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Long-term results and complication following Achilles tendon rupture repair

N.E. Magnitskaya[1]✉, A.N. Logvinov[2], M.S. Ryazantsev[2], P.S. Andreev[2,3], I.A. Vasilyev[2,3], D.A. Bessonov[2,3], D.O. Ilyin[2,3], A.V. Frolov[2,3], A.V. Korolev[2,3]

[1] Medswiss Medical center, Moscow, Russian Federation
[2] European Medical Center, European Clinic of Sports Traumatology and Orthopaedics (ECSTO), Moscow, Russian Federation
[3] Patrice Lumumba Peoples' Friendship University of Russia, Moscow, Russian Federation

Corresponding author: Nina E. Magnitskaya, magnitskaya.nina@gmail.com

Abstract

Introduction Currently, there is no consensus regarding optimal treatment options of Achilles tendon rupture.

The **purpose** of this study was to evaluate long term results of Achilles tendon repair using different surgical techniques, assess complication rate and subjective satisfaction

Methods The study included patients treated for Achilles tendon rupture using minimally invasive and open surgical repair. Complications including re-rupture, infection, deep vein thrombosis and neuropraxia were identified. In order to evaluate the factors influencing the risk of postoperative complications, logistic regression analysis was performed. The Achilles Tendon Rupture Score (ATRS) and the American Orthopedic Foot and Ankle Score (AOFAS) evaluated subjective outcomes.

Results 130 patients with Achilles tendon tear were enrolled (123 primary and 7 revision cases). In primary repairs percutaneous technique was used in 60 % of cases (74/123), *mini open* technique – in 16 % (19/123), and open technique – in 24 % (30/123). Re-rupture occurred in 2.4 % of patients treated with minimally invasive techniques. There were no repeated ruptures following open repairs. Predominant number of infections was registered after open repairs and made 10 %, while minimally invasive techniques had 3.2 % of infections. Logistic regression analyses showed that steroid injection, open repair, application of tapes and autografts increased the risk of infectious complications. There were no significant differences in ATRS and AOFAS scores between different primary Achilles tendon repair techniques ($p > 0.05$).

Discussion Results, obtained in the current study, are consistent with previously published data.

Conclusions Open Achilles tendon repair showed a higher rate of infections, and lower rate of re-ruptures. The anamnesis of steroid injection, open repair, application of tapes and autografts increases the risk of infectious complications.

Keywords: Achilles tendon, minimally invasive suture of the Achilles tendon, open suture of the Achilles tendon, infectious complications, recurrent ruptures

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INTRODUCTION

The Achilles tendon is the largest and strongest tendon in the human body, formed from the bundles of tendons of the superficial muscles of the posterior group of the lower leg: two heads of the gastrocnemius and soleus muscles. Achilles tendon ruptures are the most common tendon injuries [1-4].

The incidence of Achilles tendon ruptures among professional and amateur athletes is 18 cases per 100,000 people [5], in the general population from 8 to 24 cases per 1,000,000 people, with the incidence rates increasing [6-9]. Thus, according to the Danish National Register the incidence of these injuries has increased significantly from 27 to 31 cases per 100,000 over the past 20 years [10]. Moreover, Achilles tendon ruptures occur 5 times more often in men than in women [11]. According to the Swedish National Register, the incidence of acute Achilles tendon injuries has increased in recent years from 47 to 55.2 cases per 100,000 among men (17 %) and from 12 to 14.7 per 100,000 among women (14.7 %) [10]. For professional athletes, these injuries are of particular importance, since they may disable the athlete for a long time, and in some cases result in completion of a young athlete's career [12-14]. Up to 30 % of athletes do not return to their usual sports activities after surgical treatment [13, 15].

The length of the tendon is about 15 cm (11–26 cm) and the average width is about 6.8 cm (4.5-8.6 cm) [16]. In most cases, ruptures of the Achilles tendon occur in its middle part, 2-6 cm proximal to the point of its attachment to the calcaneal tubercle [17, 18]. Less common are distal avulsions, including avulsion fractures of the calcaneus [19]. Moreover, most distal Achilles tendon injuries are associated with long-term degenerative changes [20].

