

A clinical comparison of two different surgical techniques in the treatment of acute Achilles tendon ruptures: Limited-open approach vs. percutaneous approach

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ABSTRACT

BACKGROUND: Surgical treatment is the commonly preferred method for treating acute Achilles tendon ruptures (AATRs) due to advantages such as less re-rupture rates, better functional results, and an early return to physical activities. The main aim of our study is to compare two common minimally invasive surgical methods, the limited open and the percutaneous approaches, regarding clinical outcomes.

METHODS: A total of 53 patients (19 females and 34 males) who were treated with limited open (Group 1: 30 patients) and percutaneous (Group 2: 23 patients) approaches for AATRs were retrospectively evaluated between March 2019 and May 2020 in a level I trauma center. The evaluation included complications (soft tissue and skin problems, re-rupture, and sural nerve injury rates), the operation time, the duration of return to daily activities, The Achilles Tendon Total Rupture Score (ATRS), and the American Orthopedic Foot and Ankle Society (AOFAS) scores of the patients at the first and 6th months of follow-up. Patients' activity levels were compared with the Tegner Activity Scale (TAS).

RESULTS: The mean age of all patients in this cohort was 45.1±14.1. The mean postoperative follow-up period for group 1 was 36.9±8.81 weeks, whereas, for group 2, it was 35.4±8.73 weeks (P=0.24). The mean age (P=0.47), gender distribution (P=0.41), and body mass index (P=0.29) were similar for both groups. The mean operation time (group 1: 47.1±5.4 vs. group 2: 44.4±6.1, P=0.06) and the duration of return to daily activities (group 1: 49.2±7.4 vs. group 2: 48.5±9.7, P=0.38) were also similar. There was no statistical difference between groups regarding functional results at first (ATRS: group 1: 79.9±3.2 vs. group 2: 79.5±3.9, [P=0.35]), and AOFAS: group 1: 80.9±3.1 vs. group 2: 82.1±3.2, [P=0.10]) and 6th months (ATRS: group 1: 85.0±3.8 vs. group 2: 83.7±4.4, [P=0.13]), and AOFAS: group 1: 86.6±3.6 vs. group 2: 86.7±4.2, [P=0.46]). There were no statistically significant differences between groups regarding preoperative and last follow-up TAS scores (P=0.94 and P=0.46, respectively). We observed no postoperative complications in group 1. There were three complications (13.1%) in group 2. One patient (4.4%) had a re-rupture, and two patients (8.7%) had sural nerve injuries.

CONCLUSION: Although both groups had similar functional results, the limited open approach yielded better clinical outcomes according to the complication results than the percutaneous approach.

Keywords: Achilles tendon rupture; limited open approach; minimal invasive; percutaneous approach.

Cite this article as: Subaşı İÖ, Çepni Ş, Tanoğlu O, Veizi E, Alkan H, Yapıcı F, et al. A clinical comparison of two different surgical techniques in the treatment of acute Achilles tendon ruptures: Limited-open approach vs. percutaneous approach. *Ulus Travma Acil Cerrahi Derg* 2023;29:935-943.

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Ulus Travma Acil Cerrahi Derg 2023;29(8):935-943 DOI: 10.14744/tjtes.2023.90839 Submitted: 15.09.2022 Revised: 26.04.2023 Accepted: 08.07.2023
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INTRODUCTION

The Achilles tendon is the strongest in the human body and transfers the force from the gastrocnemius and soleus muscles to the calcaneus.^[1] Acute Achilles tendon ruptures (AATRs) are seen frequently in the third and fourth decades and in the male population. However, some studies report that its frequency has increased in the fifth and sixth decades.^[2,3] The Achilles tendon is often injured 2–6 cm proximal to the calcaneal insertion.^[4] Although AATRs occur mostly during sports activities, they have also been associated with many other factors, such as drugs, metabolic diseases, and structural variations.^[3,5,6]

