〈 Clinical Research 〉

Mini-Open Achilles Tendon Repair

Improving Outcomes While Decreasing Complications

Tyler Hoskins, BA, Jay Patel, DO, Joseph H. Choi, MD, Brendan Fitzpatrick, BS, Brian Begley, BA, Chris J. Mazzei, BS, Colin J. Harrington, MD, Justin M. Miller, DO, James C. Wittig, MD, and David Epstein, MD

Abstract: *An acute rupture of the Achilles tendon is a traumatic injury that can cause considerable morbidity and reduced function. Nonoperative intervention may put patients at higher risk of rerupture, whereas surgical intervention carries risk of infection, wound complications, and iatrogenic nerve injury. The mini-open Achilles tendon repair technique has been popularized in helping decrease complications. The goal of this study was to examine and compare the functional outcomes and rate of complications in patients treated with a mini-open repair technique versus a traditional open repair for acute Achilles tendon ruptures. A retrospective review was performed of all patients with a complete Achilles tendon rupture that were treated by a single foot and ankle fellowship-trained surgeon. Functional outcome scores were assessed using the American Orthopaedic Foot and Ankle scoring system (AOFAS) and the Achilles Tendon Rupture Score (ATRS). Eighty-one patients with a complete Achilles tendon rupture underwent mini-open repair and 22 patients underwent traditional open repair surgery between 2013 and 2020. The mean follow-up was 38.40 months (range, 12-71). Mean preoperative AOFAS and ATRS improved in the mini-open group from 45.60 and 47.18 respectively, to 90.29 and 87.97 after surgery ($p < .05$). Mean preoperative AOFAS and ATRS scores for the traditional open repair ($n = 22$) cohort were 44.02 and 42.27, respectively. Postoperatively, the AOFAS and ATRS scores improved to 85.27 and 86.64 (P value < .05), respectively. There was no statistically significant difference in postoperative ATRS scores. However, the mini-open repair group showed a statistically higher postoperative AOFAS score (90.30) than the traditional open-repair group (85.27) (P value < .05). The overall complication rate for our study was 2.9% (2 mini-open repair and 1 traditional open repair). The complication rate in the mini-open repair group and traditional open repair cohort were 2.4% and 4.5%, respectively (P value > .05). One patient in the mini-open repair cohort (1.2%) reruptured his Achilles tendon 4 months postoperatively. A second patient in the mini-open repair group (1.2%) developed a superficial skin infection and suture irritation. One patient (4.5%) in the traditional open repair group developed a superficial skin infection. There were no sural nerve injuries in our series. The mini-open approach to repair a ruptured Achilles tendon is a viable treatment option to decrease the incidence rate of postoperative complications and rerupture rates while also producing a superior cosmetic result.*

Level of Evidence: *3 (retrospective cohort study $N \geq 30$).*

Keywords: achilles; rupture; minimally invasive; repair

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DOI: 10.1177/19386400221078671. From Department of Orthopaedic Surgery, Morristown Medical Center, Atlantic Health System, Morristown, New Jersey (TH, JP, BF, BB, CJM, CJH, JMM, JCW, DE) and Department of Orthopaedic Surgery, St. Joseph's Medical Center, Paterson, New Jersey (JHC).
Address correspondence to: Tyler Hoskins, BA, Department of Orthopaedic Surgery, Morristown Medical Center, Atlantic Health System, 100 Madison Ave, Morristown, NJ 07960; e-mail: tylerhoskins3@yahoo.com.

Introduction

The Achilles tendon is one of the most vital tendons in the lower extremity due to its multifunctional anatomy and physiology. The tendon serves as the transmission of power from the gastrocnemius and soleus muscles to the heel and the foot, which plays an integral part in the ability to walk and run effectively.[1] Unfortunately, the Achilles tendon has a high incidence of rupture, with some studies reporting 8.3 ruptures per 100,000 people.[2] The injury typically occurs within the third to fifth decade of life and is most prevalent in patients who participate in recreational sports. The injury most commonly manifests as a sudden onset of pain in conjunction with local swelling/bruising, and an audible "popping" sound is occasionally heard. The optimal treatment method for this debilitating injury remains controversial. The functional impairment of achilles tendon ruptures includes difficulty walking, inability to stand on one's toes, and weak plantarflexion of the ankle. Nonoperative intervention involving immobilization may put patients at higher risk of rerupture, deep vein thrombosis, pulmonary embolism, and infection. On the contrary, surgical intervention introduces the risk of infection, wound complications, and iatrogenic nerve injury. With the current literature reporting infection and rerupture rates as high as 2.8% and 3.6%, respectively, as well as similar functional results for each management option, it becomes imperative for surgeons to decide on the optimal approach to avoid any complications and their sequelae.[3]

