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Arch Basic Clin Res 2025; 7(1): 24-30 • DOI: 10.5152/ABCR.2025.24246

Original Article

Comparison of the Functional Outcomes of Biological Repair and Standard Open Repair for the Treatment of Achilles Tendon Rupture

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Cite this article as: Özkul B, Gönen Aydın C, Büyükkuşçu MÖ, Öztaş D, Yıldız Kİ, Dırvar F. Comparison of the functional outcomes of biological repair and standard open repair for the treatment of achilles tendon rupture. *Arch Basic Clin Res.* 2025;7(1):24-30.

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ABSTRACT

Objective: The aim of this study was to compare the functional outcomes of patients who underwent Achilles tendon repair either with biological technique or standard open technique.

Methods: A retrospective evaluation was made of 71 patients who were surgically treated for Achilles tendon rupture. The patients were separated into 2 groups according to the surgical technique and type of rehabilitation. Group 1 comprised 20 patients who underwent biological repair and early rehabilitation. Group 2 comprised 23 patients who were treated with a standard open surgical technique and late rehabilitation–early immobilization. The primary functional outcome measurements were the American Orthopaedic Foot and Ankle Society (AOFAS) score and isokinetic strength measurements assessed by a Cybex NORM device.

Results: The mean time to return to daily activities was determined to be statistically significantly shorter in group 1 than in group 2 ($P = .014$). No significant difference was found between the groups in respect of the AOFAS scores of the operated side ($P = .824$). A significant decrease was determined on the operated side compared to the normal side in the isokinetic strength measurements of group 2 ($P < .05$).

Conclusion: According to the results acquired from this study biologic repair resulted in a significantly shorter time to return the daily activities with similar clinical outcomes compared to the classic repair.

Keywords: Achilles tendon, biological repair, early rehabilitation, open repair, tendon rupture

INTRODUCTION

The Achilles tendon is the most frequently ruptured tendon in the body, with a currently increasing reported incidence of 21 ruptures per 100 000 person-years.[1-5] A systematic review indicates that 50.3% of Achilles tendon ruptures are treated with surgical repair.[6] Recent studies have emphasized that conservative treatment is an option for Achilles tendon injuries.[6-9] However, surgical treatment is still recommended as the primary option as it provides early rehabilitation with an early return to daily activities and lower rates of re-rupture.[4,7,10,11] It has been shown that together with surgical treatment, an early isokinetic rehabilitation program is effective in regaining calf muscle strength.[12] In addition to the functional benefits of classic open surgery treatment, there are also complications such as secondary scar tissue and soft tissue infection.[4,5,13] Although minimally invasive or biological repair methods which protect the vascular structure of the tendon have been defined in the literature,[3,4,11,14] minimally invasive surgical techniques (percutaneous) in particular may cause complications such as tendon elongation, re-rupture, and sural nerve injury.[15,16]

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Received: December 28, 2023
Revision Requested: December 6, 2024
Last Revision Received: December 8, 2024
Accepted: December 10, 2024
Publication Date: March 5, 2025

The aim of this study was to compare the functional outcomes of patients who underwent Achilles tendon repair either with biological technique or standard open technique. We hypothesized that biologic repair and early rehabilitation result in better clinical outcomes compared to standard open repair technique.

MATERIAL AND METHODS

Study Population

This retrospective study was performed under the approval of Ankara Yıldırım Beyazıt University Institution's Ethical Review Board (Date: 15.02.2021; Number: 09) and conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from each patient. Patients between 18 and 65 years old with a diagnosis of Achilles tendon rupture and who underwent primary repair were included in the study. Exclusion criteria were: bilateral rupture or previous rupture of the contralateral side (n = 1), accompanying fracture (n = 1), previous history of corticosteroid use (n = 2), impaired skin integrity (n = 1), rupture at the calcaneus attachment side (n = 4), re-rupture (n = 2), repair applied later than 14 days after trauma (n = 2), non-attendendance at final follow-up (n = 9), and age <18 years or >65 years (n = 6). A total of 28 patients were excluded from the study, leaving 43 patients who participated in the study.

Patients were grouped according to the 2 senior surgeons' preferred technique for the treatment of Achilles tendon rupture. One surgeon routinely performs classic repair while the other surgeon routinely performs biological repair. Group 1 comprised 20 patients with a mean age of 43 years (range, 31-61 years) who underwent biological repair and early rehabilitation. Group 2 comprised 23 patients with a mean age of 42 years (range, 31-54 years) who were treated with a standard open surgical technique and late rehabilitation–early mobilization.