The analysis of the prevalence of Achilles tendon ruptures among different age groups revealed two main peaks: ages of 40 years and 60-65 years [2, 4, 21]. The first peak is due to sports injuries, while the second is more often characterized by tendon damage due to degenerative changes [7]. The largest number of calcaneal tendon ruptures in the population, according to various literature data, belongs to sports injuries (60-70 %) [22-24]. The most common sports in which Achilles tendon ruptures occur are football, tennis, indoor ball games (basketball, volleyball), jumping and running disciplines of athletics, American football and baseball [25, 26].

To date, there is no consensus in the literature regarding the optimal treatment method for patients with Achilles tendon ruptures [27, 28]. On the one hand, surgical treatment can reduce the risk of re-rupture and achieve higher functional results but, on the other hand, it results in a number of complications, including infectious and neurological ones.

Depending on the type and height of the injury, its duration and concomitant pathology, calcaneal tendon repair can be performed using an open approach, a minimally invasive approach in the projection of the rupture, or percutaneously. Open suturing has remained the gold standard for many years, providing high strength and low risk of re-rupture [29, 30]. The negative factor of this repair method is necrotization of the edges of the postoperative wound and a high risk of infectious complications. Many authors give preference to percutaneous repair, which is characterized by lower infectious risks, but higher risks of developing n. suralis neuropathy.

According to McMahon, the results of open and "mini open" repir techniques are comparable in terms of complications such as repeated ruptures, infection, thrombosis of the lower limb veins, contractures and n. suralis neuropathy. [31] According to Baumfeld et al., subjective results using open and percutaneous suturing techniques are comparable [32].

Purpose of this study was to evaluate long term results of Achilles tendon rupture surgical repair using different surgical techniques, assess complications and subjective satisfaction

MATERIALS AND METHODS

Patients who underwent surgical treatment for calcaneal tendon rupture from October 2010 to April 2020 were included in the study. For Achilles tendon repair, the following methods were used: minimally invasive and open. The minimally invasive method included percutaneous repair by stitching with a transverse mini-approach in the projection of the rupture (*mini open*). All operations were performed with patients in the prone position under spinal anesthesia and intravenous sedation. In the (*mini open*) technique and open repair, a pneumatic tourniquet was used on the proximal third of the thigh.

Indications for minimally invasive repair were acute primary ruptures of the Achilles tendon. The choice between the percutaneous repair and *mini open* technique was made depending on the surgeon's preference. For percutaneous repair, the classic Bunnel – Cuneo suture technique was used with tying and immersion knots through two punctures in the projection of the rupture (Fig. 1). In the *mini open* technique, a transverse approach was performed in the projection of the rupture up to 4 cm long, through which the matching of the ends of the tendon and the immersion of the knots were assessed (Fig. 2).

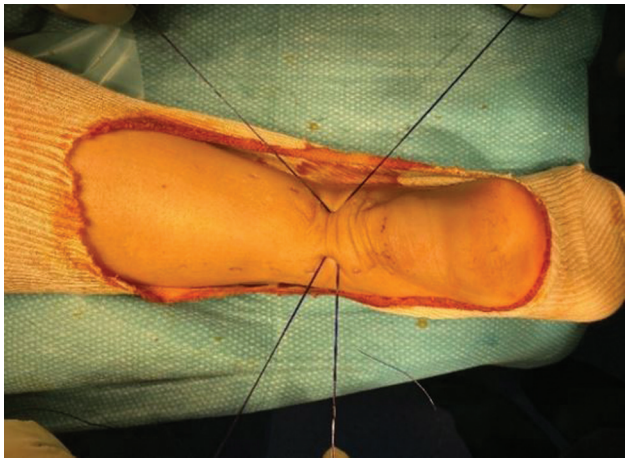

Fig. 1 Percutaneous repair of the Achilles tendon

Fig. 2 *Mini open* repair of the Achilles tendon

Indications for open repair of the Achilles tendon were primary ruptures in professional athletes, long-standing ruptures (4-6 weeks or more since the moment of injury), repeated ruptures, degenerative ruptures due to long-term tendinopathy or previous injections of hormonal drugs, tendon evulsions from the calcaneal tubercle. For open repair, S-shaped, medial or midline approaches were used with full visualization of the ends of the torn tendon (Fig. 3). The type of approach for open suturing was determined depending on the height and duration of the rupture, as well as the planned type of reconstruction.