Recently, the mini-open or percutaneous repair technique has become increasingly popularized in treating acute Achilles tendon ruptures. This procedure now involves a smaller skin incision over the rupture site with the percutaneous passing of sutures in a transverse and locking fashion, and subsequently securing the distal and proximal portions of the tendon together. Ma and Griffith introduced this concept in 1977 as an alternative to the open repair due to its theoretical potential to reduce wound complications.[4] The technique also results in superior cosmetic outcomes due to its less-invasive nature and transverse incision. In addition, the financial implications of this procedure have also been deemed more favorable, mainly attributed to the significantly shorter hospital stay and reduction in surgical time associated with the percutaneous approach.[5-7] The goal of this study was to examine the efficacy and rate of complications of the mini-open repair procedure versus the traditional open repair for complete acute Achilles tendon ruptures.

Methods

A retrospective review was performed of all patients with a complete Achilles tendon rupture that were treated with either a percutaneous, minimally invasive technique or a traditional open repair by a single foot and ankle fellowship-trained surgeon between 2013 and 2020. Functional scores both preoperatively and postoperatively were assessed using the American Orthopaedic Foot and Ankle scoring system (AOFAS) and the Achilles Tendon Rupture Score (ATRS). Outcomes, complications, and any reoperations were recorded through retrospective chart review, direct patient examination, and phone calls to patients and their families. Demographic data, such as age, sex, laterality, and body mass index (BMI), were also collected (Table 1).

Inclusion criteria for the study were as follows: patients treated at our facility for an acute Achilles tendon rupture with either a mini-open repair or traditional open repair technique, patients with a complete rupture of their Achilles tendon, and patients with a minimum of 1-year of follow-up. Exclusion criteria included: patients who underwent nonoperative treatment and patients with partial Achilles tendon ruptures. Statistical analysis was performed using the Wilcoxon signed-rank test for comparing the AOFAS and ATRS score improvement within groups. Welch's *t*-test was used to compare the AOFAS and ATRS scores between the 2 different groups due to the differing sample sizes. Results were deemed statistically significant if the calculated *P* value was less than .05.

Mini-open Surgical Technique

All surgeries were performed under general anesthesia with the patient in the prone position. Each mini-open procedure began with a transverse 2- to 3-cm incision over the central portion of the Achilles defect (Figure 1). In contrast, the open repair procedure began with a 6- to 9-cm longitudinal incision down the midline of the Achilles defect. Dissection is then carried down to subcutaneous tissue and hemostasis was obtained. The paratenon is carefully identified for later repair and incised horizontally. After a complete rupture of the Achilles tendon is confirmed, irrigation and debridement of the resultant hematoma is carried out. Using a hemostat, the layer between the Achilles tendon and paratenon is identified and meticulously developed. The 2 stumps of the Achilles tendon rupture are debrided of frayed tissue (Figure 2). An Arthrex PARS Achilles Jig System (Arthrex, Naples, Florida) is positioned around the proximal portion of the Achilles tendon, and sutures are subsequently passed in a sequential fashion. A locking suture is then passed using a passing suture. The PARS jig is then positioned for the distal aspect of Achilles tendon rupture. The sutures are passed through until adequate fixation of the distal stump is achieved in a similar fashion. The ankle is then placed in an equinus position, equal to the resting tension of the contralateral side. The sutures are tied in sequential fashion. A layer of paratenon is closed over the sutures forming a layer between the tendon and the subcuticular layer. The subcuticular layer is closed using 3-0 monocryl and the incision is closed using 3-0 nylon in vertical mattress-type fashion. A well-padded AO splint and dressing were placed on the extremity after each procedure. Postoperative protocol for each patient included a transition to a walking boot at 10 to 14 days with heel wedges and a period of nonweightbearing for 4 weeks. Protected range of motion in plantarflexion was

Table 1.

Selected Patient Demographics.

