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ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

Prognostic model of clinical scores in evaluation of treatment outcome in patients with acute Achilles tendon rupture – surgery vs. immobilization

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SUMMARY

Introduction/Objective When choosing the appropriate treatment for Achilles tendon rupture, there may be a dilemma when choosing the optimal treatment.
The objective of this study was analyzing groups of patients with acute closed Achilles tendon injury, comparing early recovery and functional parameters in relation to treatment and first choice treatment suggestion.

Methods The prospective study included 80 patients with acute Achilles tendon rupture. The treatment was surgery or immobilization.

Results There is a difference in the mechanism of injury between surgically and non-surgically treated (p = 0.026). In total, 50 (62.5%) patients were operated and 30 (37.5%) patients were treated with circular plaster. The difference (p = 0.000) between the groups in the duration of treatment, The American Orthopaedic Foot and Ankle Society (AOFAS) score and Visual Analogue Scale of pain (VAS) was shown. Patients undergoing surgery in the first two days had better clinical results in terms of The Achilles tendon Total Rupture score (ATRS), AOFAS and VAS. Higher satisfaction was achieved in younger people (p = 0.036). Patients whose treatment lasted shorter were more satisfied with their status (p = 0.001). ATRS and AOFAS score are higher in patients who are more satisfied with their own status (ATRS p = 0.301; AOFAS score p = 0.001). Six months after the treatment, 78.75% (63/80) of patients were fully functional.

Conclusion The therapy of choice in the treatment of acute Achilles tendon rupture is surgical, as surgical treatment is shorter; rehabilitation is faster and shorter, and the total costs associated with treatment and absence from work are lower.

Keywords: Achilles tendon; scores; ATRS; AOFAS score; VAS pain

INTRODUCTION

The Achilles tendon is the thickest and strongest tendon in the human body. Rupture of the Achilles tendon accounts for 35% of all acute tendon ruptures [1, 2, 3]. Over a period of 30 years, a tenfold increase has been recorded in the rates of incidence from18 to 21 per 100,000 inhabitants per year [1, 2, 3]. Acute Achilles tendon rupture (ATR) is not only common in professional athletes, but occurs in 61% of individuals who play informal recreational sports. Bilateral ATR occurs in about 25–30% of cases [4].

Research shows that ATRs occur at a rate of 75% for people between the ages 30–40 [3]. It has registered a significant rise in ruptures in the 40–59 demographic. It is more common in males, non-obese and obese patients. The frequency ratio of acute ATR between men and women is 3: 1 [1, 2, 5, 6].

Achilles tendon injuries are associated with risk factors ranging from inflammatory and degenerative changes, to the long-term use of corticosteroids, testosterone, growth hormones, and quinolone antibiotics [4, 6]. The tendon connects *musculus triceps surae* for calcaneus on the back of the lower leg, and actively plantar stretches the foot and raises the heel and the entire body to the toes. During physical exertion, it exposes her to a large load on stretching, especially with insufficient physical preparation and warm-up.

The weakest part of the Achilles tendon is 2–6 cm above the attachment on the calcaneus; approximately 80% of rupture cases occur here; and a limited portion of the blood supply comes from the tendon. Tendon ruptures are caused by a potent dorsiflexion force applied to calf and/or foot [3].

The clinical picture includes a very strong pain and impossibility of plantar flexion, especially standing on the toes of the injured foot. The diagnosis is made by clinical examination (normally confirmed by the Thompson Test or a palpation test), an ultrasound examination, or by magnetic resonance imaging [1, 4, 6].

The treatment options for acute Achilles tendon injury comprise both initial care and

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further non-surgical and surgical rehabilitation. Initial care includes the P.R.I.C.E. procedure (protection, rest, ice, compression, and elevation). Although identifying treatment is challenging, there are several modalities, from conservative therapy to open surgical reconstruction, available to patients. No matter what the technique is, relatively good, functional outcomes are likely.

Surgical treatment has a lower rate of re-rupture compared to conservative therapy (4% *vs.* 10%, respectively), and fewer working days, but records higher rates of complication. Minimally invasive percutaneous techniques are an alternative to traditional treatment. And despite similarly low rates of re-rupture and early complications compared to open surgery, it is accepted that percutaneous techniques be used with caution because sural nerve lesions are possible [2, 6, 7].

