

# Physical rehabilitation after achilles tendon ruptures: a review of modern approaches

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**Purpose:** to conduct review methodological approaches to physical rehabilitation after Achilles tendon ruptures.

**Material & Methods:** analysis and synthesis of the foreign and domestic special scientific and methodical literature on physical rehabilitation after surgical treatment of Achilles tendon rupture.

**Results:** restore function lower limb and gait parameters is a long, complex and difficult process. Qualitative rehabilitation process should be accompanied by adequate motor mode and its extension, axial load and special exercise. The most significant differences are observed in the approach concerning types of immobilization, its term and necessity at all, timing axial load. Among the options of immobilization allocated gypsuming, a variety of cast, orthosis, splints and braces. In the later stages of rehabilitation recommendations are somewhat different of terms of basic loads such as the rise of the fingers, walking without assistive devices.

**Conclusion:** problem of design protocol of physical rehabilitation after achilles tendon ruptures is not completely solved.

**Keywords:** achilles tendon ruptures, surgical treatment, rehabilitation, physical load, exercise.

## Introduction

Restoration of the normal function of the operated limb is a lengthy process, as it includes the adaptation of the ends of the achilles tendon, the normalization of the neuro-trophic disorders of the triceps muscles of the lower leg, and the restoration of motor, domestic, labor and sports skills. At each stage of the postoperative period, specialists are faced with tasks that can generally constitute a rehabilitation system for the patient. Despite the importance of the issue, there is no unanimity in the available literature about the principles and timing of the motor activation of these patients [18].

On the other hand, physical factors, adequate motor conditions and its timely expansion are among the main factors of the full restoration of the achilles tendon and increase of its strength [4]. Available knowledge on the biology of tendon regeneration and regulation mechanisms are of great importance in surgery and rehabilitation [14; 19; 27].

Postoperative restorative treatment is an important moment for achieving an optimal joint condition and functional restoration of the entire limb. However, it is necessary to take into account such opposite requirements: on the one hand – the need for protection and shaking of the operated tendon from excessive loads, and on the other hand – it is possible to minimize the negative effect of immobilization on the condition of muscles, trophic joints, proprioception [47].

In the domestic and foreign literature there is no uniform approach to the tactics of managing patients after the operative restoration of the integrity of the calcaneal (achilles) ten-

don [18].

## The relationship of research with scientific programs, plans, themes

The research was carried out in accordance with the Consolidated Plan of research in the field of physical culture and sports for 2011–2015. On the topic 4.4. “Improving the organizational and methodological foundations of programming the process of physical rehabilitation in dysfunctional disorders in different systems of the human body”. State registration number 0111U001737.

## The purpose of the research

To conduct review methodological approaches to physical rehabilitation after achilles tendon ruptures.

## Material and Methods of the research

*Methods of research:* analysis of scientific literature, synthesis and generalization.

## Results of the research and their discussion

In one of the foreign studies [22] it was noted that until recently attempts to optimize the postoperative regime after surgical treatment of tendon ruptures were sufficiently empirical, the temporal characteristics and gradation of the exercise regimen lacked clear conceptual bases. The magnitude of the loads, applied in previous studies, had no clear control, and likewise did not investigate the effect of the excursion of the

operated site, and the formation of a gap in clinically significant models.

In foreign articles, it is reported that the greatest differences between different protocols and approaches to postoperative restorative treatment and rehabilitation of patients with tendon injuries cause an early postoperative period and methods of influencing tendons in the early stages of healing during the first three to six weeks. It is pointed out that early mobilization is the most common method of management after surgery on tendons from those reported in the literature. Therefore, at present, specialists should understand not only what these options represent, but why and when to use them. There is not only one correct way of carrying out rehabilitation after surgery on the tendons, and therefore a specialist who does not understand the path of development of modern methods is ill-prepared to develop an appropriate individual treatment for each patient [41].

A new approach to both surgical treatment and rehabilitation measures was proposed by R. Cetti in 1988 namely, the new tendon suture and postoperative splint for immobilization, which allows the movement without the weight in the amount of 20° and save equinus foot, and also create the opportunity to walk the day after the operation, subject to the possibility of only minor discomfort, promoted a rapid return to normal mobility with a normal force of plantar flexion and allowed in the future to resume playing sports at the same level as before the injury [23].