Total group (n = 103)	
Age, y, mean (SD)	42.7 (11.9)
Sex, n (%)	
Male	88 (85)
Female	15 (15)
Laterality, n (%)	
Left	45 (43.6)
Right	58 (56.4)
BMI, y, mean (SD	27.3 (4.3)
Mini-open repair group (n = 81)	
Age, y, mean (SD	41.4 (10.7)
Sex, n (%)	
Male	68 (84)
Female	13 (16)
Laterality, n (%)	
Left	31 (38.3)
Right	50 (61.7)
BMI, y, mean (SD)	27.1 (4.2)
Traditional open repair group (n = 22)	
Age, y, mean (SD)	47.1 (15.0)
Sex, n (%)	
Male	20 (91)
Female	2 (9)
Laterality, n (%)	
Left	14 (63.6)
Right	8 (36.4)
BMI, y, mean (SD)	28.1 (4.4)

Abbreviation: BMI, body mass index.

initiated at that time. After 4 weeks, patients were advanced to weightbearing as tolerated in their walking boot and progressive removal of heel wedges from 6 to 8 weeks postoperatively under the supervision of a physical therapist. The walking boot was discontinued at 8 weeks with a transition to a sneaker with heel lift. Progressive strengthening and range of motion exercises were carried out over the next several months with a jogging program initiated when single leg heel rise of the operative extremity could be performed. A progressive return to high-impact and sport-specific activities were then introduced with a goal of returning to sport at 6 to 9 months after surgery.

Open Repair

All surgeries were performed under general anesthesia with the patient in the prone position. Each open procedure began with an 8- to 12-cm posteromedial incision centered over the tear and carried down to the paratenon. The paratenon was then exposed and it, along with full thickness skin flaps, was retracted to expose the tendon rupture. The proximal tendon segment was then mobilized, and the malleable retractor was advanced proximally within the paratenon to break up adhesions. The fascia of the posterior compartment was then incised anterior to the tendon rupture exposing the flexor hallicus longus muscle. The tendon was then repaired using nonabsorbable braided sutures. The sutures entered the tendon anteriorly so that the knots sit along the anterior surface of the tendon and do not irritate the posterior closure. The final tension should mirror the resting position of the contralateral side and restore a normal Thompson Test. With the knee bent, the ankle rested in 10° to 15° of equinus. The core sutures were then tied together to complete the repair. The paratenon layer was closed with a running 0 vicryl suture. The subcutaneous tissue was closed with 3-0 monocryl sutures, and skin was closed with 3-0 nylon suture. A posterior short-leg splint was then applied for 10 to 14 days set in the resting position.[4,5,7]

Results

During the study period, a total of 103 patients met the inclusion criteria. The most common cause of injury reported was recreational sports

Figure 1.

A transverse 2- to 3-cm incision over the central portion of the Achilles tendon defect.

Figure 2.

The proximal stump of the Achilles tendon was found and retracted through the transverse incision for debridement of the frayed tendon edges.

activity. Eighty-one patients received the mini-open repair and 22 patients received the traditional open repair. The mean follow-up period for our patient cohort was 38.40 months (range, 12-71). The average age and BMI for all subjects was 42.7 years (range, 17-70) and 27.3 (range, 19.1-44.3), respectively. Of the 103 subjects included in the study, 88 were male (85%) and 15 were female (15%). Fifty-eight patients tore their right Achilles tendon (56.3%) and 45 patients tore their left (43.6%). Mean preoperative AOFAS and ATRS scores for the mini-open (n = 81) cohort were 45.57 and 47.48, respectively. Postoperatively, the AOFAS and ATRS scores improved to 90.30 and 86.96 (P value $< .05$), respectively. Mean preoperative AOFAS and ATRS scores for the traditional open repair (n = 22) cohort were 44.02 and 42.27, respectively. Postoperatively, the AOFAS and ATRS scores improved to 85.27 and 86.64 (P value $< .05$), respectively.

Comparison of functional scores, Table 2.

There was no significant difference between preoperative AOFAS scores between the 2 cohorts; however, the mini-open repair group (47.48) had a higher mean preoperative ATRS score than the traditional open repair group (42.27) (P value $< .05$). The mini-open repair group showed a statistically higher postoperative AOFAS score (90.30) than the traditional open-repair group (85.27) (P value $< .05$). There was no statistical difference in postoperative ATRS scores between the 2 groups.