Surgical treatment, for instance, also involves joining the ends of the tendon with one of several surgical techniques. This method of treatment has several advantages, namely for the anatomical restitution of the tendon and preservation of its length, the reduction of the tendon scar tissue at the site of adhesion, and primary healing of the tendon at the optimal time. Some scholars maintain that surgical treatment is superior only if done within the first 48 hours of rupture, while others argue for surgical treatment, best performed within the first week of rupture [8].

Non-operative, conservative treatment, however, involves wearing a knee-length circular cast with the foot in a gravitational equinus and the knee in a slight flexion of about 10°, for 6–8 weeks. As physicians, we reserve this method of treatment for people who lead a sedative lifestyle and more comorbidities because patients recover more slowly and are at higher risk of Achilles tendon rerupture by up to 50%, perhaps more [6, 9, 10]. Although each method of treatment has its advantages and disadvantages, there is no consensus on which option is the best. Surgical treatment appears to reduce the risk of rerupture and give a better functional outcome compared to non-surgical treatment. The percentage of re-ruptures in operated patients is 0–11% [7–13].

There are several approaches to surgical techniques for treating a fresh tendon ruptures. The operative approach is posteromedial, recommended with a relief incision in the shape of an elongated letter "S", along the inner edge of the tendon. The posterior medial and posterolateral approaches are less commonly used. They show the best results in younger athletes among those with early surgery; among older recreationists, surgery can be avoided by immobilizing the lower leg for 6–8 weeks, depending on the severity of the injury [8].

After 12 weeks, the patient should be able to walk without an immobilization boot, have a near complete range of motion, and a certain level of muscle strength. Complete recovery from ATR surgery takes 6–9 months, depending, a great deal, on the quality of physical therapy experienced by the patient. Research has shown that accelerated postoperative protocol, with gradual loading and mobilization of the joint results in better general health and vitality in the six months immediately following surgery [14].

The aim of this study was to analyze the population with the acute ATR treated at the Clinic for Orthopedic Surgery and Traumatology of the Clinical Centre of Serbia in Belgrade, over a two-year period. We compared early recovery after acute ATR in operated and conservatively treated patients to the parameters of functionality relative to treatment, to suggest the treatment of first choice regarding the acute rupture of the Achilles tendon in our population.

METHODS

We designed this research as a prospective study at the Clinic for Orthopedic Surgery and Traumatology of the Clinical Centre of Serbia in Belgrade, Republic of Serbia from January 2017 to November 2019, in accordance with the standards of the institutional Committee on Ethics. The study included 80 patients of both sexes with acute ATR. All patients experienced sudden pain in the heel area, difficulty walking and were unable to lift their heel. Participation criteria for the study included: patients with acute ATR within two weeks of injury; a palpable gap at the ruptured Achilles tendon and a positive Thompson test; and a B-mode ultrasound that proved an acute ATR. All patients agreed to complete the questionnaire and provide the data for the scores and follow-up over the next six months.

Exclusion criteria from the study were chronic ATR, open ATR, incomplete clinical data, and a history of long-term corticosteroids or quinolones use, those who, although necessary, wished not to have the operation. Patients who lost to follow-up, or were followed for a period less than six months, were excluded from the study. Informed consent was not signed for reasons of confidentiality and the confidentiality of data. Instead, informed consent was oral. All operated patients signed surgical and anesthetic consent, which is in accordance with the Ethics committee principles.

Questionnaire collected research data, involving two parts. The first part was socio-demographic data (age, sex, body weight, comorbidities, occupation, mechanism of injury and lateralization of the injured Achilles tendon), and the second part of the survey contained data used for scores [The American Orthopaedic Foot and Ankle Society (AOFAS) score, the Achilles tendon Total Rupture score (ATRS), and Visual Analogue Scale of pain (VAS)].

The same specialist clinically examined all patients (palpation test and Thompson test). They performed basic laboratory and radiographic diagnostics, after which a decision was made on the method of further treatment.

Surgery was performed under spinal or regional block anesthesia, under ultrasound control. Non-operative, conservative treatment involved wearing a circular plater cast (immobilization of Paris). All patients continued physical therapy for six months. Steps of surgery are shown in Figure 1.