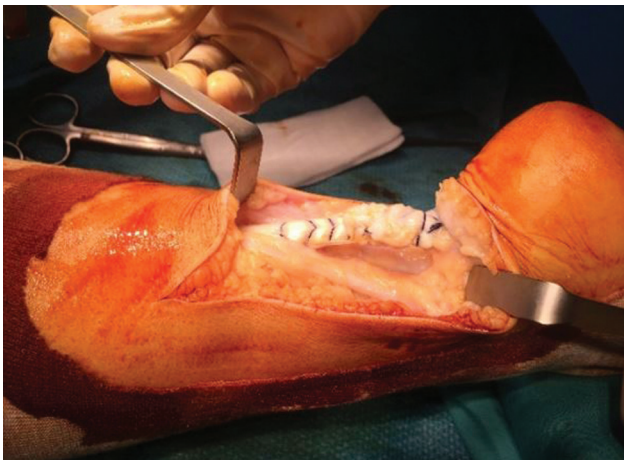

Fig. 3 Primary open repair of the Achilles tendon

If there was a gap between the ends of the tendon of more than 20 mm, reconstruction was performed using Chernavsky, Krasnov or V-Y plasty. If necessary, it was supplemented with an autograft harvested from the tendon of the semitendinosus muscle. When the Achilles tendon was torn off from the calcaneal tubercle, it was refixed to the calcaneus using anchors (Fig. 4).

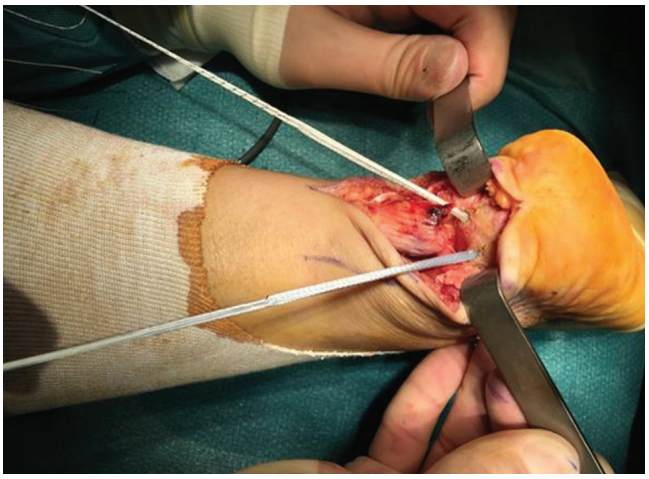

Fig. 4 Reattachment of the Achilles tendon to the calcaneal tubicle with anchor fixators

Postoperative rehabilitation included limited axial load for 6 weeks, immobilization in the equinus position of the foot for 3 weeks, followed by bringing the foot to a neutral position and continued immobilization from week 4 to 6 post-surgery.

Complications were recorded in the postoperative period: re-rupture, infection, thrombosis of the lower limb veins, n. suralis neuropathy.

At the follow-up, the result was assessed using the American Orthopedic Foot and Ankle Society Scale (AOFAS) and The Achilles Tendon Total Rupture Score (ATRS). Patients were also asked to answer the following questions: "Are you satisfied with the results of the operation?", "Would you agree to the operation, knowing in advance about its results?" The answer options were: "definitely yes," "probably yes," "probably no," and "definitely no."

Statistical data processing was carried out using the Statistica 12.0, Stat Soft Inc. To check the normality of data distribution, the Kolmogorov–Smirnov test was used. To assess normal distribution, quantitative data are presented as mean ± error; in a non-normal distribution, quantitative data are presented as median and interquartile range (IQR). Since the manifestations had a distribution other than normal in all groups, the Kruskal–Wallis test was used to test statistical hypotheses in comparing numerical data from several unrelated groups. The critical level of significance was set at 5 % ($p \leqslant 0.05$).