The ideal treatment method for AATRs is still controversial in the current literature. The risk of re-rupture, wound complications, neurological complications, and the strength and return to physical activities should be considered in the treatment choice of AATRs.^[2] Surgical treatment is the commonly preferred method for treating AATRs due to the advantages of less re-rupture rates, better functional results, and an early return to physical activities.^[1,7]

The surgical treatment of AATRs is addressed using a variety of techniques. These surgical techniques can be summed up as open repair and minimally invasive techniques. Open approaches ensure correct tendon end-to-end repair and, consequently, more stable suture fixation. However, the paratenon that supplies the tendon with blood is compromised. In addition, the skin incision traverses a poorly vascularized region of the posterior distal calf, which produces wound complications.^[8] Minimally invasive techniques (percutaneous repair and limited-open repair) have been developed to reduce the problems mentioned above experienced in open surgical techniques.^[7,9-11]

Ma and Griffith first described the “Percutaneous Repair” method, one of the minimally invasive techniques. A low wound site complication rate is the advantage of this technique. Important disadvantages include the risk of injuring the Sural nerve close to the tendon with a percutaneous needle, the inability to see the ruptured tendon ends due to the absence of an incision, and the inability to evaluate the quality of tendon repair.^[11,12] To overcome the issues of open (skin complications) and percutaneous (risk of sural nerve injury) repair techniques, the “Limited-Open Repair” method was developed.^[13]

Although many studies compare the results of minimally invasive methods and open repair, to the best of our knowledge, only one study compares the results of limited open and percutaneous approaches.^[14] The current study aims to compare the limited open and percutaneous approaches for treating AATRs in terms of the duration of return to daily activities, the rates of complications, and the functional results.

We hypothesize that the limited-open approach is superior to the percutaneous approach regarding clinical outcomes in treating AATRs.

MATERIALS AND METHODS

The ethics committee of our institution approved this study (E1-21-2019/September 22, 2021). Among 93 patients who were admitted to the level I trauma center for AATRs and treated surgically with minimally invasive methods between March 2019 and May 2020, 53 patients who met the inclusion criteria were included in our study and were retrospectively investigated from medical records. Informed consent was obtained from all participating patients. The patients, who were between 18 and 65 years of age and were administered to our clinic within 10 days of injury with closed injuries without any abrasions and tendon ruptures between 2 and 6 cm proximal from the calcaneal tuberosity, were included in the current study. The surgical team evaluated all the patients regarding gap formation, the Thompson test, and skin wrinkling. The diagnosis was confirmed with an ultrasound examination of the Achilles tendon. Patients with diabetes mellitus, severe skin wounds, abrasions over the surgical site, hypermobility syndromes, prior history of Achilles tendinopathy or enthesopathy, chronic Achilles ruptures, penetrating injuries, re-ruptures, and patients with irregular follow-up visits were excluded from the study. The flow chart of the patients in the study group is given in Figure 1.

The randomization protocol was based on the patient’s hospital admission dates (odd or even days of the month). Among the patients in this study group, the patients whose hospital admissions were on odd days of the month were operated on with the mini-open method, while the patients admitted on even days of the month were operated on with the percutaneous approach.

All the patients were operated on under epidural anesthesia by the same surgeon experienced in the surgical treatment of Achilles injuries in a prone position without a pneumatic or hydraulic tourniquet application. Suturemaxx (Tulpar, Ankara, Turkey) sutures produced from ultra-high-molecular-weight polyethylene (UHMWPE) were used in all surgical procedures.

The surgeries were performed by a single experienced orthopedic surgeon, and the postoperative clinical outcomes were evaluated by a second independent orthopedic surgeon.

Surgical Technique

In both limited open and percutaneous approaches, the medial and lateral margins of the Achilles tendon, as well as the gap at the rupture site, were determined and marked with the patient in the prone position (Fig. 2).