Modern methods of descriptive (tabulation, graphical representation, measures of central tendency and

Figure 1. Steps in surgery: position for surgery; surgical approach; Achilles tendon location; Achilles tendon rupture; postoperative suture

variability analyzed data; odds ratio, probability) and analytical statistics (distribution normality test Kolmogorov–Smirnov test; χ^2 test; t-test; linear and logistic regression; linear correlation; one way ANOVA; ROC analysis) using the SPSS, software package version 26.0 (IBM Corp., Armonk, NY, USA). Statistical significance was set as the value of $p < 0.05$.

RESULTS

Follow-up of our patients, who were divided into two groups, lasted up to 180 days. The average follow-up of patients who were surgically treated was 177 ± 11 days, and conservatively treated 175 ± 11.5 days, which is without a statistically significant difference (p = 0.437).

Table 1 shows the demographic characteristics of patients. Table 2 shows data on treatment and functionality of patients with acute ATR.

Table 1. Demographic data

Variable	Open surgery (n = 50)	Immobilization of Paris (n = 30)	p
Age (years)	42.42 ± 8.23	45.93 ± 8.91	0.077
Sex			0.021
Female	11	14	
Male	39	16	
Weight	81.28 ± 11	78.53 ± 12.41	0.305
Comorbidity			0.568
Diabetes mellitus	12	6	
Others	7	5	
Absent	31	19	
Affected side			0.358
Left	21	10	
Right	29	20	
Profession			0.568
Professions without physical activity	43	23	
Housewife/ unemployed	3	3	
Worker	4	4	
Mechanism of injury			0.026
Recreation	27	9	
Work	4	2	
Daily activities	13	12	
Does not know	6	7	

Table 2. Treatment and functionality data

Variable	Open surgery (n = 50)	Immobilization of Paris (n = 30)	p
Type of anesthesia			0.002
Spinal anesthesia	38	NA	
Regional block anesthesia	12	NA	
Duration of treatment (in days)	10.42 ± 11.42	69.17 ± 12.84	0.000
Complications			0.642
Infection	1	0	
Delayed wound healing	3	0	
Paresthesia	5	4	
Absent	41	26	
ATRS score (0–100)	89.1 ± 11.9	87.5 ± 2.97	0.473
AOFAS score (0–100)	90.18 ± 4.23	83.63 ± 6.22	0.000
VAS pain (0–10)	8.92 ± 0.6	7.93 ± 0.78	0.000
Palpation test			0.606
Positive	43	27	
Negative	7	3	
Thompson test			0.809
Positive	32	20	
Negative	18	10	
Plantar flexion (degrees)			0.007
0 (0 °)	3	0	
1 (0–10°)	15	5	
2 (11–20°)	29	15	
3 (21–30°)	3	10	
Dorsiflexion (degrees °)			0.866
3 (7–10°)	19	12	
4 (11–15°)	28	17	
5 (16–20°)	3	1	
Toe gait			0.008
No difficulties	27	25	
Mild difficulties	23	5	
Satisfaction rate (1–10)			0.000
6 (acceptable)	2	12	
8 (satisfied)	30	16	
10 (very satisfied)	18	2	
Re-rupture			0.712
No	49	29	
Yes	1	1	
Duration of treatment (days)	8.82 ± 1.32	69.1 ± 16.84	0.000
Physiotherapy	All underwent		
Full functionality after six months			0.009
Yes	44	19	
No	6	11	

ATRS – The Achilles Tendon Total Rupture Score; AOFAS – The American Orthopedic Foot and Ankle Society; VAS – visual analogue scale

Table 3. The impact on clinical outcomes over time

Interval between ATR and surgery (days)	AOFAS score (0–100)	ATRS (0–100)	VAS pain (0–10)	Satisfaction rate (1–10)
0–2 (n = 19)	90.58 ± 3.82	91.29 ± 2.81	8.95 ± 0.62	8.42 ± 0.84
3–7 (n = 31)	89.94 ± 4.5	87.77 ± 12.9	8.9 ± 0.6	8.78 ± 1.22
Significance	0.606	0.319	0.804	0.276

ATRS – Achilles Tendon Total Rupture Score; AOFAS – American Orthopedic Foot and Ankle Society; VAS – visual analogue scale

Table 4. The prediction of a positive treatment outcome by groups

Full functionality after six months	Open surgery (n = 50)	Immobilization of Paris (n = 30)	All patients (n = 80)
Predicted outcome	84% (42/50)	63.4% (19/30)	76.3% (71/80)
Observed outcome	88% (44/50)	63.4% (19/30)	78.8% (63/80)

ATRS is a composite patient-reported instrument with high reliability, validity, and sensitivity that measures symptom-related outcomes and physical activity after treatment in patients with a total ATR. ATRS is self-administered and comprises 10 questions, each valuated 0–10 points. ATRS ranges 0–100, 100 being the highest score. It tests the following in the calf/Achilles tendon/foot: strength, fatigue, stiffness, and pain. It also measures limitations in daily activities, walking, climbing stairs, jumping, and hard physical labor [2, 15].

