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Functional outcomes of repair of Achilles tendon using a biological open surgical method

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Objective: The aim of this study was to evaluate the mid-term functional outcomes of ankles following biological open Achilles tendon repair and early postoperative mobilization.

Methods: The study retrospectively evaluated 22 male patients who underwent one-sided biological open Achilles tendon repair. The American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot score, isokinetic muscle strength and endurance tests and active angle reproduction test at 15° of dorsiflexion and 20° of plantarflexion of the injured and uninjured sides were measured and compared.

Results: Mean age was 38.6 years and mean follow-up was 33.7 months. One patient had rerupture following a blunt trauma 1 month after operation. No other complication was seen. Mean AOFAS hindfoot score was 97.9 (range: 90 to 100). Peak isokinetic torque at 30°/sec (isokinetic muscle strength) and total work at 120°/sec (isokinetic muscle endurance) did not significantly differ between the operated and uninjured ankles. Proprioceptive evaluation with active angle reproduction test at 15°of dorsiflexion and 20° of plantarflexion was similar between the two sides.

Conclusion: Biological open Achilles tendon repair with early postoperative mobilization appears to be a convenient intervention for acute Achilles tendon rupture in active young patients. Treatment results in low complication rates and restores ankle strength, endurance and position sense.

Key words: Biological open Achilles tendon repair; isokinetic muscle strength and endurance; position sense measurement.

Achilles tendon ruptures are frequently seen among men aged 30 to 50 years. Surgery is preferred, especially in young patients with active lifestyle.[1] Surgery options include open, percutaneous and semi-open minimal invasive surgery. High rates of adhesions, local infection and wound problems were reported with open surgery. Although percutaneous surgery technique has lesser wound complications, incidences of tendon rupture, elongation and sural nerve trapping were reported.[2-4] Semi-open minimal invasive surgical technique enables sufficient exposure for repair without impairing tendon circulation. While sural nerve damage is reduced, complications are not entirely eliminated.[5-7] In this study, the distinguishing features of the biological open method from the open method include the prevention of iatrogenic paratenon damage and sural nerve damage via posteromedial incision. The difference from percutaneous semi-open method is the safe and strong placement

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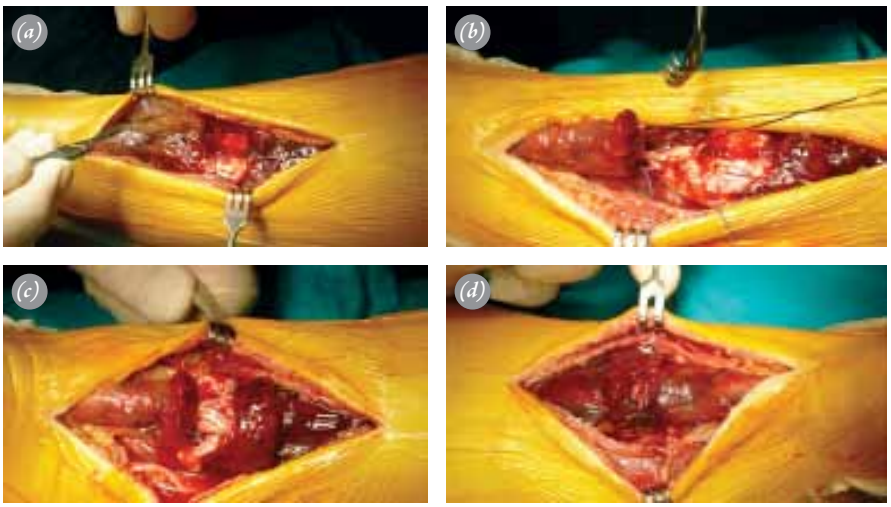

Fig. 1. **(a)** Exposure of tendon rupture site and appearance of the torn paratenon and tendon tips. **(b)** Proximal and distal placement of the 2-strand Tajima sutures before greater exposition of the paratenon. **(c)** Opposition of both tendon tips by ankle plantarflexion and suture tying. **(d)** Coverage of exposed tendon parts by using epitendinous sutures. [Color figures can be viewed in the online issue, which is available at www.aott.org.tr]

of the sutures.[8]

The aim of this study was to evaluate the effects of the biological open repair method in the surgical treatment of Achilles tendon ruptures and of an early mobilization protocol[9] on the restoration of ankle functions.