Minimization of labor costs when replacing the splint that is immobilized and the patient's discomfort in the next physical rehabilitation with progressive dorsiflexion is considered possible provided immobilization of the foot in the plantigrade position, which is an alternative option in cases of open surgical stitching of the achilles tendon and sufficient for early tension stability [42].

In the literature there is evidence that with fresh ruptures of the achilles tendon and the functional method of reference, the normalization of physiological values occurs up to 3 years after the operation, Whereas in immobilization only up to 12 months, and with chronic injuries do not occur at all (deficiency of function – 7,6%) [18; 42].

Certain researchers contrast their views with traditional ones and note that the postoperative period is possible without immobilization, and movement in the joints after surgery can be allowed, but under the condition of limiting the load [35; 43], in this case, the early free movement of the ankle after reconstruction of the achilles tendon was safe with very satisfactory clinical results [43], integrity of the suture allows an immediate controlled movement of the ankle joint, the weights can be carried out after 2 months, and early movements of the foot and ankle help the remodeling of the scar tissue and prevent the formation of skin adhesions that may further interfere with the full movement of the joint [35].

The traditional approach requires maintaining immobilization over a period of four to six weeks [48], and the intermediate approach suggests the use of functional orthoses in a few days of immobilization according to the traditional method [46; 24].

There are reports of a method of surgical reconstruction of the

achilles tendon, which allows not to apply immobilization of the operated limb, begin exercises with weights to restore the strength of the triceps muscles of the lower leg and to walk with the help of crutches with biomechanical phases of rolling and jerking in the early rehabilitation period. And 3 months after the operation, all patients returned to the previous level of household, professional and sports activity [16].

According to research, a functional approach in the rehabilitation of such patients also suggests an early onset of the reference axial load on the injured leg, which can be realized even at the stage of immobilization, but in the presence of long with a heel, and allows to some extent to neutralize the effect of immobilization, and in the future more quickly improve the functional results [26; 29].

In particular, N. Maffulli [31; 32] together with co-authors studied the influence of early axial load on mobilization and compared it with classical mobilization. The first group of subjects was immobilized in a gravitational equinus and recommended fully transferring weight to the operated leg, and the replacement of splint occurred in two weeks, which made it possible to perform complete plantar flexion and dorsiflexion not above the neutral position. Patients of the traditional method group received immobilization in full equinus, and the replacement of the splint occurred in the second week, when the ankle was fixed in average equinus, and also the fourth, when the ankle was immobilized in the plant position and allowed patients to carry weight on the leg.

Conclusions of researchers [32] amounted to the fact that the first group of patients had fewer outpatient visits, faster than twice refused to crutches, and the proposed method is safe, it does not increase the risk of recurrent fractures and reduces the time required for rehabilitation.

Domestic research M. Golovakhi and co-authors [7] confirmed the usefulness of the use of functional removable orthoses in comparison with the standard technique of the rear gypsum tire to the level of the knee joint. It was noted the possibility of safe application of the dosed load four weeks earlier than in the control group, as well as the earlier full load rejection of additional support. According to the results of the study, the functional approach positively influenced the amplitude of plantar and dorsal flexion, the level of hypotrophy and strength, the mobility of tendons (presence of adhesions between the tendon, paratenon and surrounding tissues, the limitations of the tendon slip, as well as the scale of its diameter with heterogeneity in the structure).

There is an opinion that the first-order indicators for evaluating the results of restorative treatment after the achilles tendon rupture is the quality of life. Thus, A. A. Suchak, together with co-authors [44], compared groups of patients (all patients for two weeks after the operation did not rely on the injured limb in the remaining four weeks, the first transferred weight to the limb, and the second left it unloaded). On the sixth week after the operation, the best results in the first group on the indicators of the quality of life in the spheres of physical functioning, social function, the role of emotional functioning and vitality were noted, and in six weeks after the operation there were fewer restrictions in daily activities. However, at the stage of six months, no significant differences between the groups were observed, and both groups had poor endurance of the leg muscles. There were no repeated discontinuities.