In 1994, AOFAS established rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. Originally published in *Foot Ankle International*, the Ankle-Hindfoot Rating System incorporates subject and objective evaluations of the ankle-hindfoot. Patients report their pain and physicians assess alignment. Scores range 0–100, with healthy ankles receiving 100 points. This score may assess the ankle, subtalar, talonavicular, and calcaneocuboid joint levels and may be useful for fractures, arthroplasty, arthrodesis, and instability procedures [16].

Table 3 shows the impact on clinical outcomes over time, typically from the time of ATR and surgery. Patients who received surgical treatment of the Achilles tendon within the first two days of trauma showed better clinical results in relation to ATRS, AOFAS score, and VAS pain. Assessments of satisfaction with treatment and functional status (self-evaluation) proved to show slightly better results in the second group, but without a statistically significant difference between the groups.

We analyzed patient satisfaction in relation to the age of the patient ($F = 3.470$; $p = 0.036$). We concluded that the prevalence of higher satisfaction was in younger patients. The treatment and satisfaction duration analysis ($F = 7{,}763$; $p = 0.001$) was also performed. Results further concluded that those whose treatment lasted shorter reported greater satisfaction with their status.

The results of ATRS and AOFAS score are higher in patients who are more satisfied with their own status (ATRS $p = 0.301$; AOFAS $p = 0.001$). The AOFAS score is a significant predictive indicator. VAS pain does not show statistical significance in relation to self-evaluation ($p = 0.070$)

Logistic regression analyzed the outcome of treatment aiming at full functionality through predictive variables that proved significant in statistical analysis. In our series, 78.75% (63/80) of patients were fully functional six months after acute ATR and treatment.

We made predictions using the following variables: length of treatment, ATRS, and AOFAS scores that showed a significant association with outcome.

Table 4 shows the prediction of a positive treatment outcome by groups (probability of an excellent outcome).

There is a statistically high correlation between predicted and observed numbers. Our logistic regression model used treatment duration in which the ATRS and AOFAS score had a significant predictive value, as (Wald $\chi 2 = 8.406$; $p = 0.004$) was also analyzed using ROC analysis. Exemplary models for prediction have a value above 0.5 (if less than 0.5, model is no better than a random prediction). Predictive values are shown in Figures 2 and 3 and Table 5.

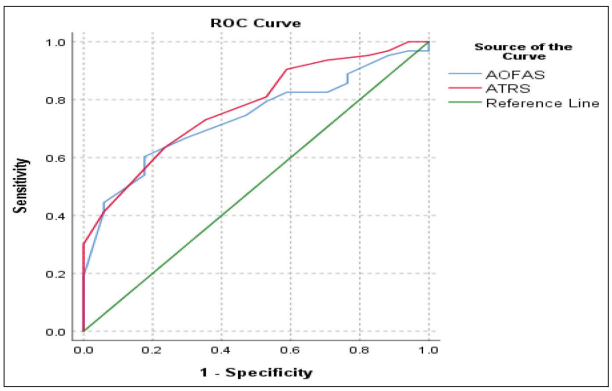

Figure 2. The area under the receiver operating characteristic curve for the following the Achilles Tendon Total Rupture Score (ATRS) and American Orthopedic Foot and Ankle Society (AOFAS) prognostic scores for the patients who fully functionally recovered within six months after acute total rupture of the Achilles tendon

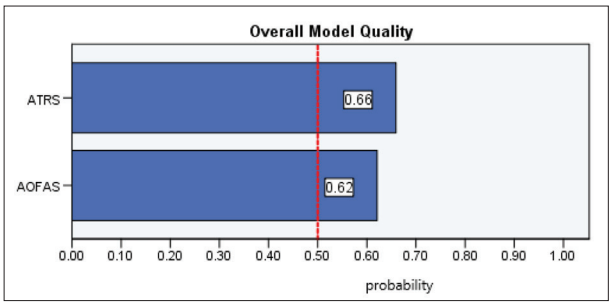

Figure 3. Overall power of prognostic model; both the Achilles Tendon Total Rupture Score (ATRS) and American Orthopedic Foot and Ankle Society (AOFAS) scores are highly reliable and internally consistent (Cronbach alpha p = 0.001)