There were 3 postoperative complications (2.9%) noted in our cohort. One patient from the mini-open repair group reruptured his Achilles tendon 12 weeks postoperatively (1.2% rerupture rate for the mini-open repair group) while participating in martial arts against standard postoperative protocol. The patient was successfully treated with an open Achilles repair and flexor hallucis longus (FHL) transfer and eventually returned to full activity. The other 2 patients, 1 from each cohort, developed a superficial skin infection and suture irritation. These patients successfully underwent irrigation and debridement along with suture removal without further complication. There were no sural nerve injuries in our study. All patients eventually returned to their previous level of activity with no decrease in quality of life.

Discussion

An acute Achilles tendon rupture is a traumatic injury that can cause considerable morbidity and reduced function. Nonoperative treatment and surgical treatment have demonstrated similar functional outcome in regards to patient satisfaction, return to sport, and strength.[8] However, other studies have shown that traditional cast immobilization leads to higher rate of rerupture (9.8% versus 3.7%) and loss of motion, whereas surgical intervention introduces the risk of infection, iatrogenic nerve injury, and their sequelae.[9,10] More recent studies comparing surgical versus nonsurgical treatment utilizing functional rehabilitation in lieu of cast immobilization have demonstrated no difference in rerupture rates and is a topic of interest.[10,11] As hospital systems continue to transition toward bundled payment model, it becomes imperative for providers to seek the most optimal method of treatment to deliver cost-effective care while simultaneously improving quality and patient outcomes.

In one of the initial studies by Ma and Griffith, 18 patients underwent mini-repair procedures for the treatment of acute Achilles tendon ruptures.[4] Their technique produced results superior to the open repair technique due to tendon continuity restoration, tendon strength restoration, and minimization of postoperative complications. The mini-open approach is thought to inherently reduce trauma to the tenuous blood supply of the skin overlying the heel cord while simultaneously reducing the surface area available for adhesion formation. Several studies have shown multiple benefits of a mini-open repair, including, equivalent or better functional outcomes, shorter OR times, decreased iatrogenic sural nerve injury, decreased or equivalent rerupture rates, decreased infection, and wound complication rates.[6,7,12]

The sural nerve is an important sensory nerve of the lower extremity that innervates the posterolateral leg and involves the lateral margin of the

Table 2.

Comparison of Mini-Open Repair Versus Traditional Open Repair Outcomes.

Mean preoperative AOFAS scores ($P = .19$)	
Mini-open (n = 81)	45.57
Traditional open (n = 22)	44.01
Mean preoperative ATRS scores ($P = .00007$)	
Mini-open (n = 81)	47.48
Traditional open (n = 22)	42.27
Mean postoperative AOFAS scores ($P = .0004$)	
Mini-open (n = 81)	90.30
Traditional open (n = 22)	85.27
Mean postoperative ATRS scores ($P = .77$)	
Mini-open (n = 81)	86.96
Traditional open (n = 22)	86.64

Abbreviations: AOFAS, American Orthopaedic Foot and Ankle scoring system; ATRS, Achilles Tendon Rupture Score.

hindfoot, midfoot, and ankle joint. One of the most common complications associated with the percutaneous approach is sural nerve injury, with some studies reporting up to a 18% rate of iatrogenic injury.[13,14] Some surgeons minimize the risk of damaging the sural nerve by utilizing ultrasound devices to approximate the location of the nerve when performing surgeries of the lower extremity.[15] In addition, Blackmon et al reported a reliable method to reduce sural nerve injury through the use of a regression equation.[16] The equation enables surgeons to approximate the location of the intersection point at which the sural nerve crosses the lateral border of the Achilles tendon, a vital surgical landmark under this type of procedure. In our study, no sural entrapment or injury was reported. The senior author (D.E.) employs a meticulous dissection of the subparatenon layer to ensure that the percutaneous Achilles guide is deep to the paratenon. This allows for the sural nerve to be safely identified, and thus may contribute to a decrease in sural nerve irritation.

The goals of treatment for a ruptured Achilles tendon include rapid restoration of the tendon, a painless extremity, and good functional outcomes. To justify employing the percutaneous approach over the open repair technique, these conditions must be met while simultaneously reducing postoperative complications. In our study, the postoperative AOFAS and ATRS functional outcome scores for the patients were significantly improved ($P < .05$). Although one patient (0.9% of all subjects) reruptured his Achilles 12 weeks postoperatively, all patients eventually returned to their previous level of activity with no decrease in quality of life. Yang et al performed a meta-analysis that included 5 randomized controlled trials and 7 retrospective cohort studies comparing the functional outcomes and complications associated with percutaneous versus open repair of acute Achilles tendon rupture.[11] When compared to the open repair group, the functional outcome scores for patients who underwent a percutaneous approach were significantly higher ($P = .005$). Our study also supports this conclusion with our mini-open repair group producing a higher postoperative AOFAS score than the open repair group (90.30 vs 85.27) ($P < .05$).