Materials and methods

Patients admitted between July 2008 and November 2011 due to Achilles tendon rupture and operated using the biological open method for repair were invited to the clinic for retrospective evaluation. Twenty-two male patients treated for acute rupture of the Achilles tendon (torn area extending 2 to 8 cm proximal from the calcaneal tuberosity) and who had no comorbidities (i.e. diabetes, rheumatoid arthritis, corticosteroid use) were included. All patients had a history of amateur participation to sports (basketball, football). Demographic data of patients is given in Table 1.

Patients were operated under general or spinal anesthesia in the prone position. The knee was positioned at 15° of flexion. Pneumatic tourniquet was applied during operation. An 8 to 10 cm longitudinal incision was planned. Unlike classical open surgery, an incision was made medial to the tendon in order to avoid the sural nerve (Fig. 1). The subdermal tissues were then dissected in a full layer (without decollating). Two types of Achilles tendon rupture were observed; 2 patients had an intact paratenon and 20 patients a torn paratenon.

In cases of torn paratenon, the paratenon was minimally exposed and tendon tips were exposed at the tear site. Two Tajima sutures were placed with a 2.0G absorbable braided thread on both tendon tips.[10] Both trunk sutures were placed at the anteroposterior plane. The transverse leg of the trunk sutures were placed 4 cm away from the repair site in suitable cases (in patients with a shorter tendon stump, the transverse leg of the suture was passed from the most distant place). Tendon clutch of sutures was controlled by traction applied to suture legs. Both tendon tips were opposed and gap formation was prevented. The repair was strengthened by epitendinous continuous sutures using 3.0G absorbable braided thread after tying both suture terminals (Fig. 2a).

The paratenon was not opened to expose the tendon tips in patients with intact paratenon. At the proximal corner of the tendon, repair was made using continuous trunk sutures locking its own tie (Kessler) (Fig. 2b).

Following repair, the tourniquet was removed and bleeding control was performed. Subcutaneous tissue was closed using 2.0 absorbable braided thread and skin was closed using 3.0 non-absorbable monofilament

Table 1. Demographic characteristics of the patients.

	Mean (range)
Age (years)	38.6 (28-50)
Height (cm)	173.3 (165-187)
Weight (kg)	83.5 (69-116)
Time to operation after injury (days)	7.5 (1-30)
Follow-up time (months)	33.7 (13-60)

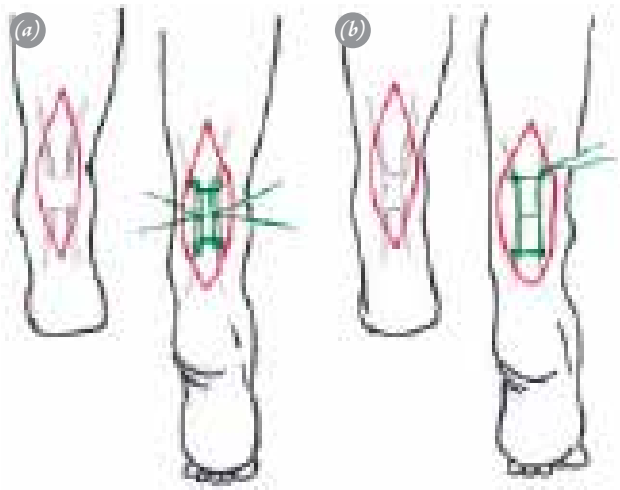

Fig. 2. **(a)** The 2-strand Tajima suture technique was used on tendons with torn paratenons. **(b)** The Kessler suture technique was used on tendons with intact paratenons. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

Fig. 3. Angle-adjusted walking boot. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

thread or non-absorbable braided thread. A short-leg plaster cast keeping the ankle at 25 to 30° of plantarflexion was applied for 10 days.

The short-leg plaster cast and sutures were removed at the 10th postoperative day. An angle-adjusted walking boot was applied at 25 to 30° of plantarflexion (Fig. 3). The early mobilization protocol is summarized in Table 2.