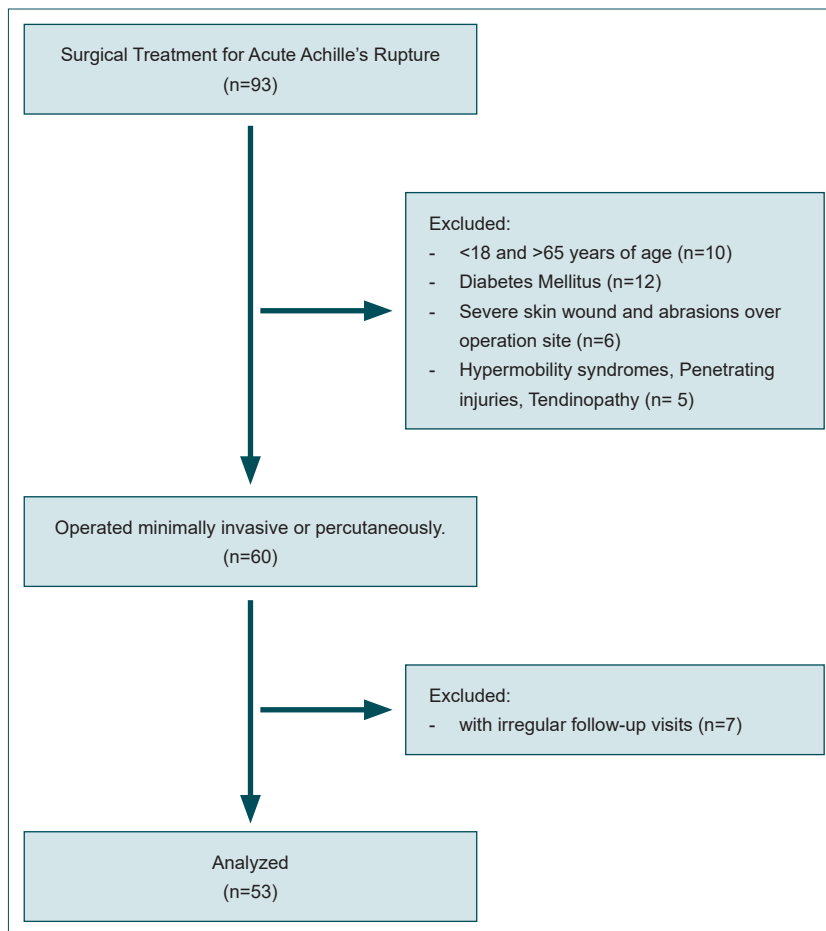


Figure 1. The Flow chart of the patients in the study group.



Figure 2. Percutaneous (a) and limited open (b) Achilles repair techniques.

For the limited-open approach (Group I), a 2-cm transverse incision was made over the gap formation. Through this incision, the interval between the superficial fascia of the leg and the paratenon is developed. From this incision, ruptured proximal and distal tendon ends were observed. With the

technique described by Bunnell,^[15] distances of 1.5 cm and 3 cm from the gap site on the proximal stump and a distance of two cm from the gap site on the distal stump were chosen as the entry and exit points for the straight suture needle (16 gauge) in each patient. After performing proximal and

distal tenocutaneous sutures, the ends of the sutures were retrieved from the mini-incision using a forceps clamp or a suture collector hook. While the foot is in maximum plantar flexion posture, the proximal and distal suture ends are knotted over the tendon. The suture-tendon construct, the convergence of both tendons' ends, and the gap closure were directly observed through the mini-incision. The paratenon was then closed using a size-two absorbable suture (Fig. 3).

For the percutaneous approach (Group 2), the rupture site was palpated. The No. 11 scalpel was used to make two stab incisions on the medial and lateral edges of this gap. The suture was passed through the Achilles tendon with the help of a straight needle (16 gauge) using the Bunnell technique, and sutures were carried from the tendon's medial and lateral stab incisions using a suture carrier hook instrument (Fig. 4). While the foot is in maximum plantar flexion

posture, the proximal and distal suture ends are knotted near the tendon.

Postoperative Management

A single dose of low-molecular-weight heparin (enoxaparin sodium, 4000 i.u., subcutaneous) was administered for 14 days to patients who underwent surgery using both techniques to prevent deep-vein thrombosis.