Furthermore, the open repair group in the Yang et al study had a higher incidence of deep infection (3.6% versus 0.6%) and a significantly longer time of operation (24-54.55 min vs 45.9-68.8 min). Several studies have reported a strong correlation between the length of surgery and risk of infection).[3,17] Jildeh et al retrospectively reviewed the records of 423 patients who underwent a traditional open repair. They found that longer tourniquet times and greater estimated blood loss were associated with an increased rate of deep surgical site infections. In addition, patients with longer operation times had increased rates of rerupture.[3] Our study had no incidences of deep surgical site infections.

Given the increasing burden of healthcare costs on the economy, surgeons and hospital systems are tasked with choosing the most cost-effective method of treatment without compromising patient outcomes. Carmont et al analyzed the results of 49 patients who underwent a percutaneous approach for an Achilles tendon rupture versus 35 that were treated using an open repair technique. They reported no statistically significant difference in patient outcomes between the 2 cohorts, but found the percutaneous approach to be significantly cheaper than the open repair (£935 versus £574).[18] This was largely attributed to the decrease in hospital stay in the percutaneous group. Goel et al reported a savings of $236,000 over the 3 years of their study recruitment, which represented a savings of $949 per patient and was also attributed to a decrease in hospital

stay.[19] Ebinesan et al. estimated that a mini-repair procedure under local anesthetic is about one-third the cost of a traditional open repair surgery.[5] Although we did not analyze the length in hospital stay for each cohort, several studies reported equal or superior functional outcomes with less wound complications and greater cost savings in mini-open procedures compared to traditional open procedures.[13,20]

In addition, the decision to use the AOFAS scoring system must be addressed. The rating system combines physical examination criteria with patient-reported pain and function items.[21,22] When a clinical examination is part of a scoring system, this introduces a high risk of interobserver variability as different examiners may have different measuring techniques, which thus can affect the reliability of the score.[21,23] One study conducted an analysis examining the limitations of the AOFAS scoring system. They concluded that the small number of response categories available for each item resulted in limited measurement precision and could lead to skewed distribution.[24] However, the AOFAS scoring system continues to be among one of the most reliable and commonly used measuring tools used by researchers to analyze data regarding functional outcomes following foot and ankle procedures.[24-27]

There were several limitations to our study. First our study was a retrospective study and therefore has all of the inherent biases of retrospective reviews. Our study only included patients with a complete Achilles tendon rupture; patients with that were treated surgically with a partial rupture were excluded. In addition, our study had a smaller comparison group undergoing traditional open repair (n = 22) in comparison to the mini-open repair group (n = 81), leading to potential difficulties in accurately comparing the data. While our series has only 103 patients, no patients were lost to follow-up. Furthermore, all of the cases were performed by a single surgeon (D.E.) with no change in technique or postoperative protocols.

Conclusion

In conclusion, our study supports the use of the mini-open repair technique for acute Achilles tendon ruptures. Our results demonstrate a low complication rate, excellent functional outcomes, and return to previous level of activity/sport. Although the complication rates between both cohorts were not statistically significant in our study, the literature reports a lower incidence of postoperative wound complications in the mini-open repair approach. The authors believe that by decreasing the complication rate, the mini-open technique leads to more cost saving benefits than the traditional open repair procedure. Further high-powered prospective randomized controlled trial comparing the efficacy of this procedure to other surgical methods are necessary to further validate our findings. As more surgeons become comfortable with mini-open approaches, we believe there will be a paradigm shift in the standard for operative treatment of acute Achilles tendon ruptures.

Declaration of Conflicting Interests

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Ethical Approval

Not applicable, because this article does not contain any studies with human or animal subjects.

Informed Consent

This was a retrospective chart review and no experimentation was done on human or animal subjects. As it was a retrospective chart review, institutional IRB was deemed unnecessary by our instructional IRB committee.

Trial Registration

Not applicable, because this article does not contain any clinical trials.

ORCID iDs

Tyler Hoskins https://orcid.org/0000-0003-1012-8326

Brendan Fitzpatrick https://orcid.org/0000-0001-6357-5897 FAS

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