Surgical Technique

Group 1 patients treated with biological repair were positioned prone under general anesthesia or spinal anesthesia, and entry was made with a 5-7 cm medial incision over the Achilles tendon tear. In accordance with the technique described by Ozkaya et al.,[11] if the tendon sheath (paratenon) was torn, palpation was made over the paratenon without creating additional injury to the tendon, and the 2 parts in the central section were tied end-to-end with sutures (Figure 1). In cases where the paratenon was intact, by joining the proximal tendon in the corner with continuous shaft sutures using the Kessler suture technique, it was tied at sufficient tension (Figure 2). Postoperatively, an Achilles boot or short-leg circular plaster cast holding the foot at 25°-30° flexion was applied for 2 weeks then after removal of the sutures, an Achilles boot to increase plantar flexion by 10° was used for 1 week by all patients. From the second week onwards, patients were permitted full active plantar flexion. Partial weight-bearing was allowed from the third week and full weight-bearing from the sixth week. The postoperative rehabilitation program is summarized in Table 1.

The patients in group 2 treated with open repair were positioned prone under spinal or general anesthesia, and a 10-14 cm entry incision was made. The paratenon was opened longitudinally, and the Achilles tendon was repaired with end-to-end no. 2-0 non-absorbable polyester sutures (Ethibond*Excel/Ethicon) according to the Krakow technique[17]. Postoperatively, the foot was kept in a neutral position for 6 weeks, starting with a short-leg plaster cast. In the third week, this was changed for a walking plaster cast and partial weight-bearing was started. The plaster cast was removed in the sixth week, and the rehabilitation program of active isometric and stretching exercises was applied to all the patients.[12]

Data Evaluation

Patients' gender, affected side, body mass index (BMI), time of return to daily activities (including sports), and

MAIN POINT

- In this study, emphasis was placed on the importance of biological repair and early rehabilitation in Achilles tendon repair. It has been shown that tendon strength and resistance can be achieved quickly and that the advantages of early rehabilitation provide an early return to daily activities.

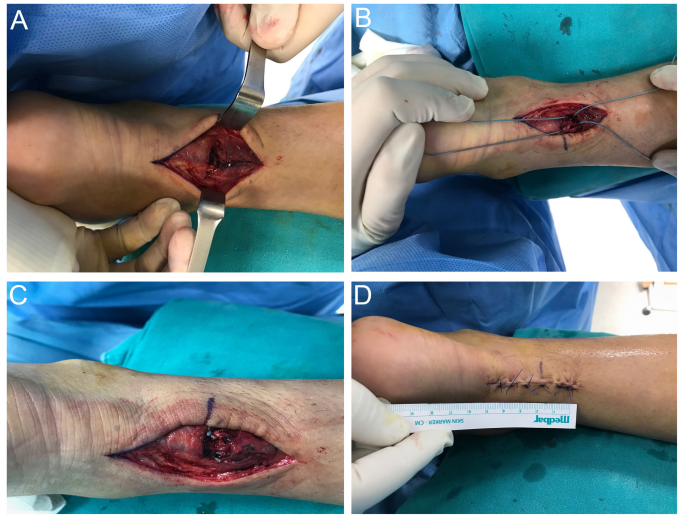

Figure 1. (A) Tendon's rupture and paratenon continuity are seen. (B) Two sutures are placed opposite each other at the rupture site. (C) Sutures knotted when the ankle is in plantarflexion and the ruptured paratenon ends repaired. (D) 5 cm of skin suture was seen.

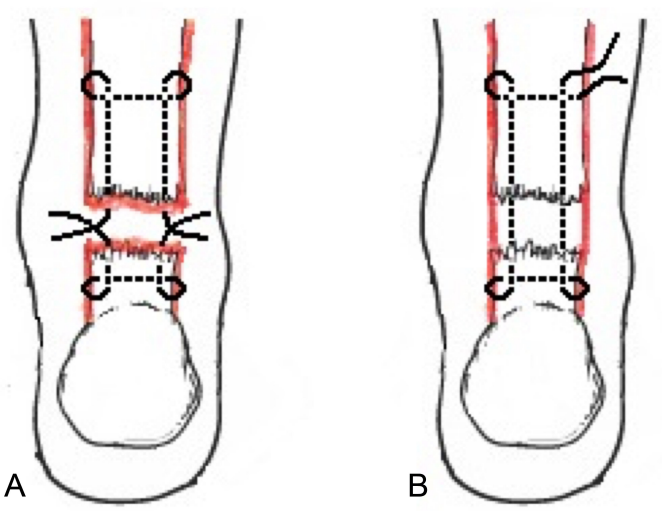

Figure 2. (A) When paratenon is ruptured, place the suture knots at the rupture level. (B) In cases where the paratenon is intact, the single suture knot stays out of rupture site.