Patients received a short-leg cast with the ankle in 20° of plantar flexion following surgery. All patients were permitted active and passive knee flexion and extension movements as early as the postoperative period. On the 3rd, 7th, and 4th days after surgery, a single surgeon who was not the surgeon who performed the operation conducted follow-up visits in the outpatient clinic.

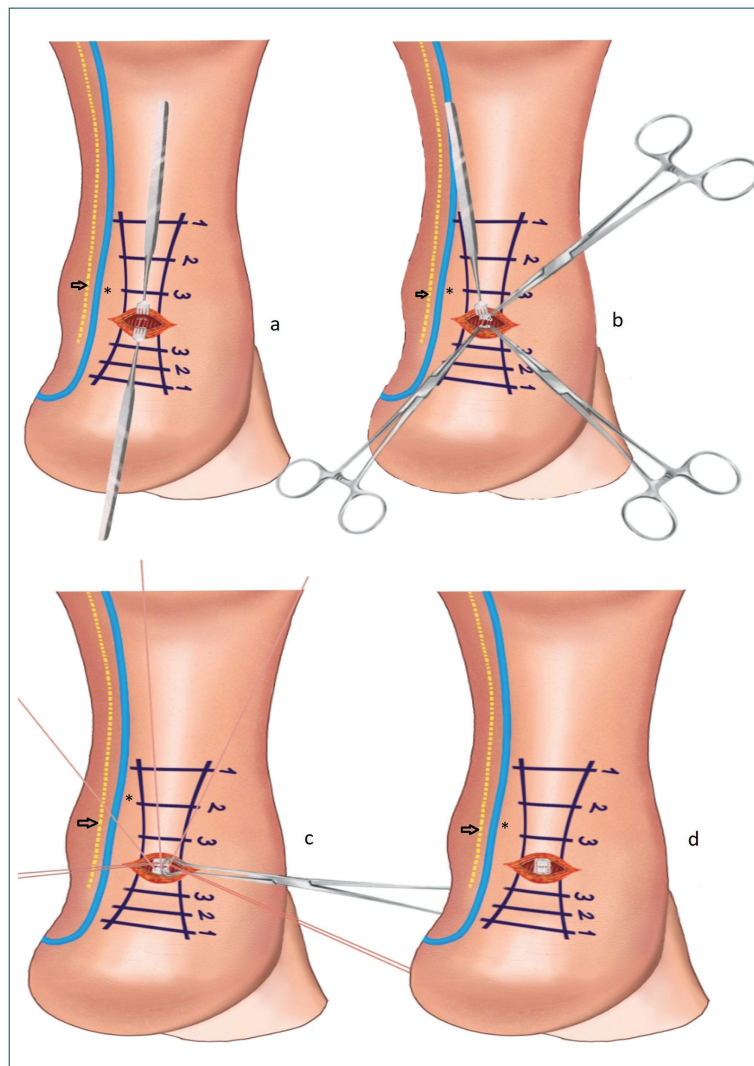


Figure 3. Figure 1. Limited-open repair of the Achilles tendon. (a) a mini-incision over the gap formation. (b) The interval between the superficial fascia of the leg and the paratenon is developed. (c) The suture, which is passed through the tendon with the help of a needle or cannula, is pulled to the incision line with the help of a clamp. (d) Distal and proximal sutures are knotted over the tendon, and the paratenon is repaired. (*: Saphenous vein, →: Sural nerve).