Similar conclusions on the use of functional protocols for immobilization are given in meta-analyses and other works, namely: a more positive effect on the improvement of subjective well-being [33; 45], recovery rate [34], faster return to previous sports level [33], no effect on recovery rate [45], incidence of complications and repeated ruptures [33; 45].

On the other hand, there are facts that surgical treatment and the patient management protocol are not statistically better than the conservative approach, in terms of functional outcomes, physical activity or quality of life [40].

However, it should be noted that the effectiveness and safety of the functional approach in the immobilization period is quite dependent on the patient's awareness of what is required of him, and the limits of the expansion of the functional load, as well as the lack of the ability to independently determine possible loads and their attempts.

Therefore, since the patient can be discharged from the hospital for outpatient treatment just the day after the operation, it is important to build knowledge on the motor activity of interest and its limitations, as well as walking skills with crutches to prevent falls and injuries [28; 30]. The opinion of the surgeon is important. Active motor rehabilitation in the postoperative period is possible with the surgeon's confidence in the ability of the made tendon suture, as well as a clear understanding and performance of the patient's medical prescriptions [17].

The cases of repeated of the achilles tendon rupture in the application of the functional protocol of reference led the authors [21; 25; 17] on the idea that it is necessary to conduct careful selection of patients in order to fully implement the structure of the rehabilitation regime.

Also, in addition to the characteristics of the patient, one should take into account the characteristics of the environment in which the patient will stay after surgical treatment, namely those that affect the safety of movement and in turn depend to a certain extent on the economic development of the state [11].

In case of doubtful possibilities of the patient, it is possible to use limb fixation with a plaster bandage from the upper third of the shin to the metacarpophalangeal joints in the position of moderate flexion of the foot on 20–30° within 4 weeks after the operation, as well as the withdrawal of the foot to a neutral position and walking with a dosed load in the bandage for another 2–3 weeks. Fixation of the knee joint is considered impractical due to its insignificant influence on the tension of the achilles tendon and considerable inconvenience to the patient [17].

Analysis of the literature leads to the conclusion that the literature is more and more detailed about the period of immobilization, but no less important period after immobilization remains uncovered completely or partially.

Considering the dynamics of the restoration of the functional state and the reduction of the deficit, the scientists emphasize the need to improve and intensify the treatment during the first year to improve the final result, since the majority of patients with achilles tendon rupture are not fully recovered 2 years after the injury, and the results differ only slightly after a

year and two years [39].

It should be noted the authors' opinion that existing rehabilitation programs suffer, as a rule, fragmentation, in most of them there is no clinical and morphological characteristics, a clear periodization and a detailed description of rehabilitation tools and technologies [6; 11].

A more active period of rehabilitation, namely after immobilization, using a wide range of tools and methods among the contingent of athletes was considered in the work of M. I. Gershburg and his co-authors [6], however, the features of the immobilization period were also noted. The positive effect of the use of proprioceptive and plyometric exercises, as well as biomechanical stimulation (other means of kinesis and hydroquinotherapy were the same), which was manifested in improving the contractility of the triceps muscle, the results of the complicated Romberg sample and goniometry, and also in the earlier possibility of performing motor tests.

Belarusian Research Institute of Traumatology and Orthopedics, [17] proposes the following method for post-operative patients after achilles tendon rupture :

- limb immobilization is performed via short gypsum splints, ankle fixing in position moderate (20–30°) solebending of the foot. The knee joint and toes are not fixed;

- during the first week after the intervention, foot movements and exercises are performed to gradually extend the limb in the knee joint;

- from the second week after the operation, under the condition of normal wound healing 3–4 times a day, the splint is removed and the metered foot movements are performed within a painless amplitude in order to gradually achieve a neutral position of the foot, a shin and foot massage;

- after the withdrawal of the foot to the neutral position (usually at the 3rd or 4th week), a gradual transition to the full load of the limb is carried out within 3–4 days using an orthosis that fixes the foot in a neutral position; Lessons on an exercise bike in ortega;

- after six weeks of immobilization, walking in ordinary shoes with a heel of 2 cm, metered strength exercises, swimming in the pool;

- after 3 months, easy jogging with a gradual increase in motor activity and the transition to game sports in the fifth to sixth months after surgery.