from the final follow-up examination, the American Orthopaedic Foot and Ankle Society (AOFAS) Score were evaluated at 2020[18] and the measurements of strength and resistance tests made with the isokinetic dynamometer were recorded through our medical charts. Social activities, active sports, and long walks outside of work-life which were customary before the Achilles tendon rupture were evaluated as daily activities. For the measurements of muscle strength and resistance, the Cybex NORM® isokinetic dynamometer device was used at 2020 (HUMAC® NORMTM Testing & Rehabilitation System, USA).

Before the test, the patients did 10 minutes of mild tempo running, and after the test, stretching exercises. In the prone position with the hip and knee in full extension, the device was placed first on the sole of the healthy foot. In the first stage, 5 repetitions were made at the rate of 30°/s then the after 20 seconds rest, the second stage was applied of 15 repetitions at the rate of 120°/s. Strength was measured at peak torque at 30°/s and resistance as the total values at 120°/s. The active angle reproductions of the ankle were tested by measuring ankle position proprioception at different angles with the Cybex NORM ® device. The patient's foot was moved passively to 15° dorsiflexion by the person applying the test, held in that position for 10 seconds, and the patient was told that this point was point A. The foot was moved passively into a neutral position, then the patient was asked to find point A and the angle was recorded. A similar procedure was applied for 20° plantarflexion. The measurements were taken 3 times to eliminate any problems of device incompatibility (Figure 3). The closest results were accepted for analysis. These points found by the patients were recorded as the value ± standard deviation (SD).

Statistical Analysis

Statistical analysis were performed using SPSS 22.0 software (IBM SPSS Corp.; Armonk, NY, USA). Numeric variables were given as means and standard deviations (SDs), while categorical data was given as frequencies and percentages. Comparison of means was performed using the Mann–Whitney *U* test or Student's *t*-test. The Wilcoxon test was applied in the analysis of repeated measurements. Comparison of frequencies was performed using chi-square test. A *P* value <.05 was accepted as statistically significant.

RESULTS

The demographic data of the patients are summarized in Table 2. No significant difference was found in respect to

Table 1. Postoperative Rehabilitation Program

Postoperatif period (Week)							
1. Week	**2. Week**	**3. Week**	**4. Week**	**5. Week**	**6. Week**	**7. Week**	**8. Week**
Plantar flexion 25°-30⁰	Plantar flexion 25°-30⁰	Plantar flexion 15°-20⁰	Plantar flexion 5°-10⁰	Plantar flexion 5°	Neutral flexion	Neutral flexion	Neutral flexion
		Full active plantar flexion	Full active plantar flexion	Full active plantar flexion	Full active plantar flexion	Full active plantar flexion	Full active plantar flexion
		Partial weight bearing	Partial weight bearing	Partial weight bearing	Full weight bearing	Full weight bearing	Full weight bearing
						Active stretching and izometric exercises	Active stretching and izometric exercises
						Active proprioceptive exercises	Active proprioceptive exercises

age, gender, BMI, and duration of follow-up. The time of return to daily activities (including sports) was determined as mean 83 ± 41.1 days in group 1 and 95 ± 24.7 days in group 2. The time to return to daily activities was determined to be statistically significantly shorter in group 1 than in group 2 (P = .014) (Table 2). No significant difference was found between the groups in respect of the AOFAS scores of the operated side (P=.824). The mean AOFAS value of the operated side in both groups was good-excellent (80%-89%, 90%-100%, respectively)[18] and in both groups this was statistically significantly lower than the score of the healthy side (P = .001 and <.001, respectively).

No statistically significant difference was determined between the operated and healthy sides of both groups with respect of dorsiflexion range of movement and calf circumference (in cm). Statistical evaluation was made between the operated and normal sides and within both groups concerning the values of 30°/s dorsiflexion (strength), 120°/s dorsiflexion (resistance), 30°/s plantar flexion (strength), 120°/s plantar flexion (resistance), feeling of joint position in 15° dorsiflexion, and feeling of joint position in 20° plantar flexion. Within these values, a significant decrease was determined on the operated side compared to the normal side in the 30°/s plantar flexion (strength) and 120°/s plantar flexion (resistance) test values of group 2 patients (P=.015 and .030, respectively) (Table 3). No significant difference was determined in any of the other parameters. No re-rupture, wound site infection, or neurovascular deficit was determined in any patient of either group.