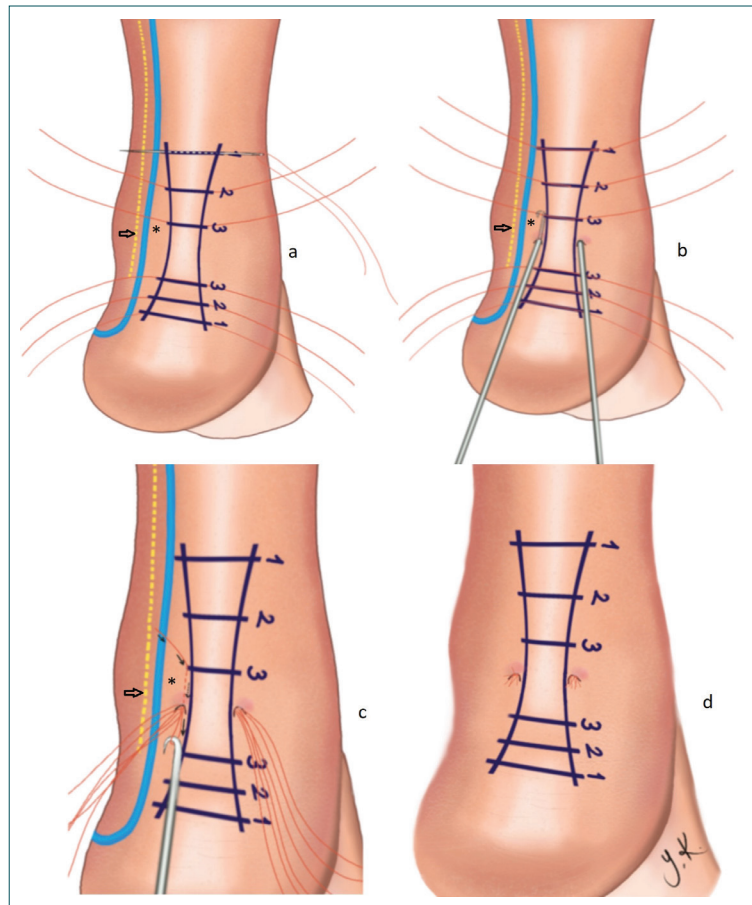


Figure 4. Percutaneous repair of the Achilles tendon. (a) The medial and lateral edges of the proximal and the distal parts of the tendon are determined, and sutures are passed through the determined points of the tendon with the help of a needle or cannula. (b) Two stab incisions (medial and lateral) are made at the rupture site and the sutures are pulled from the determined points to the incision lines with the help of a mini hook. (c) Sutures are pulled out from the stab incisions and are knotted over the tendon. (d) The skin is closed. (*: Saphenous vein, \longrightarrow : Sural nerve).

At the end of the 2nd week, the patients' casts were removed. Active dorsiflexion was permitted beginning in the 3rd week. Active resistance and stretching exercises were initiated after 6 weeks. Immediately after surgery, patients were mobilized. First 2 weeks of non-weight bearing, followed by partial weight-bearing between weeks 2 and 6. After 6 weeks, complete weight-bearing was permitted.^[16]

The term "return to daily activities" refers to the patients' ability to resume their preinjury daily routines, like independently walking and going up and down stairs but not participating in sports or hard work. Patients' preinjury Tegner Activity Scale (TAS) scores were noted to clarify the homogeneity between groups regarding patients' daily activity levels. In the 1st month of follow-up, the Achilles Tendon Total Rupture Score (ATRS) and American Orthopedic Foot and Ankle Society (AOFAS) scores of the patients were calculated. The outpatient follow-up and clinical score evaluations of the patients were performed by an experienced orthopedic surgeon blinded to the applied surgical technique. Wound complications, sural nerve injuries, re-rupture rates, and the

duration of return to daily activities were evaluated. In the 6th month of follow-up, the AOFAS, ATRS, and TAS scores of the patients were once again evaluated.

Statistical Analysis

The statistical analysis was performed with SPSS 22 (IBM Corporation, Armonk, New York) program. The data obtained by counting were expressed in numbers and percentages. Visual (histograms and probability graphs) and analytical methods (Kolmogorov–Smirnov and Shapiro–Wilk tests) examined the appropriateness of the variables obtained by measurement. In comparing the data obtained by the measurement, the Student's T-Test was used for variables with a normal distribution, and the Mann–Whitney U test was used to compare variables without a normal distribution. The Pearson Chi-square test was used to compare categorical data. The statistical significance level was accepted as $P < 0.05$. Post-hoc power analysis was performed using G-Power version 3.1.9.2 (Dusseldorf University, Dusseldorf, Germany), and the power of our study was calculated as

80.8% when the effect size (d) was 0.8 and the standard error (α) was 0.05.