Table 5. Predictive strength of Achilles Tendon Total Rupture (ATRS) and American Orthopedic Foot and Ankle Society (AOFAS) scores analyzed by receiver operating characteristic (ROC) curve

Predictive variables	Area under the ROC	p	CI 95%
ATRS	0.773	0.000	0.659–0.886
AOFAS	0.736	0.000	0.621–0.852

DISCUSSION

Despite increased incidences of ATR, the best strategy for treatment remains a topic of debate. Surgical treatment is preferred options for many authors, as it decreases the time needed to go back to work after injury, better quality of life and full functionality.

Knobe et al. [11] compared percutaneous treatment to standard open surgical treatment. The mean age of patients with acute ATR treated with standard surgery was 44.8 ± 14.1 years. Similar to the average age of our patients who were treated with standard open surgical treatment and conservative, our work is in line with the current state of the literature, which shows an increased trend in the 40–59 age group [11]. One domestic study, conducted by Vidić et al. [17] 15 years ago, found a preference for the surgical treatment of acute ATR over a more conservative treatment where the average age of patients was 38.8 ± 2.79 years [17]. Considering these data, we can say that in Serbia there is a tendency to move the age group with the highest frequency of acute ATR.

According to the current literature, sex distribution shows a higher incidence of acute ATRs in males. The frequency ratio of acute ATR between men and women in literature is 3:1. In the systematic review done by Abubeih et al. [3] in 2018 we were able to find different men to women ratio raging from 1:1 to 2:1, as well results in compliance with ours.

Overall, a higher frequency of injury to the left Achilles tendon was noted. This differs from our study, where the frequency of acute rupture of the right Achilles tendon is higher [6, 11, 12].

Grubor and Grubor [4], analyzed the treatment of acute ATR, where the frequency of surgical treatment is higher, 81% of patients were operated upon (45% by percutaneous technique; 36%, surgical technique). Our study identifies a statistically significant difference in the treatment of acute ATR. Our study analyzed the mechanism of Achilles tendon injury, and found that the most common injury was observed during recreational sports activities, and in our study, those were treated surgically, while the highest frequency of injuries of those conservatively treated in our study, occurred during daily activities, which is a statistically significant difference.

On average, all patients treated surgically or conservatively within two days of injury, according to the study, which is approximately the same as our results (3.82 ± 1.20 days for surgically treated and 2.67 ± 14.48 days for patients with immobilization). All patients who underwent an open surgical technique were under spinal anesthesia. In our study, besides spinal anesthesia, local infiltrative anesthesia was used. There is also a statistically significant difference compared to our research [4].

The complications of Knobe et al. [11], were present in 34% of cases while in our study they were present in 16.25% of cases; the most common in both studies were paresthesias. Paresthesias can be the result of surgical treatment or diabetes mellitus [11]. Grubor and Grubor [4], had a similarly low frequency of ATRs as early complications (one surgically treated; another, conservatively treated). There were two reversals of the Achilles tendon registered in the group of patients treated with open surgical treatment, four re-ruptures occurred in those conservatively treated [4]. We registered one case of Achilles tendon re-rupture in a group of conservatively treated patients. In the study of Vidić et al. [17], they applied a percutaneous surgical treatment in the control group.

Much like our study, the average duration of treatment of operated and conservatively treated patients in the study of Grubor and Grubor [4], and is nine days in open surgery patients. In Serbia, the average duration of treatment is 8.82 ± 1.32 days, and 9.6 weeks in conservatively treated, while in Serbia, 69.17 ± 12.84 days [4]. This is important owing to the ability to return to work, but also the impact on one's quality of life, and the impact of both the direct and indirect costs of treatment.

In a ten-year follow-up study post-acute ATR surgery, Seker et al. [1] estimated the extent of movement and the mean value of dorsiflexion of the foot on the side of the operated Achilles tendon to be 18° (10–20°). In our study, the highest frequency of patients ranged 10–15° (median 14°). The mean value of plantar flexion in study by Seker et al. [1] was 30° (ranging 20–40°); in ours, the highest frequency was 20–30° (with a median of 28°) in surgery patients. In the same study, they averaged the AOFAS score 98.5 and the VAS pain was 0 for all patients. We find this to be statistically significant vis-à-vis the range plantar flexion among the conservatively treated.