Table 2. Demographic Data of the Patients

		Biological Repair			Standard Repair			
		Mean ± SD/ n (%)			Mean ± SD/ n (%)			*P*
Age		43.1	±	9.3	42.5	±	6.1	0.810[t]
Gender	Female	0		0.0	1		4.3	1.00[X2]
	Male	20		100	22		95,7	
Follow-up (month)		56.5	±	15.9	59	±	14.2	0.600[m]
VAS score		1.5	±	1.5	1.0	±	1.6	0.152[m]
Return activities (day)		83.0	±	41.1	95.7	±	24.7	**0.014**[m]

VAS, The Visual Analogue Scale. [t]Independent sample t-test / [m]Mann–Whitney U test / [X2]chi-square test.

DISCUSSION

The most important finding of this study is observing a significantly faster return to daily activities in those who underwent biologic repair and early rehabilitation. A significant decrease was also determined on the operated side compared to the normal side in the isokinetic dynamometer measurements of patients who underwent standard open repair (P < .05). Our null hypothesis can be partially accepted, as biologic repair resulted in better functional outcomes compared to standard open repair despite similar AOFAS scores.

In addition to open surgery techniques, the percutaneous surgical technique and conservative treatments are frequently preferred options.[3-5,7,19-21] Although there are many studies related to conservative treatment, no consensus on this subject has been reached as yet. High rates of re-rupture have been reported after conservative treatment,[17,22] although in a prospective, randomized, controlled study, Lantto et al.[7] reported that there was no statistically significant difference in rupture rates

Figure 3. Ankle position in Cybex NORM ® device.

Table 3. AOFAS Scores and Isokinetic Measurements of the Study Groups

	Biological Repair			Standard Repair			P
	Mean ± SD			Mean ± SD			
AOFAS							
Surgical side	89.7	±	8.2	90.4	±	8.3	.824[m]
Normal side	99.8	±	1.1	100.0	±	0.0	.284[m]
P	**.01[w]**			**.000[w]**			
Dorsiflexion 30°/s (strength)							
Surgical side	33.2	±	8.8	33.0	±	6.4	.835[m]
Normal side	33.3	±	8.2	34.3	±	7.1	.542[m]
P	.827[w]			.224[w]			
Dorsiflexion 120°/s (resistance)							
Surgical side	113.5	±	36.1	102.8	±	31.4	.342[m]
Normal side	116.2	±	38.8	113.0	±	27.4	.480[m]
P	.779[w]			.075[w]			
Plantar flexion 30°/s (strength)							
Surgical side	61.3	±	21.2	56.4	±	18.3	.443[m]
Normal side	68.9	±	23.3	66.2	±	18.3	.696[m]
P	.147[w]			.015[w]			
Plantar flexion 120°/s (resistance)							
Surgical side	165.6	±	81.6	123.0	±	69.6	.098[m]
Normal side	187.3	±	81.4	160.1	±	91.4	.147[m]
P	.390[w]			**.030[w]**			
Joint P.Sense 15° Dorsiflexion							
Surgical side	16.3	±	2.9	16.7	±	2.3	.263[m]
Normal side	15.2	±	2.2	16.1	±	2.7	.342[m]
P	.319[w]			.649[w]			
Joint P.Sense 20° Plantar flexion							
Surgical side	18.6	±	3.9	19.7	±	3.2	.332[m]
Normal side	19.6	±	2.4	19.9	±	2.7	.921[m]
P	.242[w]			.861[w]			

SD: standard deviations. [t]Independent sample t-test / [m]Mann–Whitney U test / [X2]chi-square test/ [w]Wilcoxon test.

between operative and non-operative treatments. As complications such as wound site problems, infection, and re-rupture have been predominant after classic open surgery, percutaneous surgical treatment has started to be preferred to prevent these problems.[1] However, reports have emerged of sural nerve injuries[23,24] with the use of percutaneous surgical treatment and high re-rupture rates compared to classic open surgery.[21,25] Due to the lengthy rehabilitation period and high re-rupture rates of conservative treatment, the open surgery technique was preferred for the patients in this study.