RESULTS

The mean age of all patients in this cohort was 45.1 ± 14.1 . There was no significant difference between study groups in terms of the mean age, gender distribution, body mass index, duration of the surgical operation, or mean postoperative follow-up time ($P=0.47$, $P=0.41$, $P=0.29$, $P=0.06$, and $P=0.24$, respectively). Table 1 demonstrates the comparison between groups regarding demographics, clinical results, and complications.

Both groups were homogeneous in preinjury activity levels ($P=0.94$). All patients in both groups achieved preinjury activity levels (e.g., sports participation) within approximately 6 months without a statistically significant difference ($P=0.46$). In our study, there was no patient who could not reach the previous activity level according to TAS.

ATRS scores at the first and 6th months of follow-up were not statistically significant between the percutaneous and limited open approach groups ($P=0.56$ and $P=0.50$, respectively). Although at the first and 6th month of follow-up, the mean AOFAS scores of the percutaneous approach group were higher than those of the limited open approach group, the difference was not statistically significant ($P=0.10$ and $P=0.46$, respectively). We observed no statistically significant difference between percutaneous and limited open approach groups regarding the duration of return to daily activities ($P=0.38$).

Although no postoperative complications were observed in group 1, sural nerve injuries in two patients and re-rupture in one patient were observed in group 2 (8.7% and 4.4%, respectively). The sural nerve injury was diagnosed with electromyography studies.

Although full recovery was achieved in the 6th month of follow-up in one patient with observation, we observed hyper-

Table 1. Demographics, clinical results, and complications

	Limited open (Group 1, n=30)	Percutaneous (Group 2, n=23)	P-value
Demographics			
Age	45.21±15.16	44.16±12.11	0.47
Sex	M:19, F:11	M:15, F:8	0.41
BMI	24.41±3.79	24.86±4.09	0.29
Mean Follow-up (weeks)	36.9±8.81	35.4± 8.73	0.24
Clinical results			
ATRS (1 st month)	79.9±3.2	79.5±3.9	0.35
AOFAS (1 st month)	80.9±3.1	82.1±3.2	0.10
ATRS (6 th month)	85.0±3.8	83.7±4.4	0.13
AOFAS (6 th month)	86.6±3.6	86.7±4.2	0.46
Return to daily activities (days)	49.2±7.4	48.5±9.7	0.38
Return to preinjury level of activity (weeks)	22.8±2.6	22.9±2.5	0.46
Preinjury level of activity (TAS)			0.94
Tegner level 3 (n)	5	4	
Tegner level 4 (n)	6	4	
Tegner level 5 (n)	5	3	
Tegner level 6 (n)	5	6	
Tegner level 7 (n)	9	6	
Duration of the surgery (minutes)	47.1±5.4	44.4±6.1	0.06
Complications			
Sural Nerve Damage	0	2 (8.7%)	
Re-rupture	0	1 (4.4%)	

BMI: Body mass index; AOFAS: American orthopedic foot and ankle society; ATRS: The achilles tendon total rupture score; TAS: Tegner activity scale; F: female; M: male, p: Level of significance.

algnesia and loss of discrimination in the other patient's lateral side of the foot and ankle.

DISCUSSION

The most important finding of our study is that, despite no significant difference in the functional results of AATRs treated with limited-open or percutaneous approaches, the complication rate was higher for the percutaneous approach compared with the limited-open approach.

The primary purpose of tendon repair is to provide a strong fixation during the healing period to obtain proper tendon integrity.^[7,14] Many studies in the literature showed lower re-rupture rates with various suture materials and techniques with open repair of AATRs.^[7,9,17,18] Although lower rates of re-ruptures were obtained with open repair, increased soft tissue complications have been observed with this technique.^[2,10,19] Therefore, minimally invasive repair methods and surgical instruments for these procedures have been developed to prevent postoperative soft-tissue complications due to open repair of AATRs.^[8,12,20,21] The soft tissue complication rates after open repairs of AATRs have been reported to be between 3 and 11%. In contrast, lower rates of soft-tissue complications were observed with minimally invasive techniques in the literature.^[4,9,10] In our study, we did not observe any soft tissue complications with percutaneous or limited open approaches. We attribute this situation to two reasons. Firstly, we excluded patients with other diseases that may prevent wound healing (exclusion criteria). Secondly, every effort was made to minimize damage to soft tissue during operations on every patient.