A logistic regression model was used to identify factors influencing the final treatment results and determine cause-and-effect relationships. To form the model, all available factors (signs) were used, and the results obtained were checked by cross-validation. Primary input data were used as factors: age (⩽ 40 years / > 40 years), gender (m/f), body mass index (< 25 / ⩾ 25), time since injury (⩽ 72 hours / > 72 hours), surgeon experience (more than 25 years or less), level of sports activity (professional, amateur, not involved), history of glucocorticosteroid (GCS) injections into the Achilles tendon area (yes/no), type of suture material used (absorbable/non-absorbable), use of autografts (yes/no), type of postoperative immobilization (plaster cast/orthosis), use of a tourniquet intraoperatively (yes/no), type of calcaneal tendon repair (mini-invasive/open). The final result factors were the occurrence of postoperative complications: infection or re-rupture. Several models were built in which the occurrence of different types of postoperative complications was considered either as different events or as one event. Most of the studied features were of a qualitative nature, and in order to conduct a correct statistical analysis, all these features were converted using the binary coding method. Next, the data was normalized and all values were brought to a single scale.

The study was approved by the institutional ethics committee and was conducted in accordance with the ethical standards outlined in the Declaration of Helsinki.

RESULTS

The surgical treatment results of 130 patients with Achilles tendon rupture were analyzed: 123 patients with primary injury and 7 patients with recurrent injury. The median age of patients included in the study was 40 years (IQR 36-48 years). The median follow-up period was 7 years (IQR 5-10 years).

Among patients with a primary rupture, percutaneous repair was performed in 60 % of cases (74/123), *mini open* repair was performed in 16 % (19/123), and open repair of the calcaneal tendon was performed in 24 % (30/123) .

All minimally invasive surgeries were performed for acute Achilles tendon injuries. During the follow-up period, recurrent tendon rupture was detected in 2 patients after percutaneous repair and in 1 patient after the *mini open* technique. Those patients subsequently underwent open calcaneal tendon repair. In the open repair group, 18 operations were performed for acute traumatic injury to the calcaneal tendon, 12 operations were performed for primary degenerative or old rupture. No re-ruptures were diagnosed after open repair. All patients underwent open surgery for re-rupture of the calcaneal tendon. In the follow-up period after percutaneous suture of the Achilles tendon, the following complications were diagnosed: 4.1 % (3/74) of cases – infectious complications, 10.8 % (8/74) – deep vein thrombosis of the lower extremities and in 1.4 % (1/74) – n. suralis neuropathy. After the *mini open* technique in the postoperative period, deep vein thrombosis of the lower extremities was detected in 5.2 % of cases (1/19); no other complications were diagnosed in this group of patients. After the open method for primary ruptures of the Achilles tendon, infectious complications were detected in 10 % of cases (3/30) and neuropathy n. suralis in 3.3 % (1/30). Analysis of anamnestic data showed that among the 3 patients who had infectious complications after open repair, two had previously received injections of hormonal drugs into the Achilles tendon area. In patients with repeated rupture of the Achilles tendon, no infectious or neurological complications were diagnosed; thrombosis of the veins of the lower extremities was detected in 2 cases (Table 1.)

Table 1

Distribution of patients with Achilles tendon ruptures into groups and number of complications

Groups of patients	Number of patients, total	Re-ruptures		Infection		Thrombosis		Neuropathy	
		abs.	%	abs.	%	abs.	%	abs.	%
Primary ruptures	**123**	3	2.4	6	4.8	9	7.3	2	1.6
Mini-invasive repair:	93	3	3.2	3	3.2	9	9.7	1	1.1
Percutaneous suture	74	2	2.7	3	4	8	10.8	1	1.4
Mini open repair	19	1	5	–		1	5	–	
Open repair:	30	–		3	10	–		1	3.3
Acute primary	18	–		–		–		–	
Neglected and degenerative rupture	12	–		3	25	–		1	8.3
Re-ruptures	7	–		–		2	28	–	
Total:	130	3	2.3	6	4.6	11	8.5	2	1.5

We were unable to identify a significant relationship between the studied factors (primary data) and the development of postoperative complications. However, it was found that injection of corticosteroids into the area of the calcaneal tendon, open repair of the calcaneal tendon, and the use of augmentation tapes or autografts increase the likelihood of developing infectious complications.