Ankle plantar- and dorsiflexion angles were measured. In order to evaluate atrophy, calf circumference 10 cm distally to the tibial tuberculum was measured. Functional evaluation was performed using the American Orthopedic Foot and Ankle Society (AOFAS) hindfoot score (100 to 90 points: excellent, 89 to 80 points: good, 79 to 70 points: moderate, below 70: poor).[11]

A Cybex NORM® isokinetic dynamometer device (Cybex International Inc., Medway, MA, USA) was used to measure strength and endurance. Previous studies have utilized isokinetic assessments although no standard protocol has been established.[12-15] Patients warmed up using an exercise cycle ergometer for 5 minutes and passive stretching exercises for the gastrosoleus before testing. Isokinetic measurements were performed

Fig. 4. Position of the patient while performing isokinetic ankle measurement on Cybex NORM® isokinetic dynamometer device. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

Fig. 5. Evaluation of proprioception. The instructor teaches the patient movement by positioning his ankle to targeted joint angle in the prone position. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

using the Cybex NORM® device in the prone position. The foot was placed on the test table with the hip and knee in full extension (Fig. 4). Before each measurement at different movement speeds, the patient performed active plantarflexion and dorsiflexion three times without full-strength for run-in. Strength and endurance tests were performed at 30°/sec speed for 4 repeats and at 120°/sec speed for 15 repeats. Strength was peak torque at 30°/sec and endurance was total work at 120°/sec.

The Cybex NORM® isokinetic dynamometer device was used to measure ankle position proprioception and ankle active angle reproduction of the patients was tested. Reliability and validity of this method has been demonstrated in patients with ankle instability in previous studies.[16,17] Measurements were taken at 15° of dorsiflexion and 20° of plantarflexion.

The ankle of the patient was positioned at 15° of dorsiflexion passively by the instructor and kept in this position for 10 seconds (Fig. 5). At the end of 10 seconds, the ankle was passively brought to the neutral position. The patient was then asked to actively bring the foot to 15° of dorsiflexion. The active angle degree was recorded. The same procedure was performed for 20° of plantarflexion. Measurements were performed before strength tests and the best of the 3 attempts for each ankle was recorded.

Descriptive statistics of data included means and standard deviations. The independent samples t-test was used for analysis of quantitative data and the chi-square test for qualitative data. SPSS 20.0 software was used for all analyses. P values of less than 0.05 were considered significant.

Results

One patient had rerupture at the 1st postoperative month due to blunt trauma at the operation site. No other complications were observed in any patient.

There was no significant difference between ankle plantarflexion and dorsiflexion strength and endurance measurements between the injured and uninjured side (Table 3). Bilateral proprioceptive properties of patients were comparable (Table 3).

AOFAS scores of the patients are given in Table 3. Range of motion was comparable between the operated and uninjured side. There was no significant difference in the measurements of calf circumferences in both extremities (Table 3).

Discussion

Treatment approach for Achilles tendon rupture and rehabilitation protocols after primary treatment have been

Table 2. Postoperative early rehabilitation protocol.

1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week
25-30° plantarflexion	25-30° plantarflexion	15-20° plantarflexion Full active plantarflexion Partial loading	5-10° plantarflexion Full active plantarflexion Partial loading	5° plantarflexion Full active plantarflexion Partial loading	Neutral flexion Full active plantarflexion Partial loading	Neutral flexion Full active plantarflexion Partial loading Active stretching exercises* Active isometric exercises† Active proprioceptive exercises‡	Neutral flexion Full active plantarflexion Partial loading Active stretching exercises* Active isometric exercises† Active proprioceptive exercises‡

*Patient stretches his Achilles tendon by active dorsiflexion using his own muscle force; †Patient pushes against wall by active ankle plantarflexion using his own muscle force; ‡Patient makes balance exercises first standing on both legs and then standing on one leg on a two-sided balance platform.

Table 3. Results of clinical, isokinetic and AOFAS assessments of the patients.