The major disadvantage of limited-open and percutaneous approaches is the increased risk of re-rupture.^[1,2,22] In a literature review, re-rupture rates were reported between 3.7% and 5.3% with percutaneous and limited open approaches. In the same study, re-rupture rates were noted between 1.7% and 2.9% with open repair of acute AATRs.^[1] In the percutaneous approach group, we observed only one re-rupture case (4.1%) in the 4th week of follow-up. Open repair was performed for the treatment of the re-rupture patient.

Minimally invasive treatment methods could cause sural nerve injuries. In the percutaneous repair group, we observed sural nerve injuries in two patients. Haji *et al.* reported transient sural neuritis in 10.5% of patients with percutaneous repair.^[23] On the other hand, Hsu *et al.* detected 3% sural neuritis in the patient group who underwent open Achilles tendon repair, while sural neuritis was not detected in the limited open repair group in their series of 270 patients.^[24] In addition, a cadaver study conducted by McGee *et al.* showed that none of the guide needles damaged the sural nerve in the Achilles tendon repair performed with a limited open approach.^[25] In our study, we observed a similar rate of sural nerve injury (8.3%) compared to the literature. A full recovery was obtained with observation in a patient with a sural nerve injury, but the sural

nerve injury was permanent in the other patient. The main reason for lower rates of sural nerve injuries in open repair could be the direct visualization of the nerve during the procedure.

AATRs are commonly seen in young adults. In these patients, early return to daily activities and obtaining better postoperative functional results are the most crucial aims of the treatment. In the literature, higher ATRS scores and earlier return to daily activities were observed with surgical repair compared to conservative treatment methods. Limited open, percutaneous, and endoscopic approaches have become popular surgical techniques recently.^[1,8,10,14] In many studies comparing the results of open repair and minimally invasive approaches, no statistically significant difference was found in return to daily activities, ATRS, or AOFAS scores.^[1,4,7,10] Similarly, our study showed no statistically significant difference in the duration of return to daily activities, ATRS, or AOFAS scores.

Our study had a few limitations. Our study was carried out retrospectively. The number of cases in our study was small, and the mean follow-up time was short, but these parameters were similar to the number of cases and the mean follow-up time in the reported studies.^[14] Since only one surgeon evaluated the patients postoperatively, inter- or intra-observer evaluation could not be performed. The outstanding feature of our study was that this was the second study on this subject. In addition, midterm results were included in our study. Also, the post-hoc power analysis of the study was over 80%.

CONCLUSION

Despite limited-open and percutaneous approaches having shown similar postoperative functional results in the 6th month of the follow-up period, according to the complication results, the limited-open approach yielded better clinical outcomes than the percutaneous approach. However, long-term prospective randomized studies with a high number of patients comparing limited-open and percutaneous methods are needed to draw a certain conclusion.

Acknowledgments: The authors are notably grateful to Dr. Yeşim Kutlutürk for her assistance in illustrating surgical techniques.

Ethics Committee Approval: This study was approved by the Ankara State Hospital Research Ethics Committee (Date: 22.09.2021, Decision No: EI-21-2019).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: İ.Ö.S., O.T., E.V., H.A.; Design: İ.Ö.S., Ş.Ç., F.Y.; Supervision: A.F.; Data collection and/or processing: İ.Ö.S., H.A.; Analysis and/or interpretation: İ.Ö.S., F.Y., A.F.; Literature search: İ.Ö.S., O.T., S.Ç.; Writing: İ.Ö.S.; Critical reviews: O.T., F.Y., A.F.

Conflict of Interest: None declared.

Financial Disclosure: The authors declared that this study has received no financial support.