Subjective questionnaire data were obtained from 32 patients in the percutaneous repair group, 9 patients in the *mini open* repair group, 13 patients in the open repair group with primary ruptures, and 5 patients with recurrent calcaneal tendon rupture (Table 2).

Table 2

Data on subjective satisfaction based on questionnaires

Groups of patients	Number of patients	AOFAS Median (IQR)	ATRS Median (IQR)
Mini-invasive methods:	41	96 (90-98)	95 (90-99)
Percutaneous repair	32	95 (90-98)	96 (89-100)
Mini open repair	9	98 (95-98)	96 (92-97)
Open repair	13	95 (90-100)	95(92-97)
Re-ruptures	5	88 (86-90)	86 (83-96)

In the percutaneous group, the median AOFAS score was 95 points (IQR 90-98) and the ATRS score was 96 points (IQR 89-100). The answer to the question "Are you satisfied with the results of the operation?" was "definitely yes" in the percutaneous group in 69 % (22/32) of patients, 31 % (10/32) of patients chose the option "probably yes"; none of the respondents answered "probably no" or "definitely no". We obtained the following results to the answer to the question "Would you agree to the operation, knowing in advance about its results?": "definitely yes" – 63 % (20/32), "probably yes" – 34 % (11/32), "probably no" – 3 % (1/32); no one answered "definitely no".

In the *mini open* technique group, the median AOFAS score was 98 points (IQR 98-100), and the ATRS score was 95 points (IQR 92-97). When answering the question "Are you satisfied with the results of the operation?" in the *mini open* group, 67 % (6/9) of patients chose the option "definitely yes", 33 % (3/9) of patients "probably yes"; none of the respondents answered "probably no" or "definitely no". The answers to the question "Would you agree to the operation, knowing in advance about its results?, the following results were obtained: "definitely yes" – 78 % (7/9), "probably yes" – 22 % (2/9); none of the respondents answered "probably no" or "definitely no".

After open repair, the median AOFAS score was 95 points (IQR 90-100), and the ATRS score was 95 points (IQR 92-97). When answering the questions "Are you satisfied with the results of the operation?" and "Would you agree to the operation if you knew in advance about its results?", 69 % (9/13) of patients in the group of primary open repair of the Achilles tendon chose the option "definitely yes", 23 % (3/13) of patients "probably yes", one patient (1/13) answered "definitely no" (8 %). There was no statistically significant difference in these subjective questionnaires between the percutaneous, *mini open*, and primary rupture open repair groups ($p > 0.05$) (Fig. 5 and 6).