A group of researchers led by K. Nilsson-Helander [37] reported that after surgical restoration of the integrity of the achilles tendon in the group of patients, an immobilization with an ankle joint was applied for 2 weeks, after that, a functional brace was applied with gradual withdrawal of the foot into dorsiflexion for 6 weeks (to –30° in the first 2 weeks, –10° in the next 2 weeks, and +10° in the last 2 weeks). After this, the patients underwent the following protocol of rehabilitation:

- weeks 8–11 – shoes with a heel lift of 1,5 cm, crutches as necessary for another 1–3 weeks visit the physiotherapist 2–3 times a week and home exercises daily (exercise bike, exercises to increase range of motion of the ankle joint, rise

on your toes while sitting; rise on your toes while standing (2 feet), walking training, balance exercises, bench legs, flexion and extension legs);

– weeks 11–16 – shoes with a heel lift of 1,5 cm up to the 16th week, a visit to a physical therapist 2–3 times a week and daily home exercises (exercises with weight gain, rise on your toes while standing, with the increase in range to stand at the end of the plantar flexion range of 1 foot; climbing; walking on a mattress);

– weeks 16–20 – visit to the physiotherapist 2–3 times a week and home exercises (with weight and intensity increase depending on tolerance, slip, quick bounces on socks with lifting of heels, from 18 weeks climbing stairs with raised heel, side jumps, jumps on 2 legs);

– weeks 20–24 – visit the physiotherapist as necessary, exercise as the previous ones, with increasing weight and intensity, depending on the portability and jogging, lateral leaps forward;

– weeks 24 and further – the continuation of physical therapy, if necessary, group sessions (similar to aerobics), a gradual return to sports (depending on the patient's ability).

A somewhat more progressive protocol after surgical treatment proposed Nicklas Olsson [38]:

– weeks 0–2 – brace with three heel lifts, the use of crutches, high-heeled shoes on the healthy side, exercise at home daily in the brace (isometric submaximal plantar flexion, flexion-extension);

– after 2 weeks – brace with two lifts, previous exercises at home (increasing intensity) with a physiotherapist twice a week (exercise bike in a brace, exercises for a range of motion without brace to 15° with plantar inflexion and with a rubber band, lifting the heels, sitting, unloaded, walking with brace and balance exercises, sit-ups (fitness ball behind the back));

– after 4 – brace with one lift, previous exercises at home; in the exercises with the physiotherapist, the angle to 10° of plantar flexion changes, the replacement of the rubber strip, lifting on the heels, sitting, with light load;

– after 5 – брейс brace, exercises at home; In exercises with a physiotherapist angle to 0°, the use of simulators, lifting on socks, sitting, with weight, bench press;

– after 6 – use of shoes with an increased heel (bilateral) for 4 weeks, golfs to prevent swelling up to 14 weeks, home exercises (from previous studies and climbing socks, standing (up to 50% of the weight on the injured side), walking) with the physiotherapist is added lifting on the socks in the training apparatus for bench press (0° plantar flexion), squats;

– after 8 – independently at home; in the exercises with the physiotherapist to increase the intensity, rise to the socks, standing, gradually to one foot, balancing exercises on the platforms;

– after 12 weeks – regular shoes after 10 weeks, barefoot after 12 weeks, classes at home in accordance with the patient's condition; in the exercises with the physiotherapist, rapid ascent to the socks, easy running on the mattress, jumping on

two legs;

– after 14 – running in the open air, if the patient has good technique, group training; return to the sport not earlier than 16 weeks.

The effect of physical exercises is also examined in the context of the effect on the elasticity characteristics of the achilles tendon regeneration and the strain rate, determined by ultrasonics, at various times after surgery and comparing parameters of different powers isometric and dynamic loads on the gastrocnemius, soleus muscle-tendon complex [5].