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ORIJİNAL ÇALIŞMA - ÖZ

Akut aşil tendon rüptürlerinin tedavisinde iki farklı tekniğin klinik karşılaştırılması: Sınırlı açık yaklaşıma karşı perkütan yaklaşım

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AMAÇ: Akut Aşil tendon rüptürlerinin (AATR) tedavisinde cerrahi tedavi, daha az re- rüptür oranları, daha iyi fonksiyonel sonuçlar ve fiziksel aktivitelere erken dönüş gibi avantajları nedeniyle yaygın olarak tercih edilen tedavi yöntemidir. Çalışmamızın temel amacı, yaygın olarak kullanılan iki minimal invaziv cerrahi yöntem olan, sınırlı açık ve perkütan yaklaşımları klinik sonuçlar açısından karşılaştırmaktır.

GEREÇ VE YÖNTEM: I. seviye travma merkezine Mart 2019 ile Mayıs 2020 arasında AATR nedeni ile başvuran, sınırlı açık (Grup 1: 30 hasta) ve perkütan (Grup 2: 23 hasta) yaklaşımlarla tedavi edilen toplam 53 hasta (19 kadın ve 34 erkek) geriye dönük olarak değerlendirildi. Hastaların komplikasyonları (yumuşak doku/cilt sorunları, re-rüptür ve sural sinir yaralanma oranları), ameliyat süreleri, günlük aktivitelere dönüş süreleri, Aşil Tendon Toplam Rüptür Skoru (ATRS) ve Amerikan Ortopedik Ayak ve Ayak Bileği Derneği (AOFAS) birinci ve altıncı aylarındaki skorları değerlendirildi. Hastaların aktivite düzeyleri Tegner Aktivite Skalası (TAS) kullanılarak karşılaştırıldı.

BULGULAR: Çalışma grubunda yer alan hastaların yaş ortalaması 45.1±14.1 idi. Ameliyat sonrası ortalama takip süresi grup 1'de 36.9±8.81 hafta iken grup 2'de 35.4±8.73 hafta olarak bulundu (p=0.24). Ortalama yaş (p=0.47), cinsiyet dağılımı (p=0.41) ve vücut kitle indeksi (p=0.29) her iki grup için benzerdi. Ortalama ameliyat süreleri (grup 1: 47.1±5.4 ve grup 2: 44.4±6.1, p=0.06) ve günlük aktivitelere dönüş süreleri (grup 1: 49.2±7.4 ve grup 2: 48.5±9.7, p=0.38) de her iki grup için benzerdi. Fonksiyonel sonuçlar açısından gruplar arasında birinci ay sonuçlarında (ATRS: grup 1: 79.9±3.2 ve grup 2: 79.5±3.9, [p=0.35] ve AOFAS: grup 1: 80.9±3.1 ve grup 2: 82.1±3.2, [p=0.10]) ve altıncı ay sonuçlarında (ATRS: grup 1: 85.0±3.8 ve grup 2: 83.7±4.4, [p=0.13] ve AOFAS: grup 1: 86.6±3.6 vs grup 2: 86.7±4.2, [p=0.46]) istatistiksel olarak anlamlı bir fark saptanmadı. Preoperatif ve son kontrol TAS skorlarına göre gruplar arasında istatistiksel olarak anlamlı bir fark saptanmadı (sırasıyla, p=0.94, p=0.46). Grup 1'de postoperatif komplikasyon gözlemlenmezken, Grup 2'de üç hastada komplikasyon (%13.1) izlendi. Bir hastada (%4.4) tekrar rüptür, iki hastada ise (%8.7) sural sinir yaralanmasına rastlandı.

SONUÇ: Çalışmamızda yer alan her iki grupta da benzer fonksiyonel sonuçlar olmasına rağmen, sınırlı açık yaklaşım perkütan yaklaşıma göre komplikasyon sonuçları açısından daha iyi klinik sonuçlar göstermiştir.

Anahtar sözcükler: Aşil tendon rüptürü; minimal invaziv; perkütan yaklaşım; sınırlı açık yaklaşım.

Ulus Travma Acil Cerrahi Derg 2023;29(8):935-943 DOI: 10.14744/tjtes.2023.90839