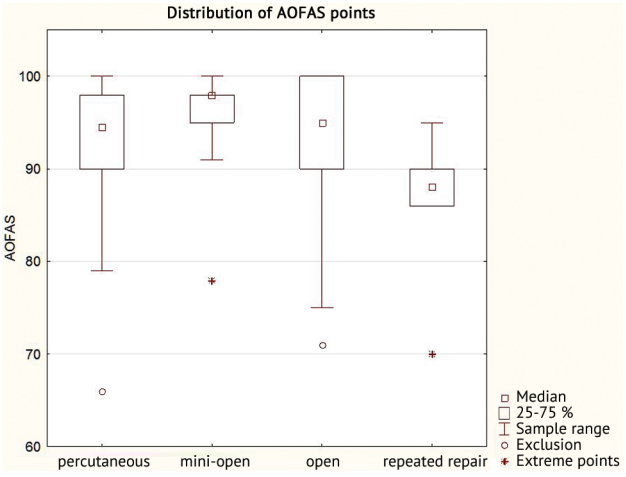

Fig. 5 Distribution of AOFAS points between the groups

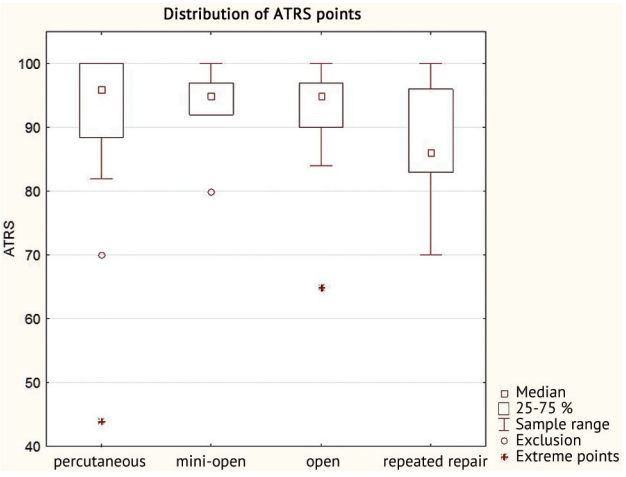

Fig. 6 Distribution of ATRS points between the groups

In the group of repeated rupture repair of the calcaneal tendon, the median AOFAS score was 88 points (IQR 86-90), the ATRS score was 86 points (IQR 83-96), which is lower than after primary repair, but no significant differences were obtained ($p > 0.05$). When answering the question "Are

you satisfied with the results of the operation?" 80 % (4/5) of patients chose the option "definitely yes", 20 % (1/20) of patients answered "probably yes". The answer to the question "Would you agree to the operation, knowing in advance about its results?", 100 % of patients chose the answer "definitely yes."

DISCUSSION

Surgical treatment of Achilles tendon ruptures is aimed at fast functional recovery, return to sports activity, good esthetic effect and subjective patient's satisfaction. The choice of the optimal surgical treatment method raises many contradictions.

The rate of re-ruptures after minimally invasive repair in our study was 3.2 %: 2 cases after percutaneous suture and 1 case after repair using a transverse approach in the projection of the rupture. Our data are comparable with the results of meta-analyses by Yang et al. and Grassi et al., where the incidence of recurrent Achilles tendon ruptures using minimally invasive methods was 3.1 % and from 0 to 4 %, respectively [14, 33]. After open repair, no repeated ruptures were diagnosed in our work. Moreover, in the study of Yang et al. the re-rupture rate after open repair was 2.7 %, in the study of Grassi et al. it ranged from 0 to 6 %. The differences may be explained by a small group for open repair in our study, as well as the inclusion of patients with degenerative and chronic calcaneal tendon ruptures in the analysis of results.

The number of infectious complications in our study was 3.2 % after minimally invasive repair of the calcaneal tendon and 10 % after open repair. Many literature sources indicate a higher risk of infectious complications after primary open repair [14, 34]. Grassi et al. analyzed the results of treatment of more than 350 patients and showed a significantly lower number of infectious complications with application of minimally invasive methods [33]. Moreover, the researchers calculated that every 10 procedures using a minimally invasive Achilles tendon repair instead of an open one avoided one infectious complication. The meta-analysis by Soew et al. showed that the number of infectious complications after percutaneous repair of the Achilles tendon was 2.9 %, which is comparable to the data obtained in our work [35]. For assessing the incidence of postoperative complications, most studies include only acute primary Achilles tendon ruptures. Thus, Fell et al. in 2020 diagnosed infectious complications after open repair in 3 % of cases, which is less than in our work, but the authors did not include old (more than 21 days from the date of injury) injuries in the analysis [36]. All infectious complications after open repair in our study were diagnosed in patients with neglected or degenerative ruptures. Ahmad et al. evaluated the results of open repair for chronic and repeated ruptures of the Achilles tendon and identified superficial infectious complications in 9.4 % of cases and deep ones in 3.1 % [37].

The incidence of thrombosis of lower limb veins after minimally invasive techniques in our work was 9.7 %, while thrombosis was detected in 8.1 % of cases among the patients who underwent open repair at the preoperative stage, which required the implantation of vena cava filters. The detection of thrombosis at the preoperative stage in the open repair group is associated with the inclusion of patients with chronic calcaneal tendon injuries in the analysis. The obtained data are comparable with previously published ones. Thus, Caolo et al. revealed deep vein thrombosis in 8.5 % of cases after minimally invasive suturing of the Achilles tendon and in 9 % after open repair [38].