	Operated side Mean±SD	Uninjured side Mean±SD	p
Dorsiflexion ROM (°)	35.2±4.2	33.7±4.0	0.234
Plantarflexion ROM (°)	33.0±6.0	33.5±6.4	0.179
Calf diameter (cm)	36.6±3.6	37.5±3.2	0.410
Dorsiflexion (Nm)			
30°/sec (force)	51.4±8.6	47.8±7.8	0.154
120°/sec (endurance)	310.0±112.6	309.9±90.0	0.151
Plantarflexion (Nm)			
30°/sec (force)	124.5±24.1	123.7±24.1	0.919
120°/sec (endurance)	500.9±130.3	554.2±110.7	0.151
Joint position sense (°)			
15° dorsiflexion	15.0±1.4	14.9±1.8	0.776
20° plantarflexion	19.7±1.5	20.1±1.5	0.323
Mean AOFAS score (range)	97.9 (90-100)		

ROM: range of motion

debated. The aim of treatment is to restore the tendon length and tension and to regain strength and force of the gastrosoleus muscle complex. Recently, aims have expanded to include early return to daily life and reduction in loss of labor. Therefore, changes in applied rehabilitation programs have become more common. While conservative treatment was preferred until 20 years ago, surgery has become the first choice in physically active young patients.[18]

Negative effects of long-term immobilization on tendon healing have been observed. Currently, postoperative rehabilitation protocols have changed to include early mobilization.[19-21]

The greatest concern with early mobilization is rerupture due to elongation of the tendon together with reduction in plantarflexion force when loaded before complete healing. Many authors have demonstrated that postoperative early mobilization had no poor results while rerupture rates were high after conservative treatment.[22-24]

Open surgical treatment enables the exposure of the tendon and uses various suture techniques to provide strong and safe repair. However, it also has some disadvantages, including wound problems (retarded wound healing and infection), impairment in the tendon blood supply due to opening of the paratenon, and adhesions to the surrounding tissues.

Percutaneous surgical repair was invented to overcome the disadvantages of open surgical treatment. Described by Ma and Griffith, excellent results without rerupture were reported, although following years witnessed increased rerupture rates and sural nerve damage.[25,26] The mini open method solved the problem of sural nerve trapping between the legs of the suture but failed to remove all complications.[5]

In our clinic, we performed a variation of open surgical method in all patients. We suggest that this surgical method spares the paratenon and tendon blood supply. Suture techniques ensure strong repair tissue for postoperative early mobilization. Therefore, we described this method as 'biological' open surgery.

In the current study, none of the patients developed complications such as wound infection, sural nerve damage, tendon shortness or adhesion. This may be due to the younger age of the patients, the lack of comorbidities and careful surgery and compliance with a postoperative rehabilitation protocol. One patient was exposed to blunt trauma to the operation site which led to a rerupture in the 1st postoperative month.

There is no standard protocol for postoperative early mobilization in the literature.[22,23] A version of Mortensen et al.'s protocol was applied to patients in our study (Table 2).[9]

Patients reported no limitation of the operated ankles in their daily life at the final follow-up. Subjective evaluation using the AOFAS hindfoot score showed excellent results (mean AOFAS score: 97.9).

Objective measurements of the gastrosoleus muscle complex function restoration showed that surgical repair followed by early mobilization led to full recovery of strength and endurance.

Ankle proprioception was evaluated using active angle reproduction. Aydın et al.[27] compared ankle pro-

proprioception of dancers and healthy volunteers using 30° of plantarflexion and 15° of inversion angles for active angle reproduction using an isokinetic dynamometer device (Cybex NORM®). The authors found no proprioceptive difference between the groups. Kaya et al.[28] retrospectively evaluated 19 patients who underwent endoscopic percutaneous Achilles tendon repair using an isokinetic dynamometer (Biodex®) to evaluate ankle proprioception and tested active angle reproduction for 10° of dorsiflexion and 15° of plantarflexion. While they found no difference between the operated and uninjured side proprioception for 10° of dorsiflexion, the operated side showed weaker proprioception for 15° of plantarflexion.

In the current study, active angle reproduction abilities of the patients were comparable in both sides at 15° of dorsiflexion and 20° of plantarflexion. As Kaya et al. performed a less invasive surgery, our results would have been worse for active angle reproduction. We think that our wider range of motion (25 degrees/40 degrees) might be related with easier perception of the position.

In conclusion, the biological open surgery treatment method for Achilles tendon rupture in young patients appears to be a safe method with lower complication rates when performed together with an early mobilization protocol. Mid-term follow up showed excellent results based on AOFAS scores. Muscle force and endurance of muscle tendon unit was restored when evaluated by isokinetic measurements. Proprioceptive properties of the operated and intact sides were comparable.

Conflics of Interest: No conflicts declared.

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