It has been reported in case series in the literature that by creating the least damage to the vascular structures around the tendon, tendon repair can be made at appropriate tension with the biological repair technique.[11,13] In the patients in group 1, the aim was to accelerate the tendon healing with biological repair and provide a rapid return to functional life with early rehabilitation. With positive effects seen on tendon healing, early rehabilitation and early weight-bearing have started to become more popular.[7,13] However, in a study investigating the reasons for re-rupture in young athletes, re-rupture was determined at a high rate (16.6%) in aggressive rehabilitation applied together with early weight-bearing after standard open repair.[26] In the current study, it was determined that sufficient functional capacity was reached without any cases of re-rupture by providing sufficient tendon healing in both repair methods. In addition to the functional benefits of classic open surgery treatment, several studies emphasize the advantages of accelerated rehabilitation, including early weight-bearing and mobilization, in achieving superior functional outcomes after Achilles tendon repair. Braunstein et al.[27] also highlighted that early mobilization protocols are effective and safe, providing better recovery in patients treated with minimally invasive techniques. In another study by Lantto et al.,[7] although early mobilization was not seen to have made any difference in the clinical and isokinetic strength tests in the long term, several studies have shown that early rehabilitation contributed to the return to social and sports life in the short term.[11,12,20,28] In patients treated with percutaneous or biological repair methods together with early rehabilitation, the return to sporting activities has been reported as mean 2.5-6 months.[5,11,19] In the current study, the group 1 patients treated with early rehabilitation were determined to have a statistically significantly shorter return to daily activities at mean 83 days (range 50-240 days) ($P = .014$).

Postoperative AOFAS values of 93-97 have been reported in the literature in patients treated with different treatment options.[4,11,13] In a study by Ozkaya et al.,[11] the mean AOFAS score was reported as 93. This high score was associated with the prevention of contractures around the ankle due to the rapid and effective healing of the tendon by biological repair and aggressive rehabilitation. In the clinical evaluations of that study, satisfactory AOFAS and Visual Analogue Scale (VAS) scores were obtained in both groups. It was concluded that different rehabilitation and repair methods did not affect the results of the patients' scoring.

Arslan et al.[13] applied biological repair to patients and reported that no significant difference was seen between the operated and healthy feet concerning ankle plantar flexion and dorsiflexion strength and resistance. In studies in the literature, loss of 4%-10% of plantar flexion and dorsiflexion strength has been determined in patients

treated surgically.[28-30] In the current study, while no difference was determined between the operated and non-operated sides in the isokinetic measurements of group 1 patients, a significant reduction was determined in the 30°/s plantar flexion (strength) and 120°/s plantar flexion (resistance) test values compared to the healthy side in group 2 patients. In a 10-year follow-up study of patients treated with primary open repair, Horstmann et al. determined a significant reduction in plantar flexion peak torque compared to the healthy side.[31] Although the current study has shown that isokinetic values equivalent to the healthy side were obtained in a short time with early rehabilitation and a biological repair method, there is a need for further studies of the long-term results of both groups.

That Achilles tendon rupture could be a predisposing factor for impaired ankle proprioception is a matter of debate.[32] In a study by Kaya et al., the feeling of the position of the joint in 10° dorsiflexion and 15° plantar flexion of the patient group treated with endoscopy-assisted Achilles tendon repair was found to be significantly lower compared to the dominant side of the control group.[32,] In the current study, no significant difference was seen in the feeling of 15° dorsiflexion and 20° plantar flexion joint position in the comparison of the operated and healthy sides in both groups. From these results, it was determined that proprioception feeling was not damaged by either of the 2 methods.

The main limitations of this study were that it was retrospective, the follow-up periods of the patients were short and mid-term, and conservatively treated patients were not included. Nevertheless, that 2 different surgical techniques and rehabilitation programs were compared with isokinetic evaluations can be considered strengths of the study.

According to the results acquired from this study biologic repair resulted in a significantly shorter time to return the daily activities with similar clinical outcomes compared to the classic repair.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of Ankara Yıldırım Beyazıt University (Date: 15.02.2021; Number: 09).

Informed Consent: Verbal informed consent was obtained from the patients who agreed to take part in the study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – B.Ö., M.Ö.B., C.G.A. Design – B.Ö., M.Ö.B., C.G.A.; Supervision – K.A., D.Ö.; Resources – K.A., D.Ö.; Materials – M.B.K.; Data Collection and/or Processing – M.B.K.; Analysis and/or Interpretation – B.Ö., M.Ö.B., M.B.K.; Literature Search – M.Ö.B., M.B.K.; Writing Manuscript – B.Ö.; Critical Review – B.Ö.; Other – D.Ö.

Declaration of Interests: The authors have no conflict of interest to declare.

Funding: The authors declare that this study has received no financial support.

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