Many researchers show that percutaneous and minimally invasive techniques have higher risks of n. suralis neuropathy than open techniques of Achilles tendon repair [14, 39]. However, subsequently, several meta-analyses showed no significant differences in the incidence of neurological complications when comparing open and minimally invasive techniques [33, 35]. According to our data, the incidence of sural nerve neuropathy was 1.1 % after minimally invasive techniques and 3.3 % with the open approach; there was also no statistically significant difference ($p > 0.05$).

Most studies indicate comparable subjective results by comparing minimally invasive and open techniques. Mean AOFAS score in Yang et al. meta-analysis was 95.9 points in percutaneous repair and 98.4 in open repair while in the study by Baumfiend (2018), 95.3 and 98.2, respectively [14, 32]. Our data are consistent with previously published ones: in the group of percutaneous repair, the median AOFAS score was 95 points and ATRS score was 96 points; in the group of *mini open* technique, the median AOFAS score was 98 points and ATRS score was 95 points. In the open repair group, the median AOFAS and ATRS scores were 95 and 95 points. After repeated rupture repair, the median AOFAS score was 88 points and ATRS score was 86 points. Our study found high patient satisfaction with the results of surgical treatment.

CONCLUSION

The choice of surgical treatment technique depends on many factors. Open repair techniques have a greater risk of infectious complications, but a lower likelihood of re-rupture. Previous injections of hormonal drugs into the area of the calcaneal tendon, application of augmentation tapes or autografts in Achilles tendon repair increase the risks of infectious complications.

Conflict of interest *Professor Korolev A.V. is an official consultant and lecturer for Arthrex.*

Financing *The study had no sponsor support and external funding.*

Ethical review *The study was approved by the institutional ethics committee and was conducted in accordance with the ethical standards set forth in the Declaration of Helsinki.*

Informed consent *All patients signed informed consents.*

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Information about the authors:

Nina E. Magnitskaya – Candidate of Medical Sciences, orthopedic traumatologist, magnitskaya.nina@gmail.com, https://orcid.org/0000-0002-4336-036X;

Alexey N. Logvinov – Candidate of Medical Sciences, orthopedic traumatologist, logvinov09@gmail.com, https://orcid.org/0000-0003-3235-5407;

Mikhail S. Ryazantsev – Candidate of Medical Sciences, traumatologist-orthopedist, Ryaz.doc@yandex.ru; https://orcid.org/0000-0002-9333-5293;

Pavel S. Andreev – orthopedic traumatologist, graduate student, pandreev@emcmos.ru; https://orcid.org/0000-0002-5750-626X;

Ivan A. Vasiliev – orthopedic traumatologist, graduate student, dr.vasilyev.ivan@gmail.com, https://orcid.org/0000-0002-1163-950X;

Dmitry A. Bessonov – orthopedic traumatologist, graduate student, Bessonovdmitry96@gmail.com, https://orcid.org/0000-0002-0532-9847;

Dmitry O. Ilyin – Doctor of Medical Sciences, orthopedist-traumatologist, ilyinshoulder@gmail.com, https://orcid.org/0000-0003-2493-4601;

Alexander V. Frolov – Candidate of Medical Sciences, orthopedic traumatologist, Associate Professor of the Department, a.frolov1980@gmail.com; https://orcid.org/0000-0002-2973-8303;

Andrey V. Korolev – Doctor of Medical Sciences, Chief Physician, Professor of the Department, akorolev@emcmos.ru, https://orcid.org/0000-0002-8769-9963.

Contribution of the authors:

Magnitskaya N.E. – conceptualization, methodology, formal analysis, investigation, review and editing, visualization and research project management.

Logvinov A.N. – methodology, validation, formal analysis, research, reviewing and editing.

Ryazantsev M.S. – conceptualization, methodology, research, visualization, review and editing of the study.

Andreev P.S. – formal analysis, research, data processing, writing the initial version of the manuscript.

Vasiliev I.A. – research, data processing, writing the initial version of the study.

Bessonov D.A. – formal analysis, research, data processing, writing the initial version of the manuscript.

Ilyin D.O. – conceptualization, methodology, research, control over the implementation of the study.

Frolov A.V. – conceptualization, methodology, research, control over the implementation of the study.

Korolev A.V. – conceptualization, methodology, research, reviewing and editing, supervision and management of the research project.