While the finds of several studies differ from ours, monitoring in the aforementioned research is far longer. This may account for the range of difference among findings [1]. Manegold et al. [2] investigated and followed-up on post percutaneous surgical treatment of acute ATR complications. They found that where ATRS was 85.4 ± 14.8, the AOFAS score was 95.3 ± 6.6 and VAS pain 0.6 ± 1, they performed analysis on the impact of the time elapsed, starting the ATR to surgery on the clinical outcome. Patients operated on in the first two days of rupture showed poorer clinical results in terms of AOFAS score. ATRS and VAS pain showed better clinical results in those operated on in the first two days of rupture. In our study, patients who underwent surgery in the first two days of an ATR showed better clinical results vis-à-vis their ATRS, AOFAS score, and VAS pain.

In Knobe et al. [11], the AOFAS score was compatible with ours and was 90 ± 8 in open surgery patients. In the same study, a self-evaluation of patients who underwent open surgical technique was performed, which was 8.40 ± 1.3 on the Likert scale, which is compatible with our results (8.42 ± 0.84 for those operated on in the first two days; 8.78 ± 1.22 for patients operated on in the period 3–7 days).

A prospective study, comparing surgical and non-surgical treatment of acute ATR followed by a physical rehabilitation protocol, showed acceptable outcomes in both groups of patients. The group of operated patients with a statistically significant difference in functionality after six months was significantly better compared to conservative patients treated.

Our study has certain limitations. The number of patients in the study is relatively small. Larger, more

multi-centric study would be recommended to generalize conclusions and give recommendations for good clinical practice.

CONCLUSION

The therapy of choice in the treatment of acute ATR should be primarily surgical, even if both methods of treatment have given reliable results. We should base the choice of treatment on the patient's characteristics and the physical therapy protocol. Surgical treatment is shorter, conditions for better and shorter rehabilitation are more favorable, and the total costs are related to treatment and duration of the absence from work is lower.

Conflict of interest: None declared.

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Прогностички модел клиничких скорова у процени исхода лечења болесника са акутном руптуром Ахилове тетиве – оперисаних и неоперисаних

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САЖЕТАК

Увод/Циљ Код избора одговарајућег третмана руптуре Ахилове тетиве понекад могу постојати недоумице у избору оптималне процедуре.

Циљ ове студије је анализа групе болесника са акутном затвореном повредом Ахилове тетиве, поређење раног опоравка и параметара функционалности у односу на третман и предлагање лечења првог избора.

Методе Проспективно истраживање је обухватило 80 болесника са акутном руптуром Ахилове тетиве. Лечење је изведено хируршком интервенцијом или имобилизацијом.

Резултати Постоји разлика у механизму повређивања између оперисаних и конзервативно лечених ($p = 0,026$). Педесет (62,5%) болесника је оперисано, а 30 (37,5%) болесника је лечено циркуларним гипсом без анестезије. Показана је разлика ($p = 0,000$) између група у дужини трајања лечења, скора Америчког ортопедског друштва за скочни зглоб и стопало (*AOFAS*) и визуелно-аналогне скале (ВАС) бола. Боље клиничке резултате у погледу скорова руптуре Ахилове тетиве (*ATRS*), *AOFAS* и ВАС бола имали су болесници који су подвргнути операцији у прва два дана. Већа сатисфакција је била постигнута код млађих особа ($p = 0,036$). Болесници чији је третман трајао краће били су задовољнији својим статусом ($p = 0,001$). *ATRS* и скор *AOFAS* су виши код болесника који су задовољнији сопственим статусом (*ATRS* $p = 0,301$; скор *AOFAS* $p = 0,001$). Шест месеци после лечења било је потпуно функционално 78,75% (63/80) болесника.

Закључак Терапија избора у лечењу акутне руптуре Ахилове тетиве је хируршка, јер је хируршко лечење краће, повољнији су услови за бржу и крађу рехабилитацију, а укупни трошкови повезани са лечењем и одсуством са посла су мањи.

Кључне речи: Ахилова тетива; скорови; *ATRS*; скор *AOFAS*; ВАС бола