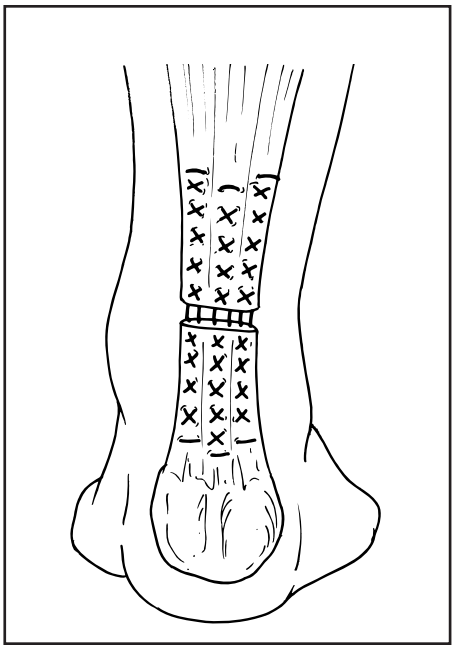

Figure 3. Triple bundle suture technique.

MINIMUM INCISION VERSUS OPEN REPAIR

Surgical repair of the Achilles tendon ruptures offers vast advantages for a low and predictable re-rupture rate of 1.4-2.8%. However, with the open repair, there lies the risk of 11.8-20% associated complications and escalating healthcare costs. Conservative care has a reported re-rupture outcome of 12-17% and also carries the risk of an array of complications, which include loss of strength. Ma and Griffith first described use of percutaneous methods to repair the tendon. Their technique reported a 50% loss of strength, which led to further studies into this field. In a systematic review by Wong et al, the re-rupture rate on 367 percutaneously fixed Achilles tendon ruptures was 4.6%.

Lim et al performed a prospective, randomized study with a minimum of six months follow-up comparing open versus percutaneous repairs. They used a modification of the Ma and Griffith technique for the percutaneous technique and the Kessler suture for the open repair. Overall, there was a statistical difference in the infective wound complication rate and a higher rate of wound dehiscence and adhesions with open repairs. Similarly, Majewski et al compared the treatment of ruptured Achilles tendon by open "end to end" surgery, percutaneous repair, and conservative therapy in a series of 73 patients. Overall outcome results were good to excellent at 2.5 years of follow-up but the percutaneous group reported an earlier return to function and activities than the other groups.

Cretnik et al in 2004 described their percutaneous technique, which was comprised of a series of four medial and lateral stab incisions and a crossed-stitch pattern. In their series of 134 procedures, a total of 95% satisfaction rate was noted with a 98% rate of patients who returned to regular pre-injury activities.

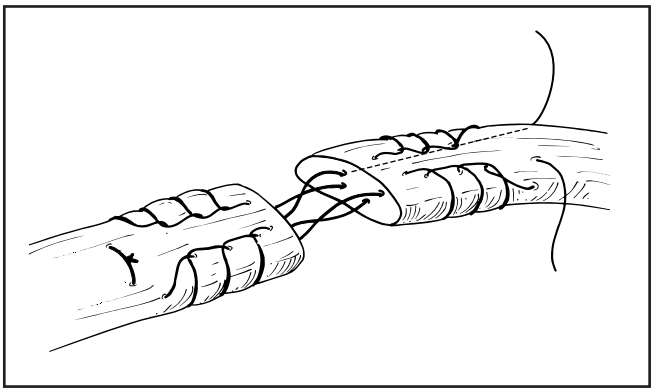

Figure 4. Giftbox suture technique.

Aktas et al in 2009 discussed the use of the Achillon device as an alternative for open repair with a reproducible percutaneous approach. The most notable advantage is avoiding the wound healing complications or at least reducing them to a minimum. However, there also lies an increased risk for sural nerve damage. The prospective randomized study looked at a head-to-head comparison of the Krakow technique versus the minimally invasive procedure with identical postoperative protocols. The results heavily favored the Achillon device with respect to fewer complications and better cosmetic outcomes. Overall, the functional results for all surgically repaired patients were similar in both groups.

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