The researchers suggest that in athletes (force at the time of injury) occurs more rapid formation of elastic regenerate tendon (strain ratio value  $2,5 \pm 0,6$ ) within 3 weeks after surgery, a shorter time is restored tendon density. Among patients who did not actively engage in sports, the formation of elastic regenerate was prolonged for a period of more than 6 weeks (strain ratio value  $3,6 \pm 1,7$ ) after the operation and for a longer time, it becomes denser. Although all patients underwent active rehabilitation in the recommended volumes according to the terms after the operation. On the basis of the work performed, differences in recovery periods after open achilles tendon ligation were shown in athletes and patients, and are not actively involved in sports, and sonolastography is presented as an effective method of monitoring the regenerative processes of the achilles tendon after surgery, reflecting the state of elasticity of collagen fibers [5].

In the guidelines for restorative treatment after the achilles tendon rupture among athletes, the main means of rehabilitation in the early period include treatment by position, physiotherapy, isometric exercises to stimulate the muscles of the thigh and extensors of the foot, general development exercises to maintain efficiency, as well as active foot movements with the possibility of using modern orthopedic technologies (for example, brace). In the period of recovery of motor functions is recommended to use the basic means of physical exercise in the hall of medical physical training, swimming pool, as well as training in walking, as well as support - laser therapy, massage and electrostimulation of the triceps muscles of the lower leg to accelerate the remodulation of the achilles tendon and increase the contractile ability of the muscles [3; 13].

In the dissertation work Ayub Hussein conducted a study of the impact of physical rehabilitation on the functional state of the triceps muscle after surgical treatment of the achilles tendon rupture in athletes, and the rehabilitation program was divided into three periods – immobilization, rehabilitation of the ankle joint function and the three-headed calf muscle, training and recreation. Thus, the athletes of the main group during the second period used post-isometric relaxation, biomechanical stimulation, as well as a series of static strength exercises for the muscles of the shins, which supplemented the dynamic exercises. The purpose of these methods was the early elimination of contractures and muscle strengthening. In the control group were used in the exercise walking, training in the gym and the pool, pneumatic, hydraulic and manual massage. The first period was not different – athletes of both groups performed isometric exercises for the leg muscles and intensive general development exercises for healthy parts of the body [1; 12].

It was found that the athletes of the main group had advantages in the speed of restoration of the amplitude of dorsiflexion, the strength of the triceps muscle, the ability to perform a running test and the test «b walking on socks in a squat». However, for some indicators (shin circumference, plantar flexion), there was no difference in recovery rate or in the final result [1].

Physiotherapeutic procedures also occupy an important place in restorative treatment after surgical treatment.

The physiotherapy in stimulating the regeneration of tendon tissue consists in the use of various physical factors that positively influence to the reparative processes. The use of methods of physiotherapy to stimulate the recovery process is due to their favorable effect on the course of postoperative inflammation, microcirculation, redox and regenerative processes, and also the formation of connective tissue [2; 8; 18]

The methodological recommendations of the investigators [17] regarding the indications for carrying out physiotherapeutic procedures are formed as follows: magnetotherapy - postoperative edema or at the beginning of physical exercise; UHF stimulation of the healing of a postoperative wound with a dubious course of the process; ultrasonics with actovegin stimulation of regenerative processes in the tendon tissues (3 weeks and more after the intervention) electrostimulation of the calf muscles - to develop movements in the ankle (stimulation of the rear extension of the foot - anterior muscle group), for the immediate stimulation of the gastrocnemius muscle (2–3 months after the operation); paraffin therapy (on the joint area) – to facilitate the development of movements in the ankle after immobilization; massage of the lower extremities – stimulation of recovery of gastrocnemius muscle function at the 2–3 month after the intervention; ultrasonics with hydrocortisone – contraindicated, as it weakens the reparative

processes in the tendon; vibromassage – contraindicated, since it can cause cystic changes in tendon regenerate. Along with this, the use of local hypothermia, UHF therapy and Bernard currents was practiced to relieve pain, reduce edema of tissues and normalize microcirculation, for improvement of trophism, blood supply and stimulation of the regenerative process, electrostimulation, ozokerite- and paraffin therapy [9; 10; 15; 20].

However, studies of the influence of specific methods of physiotherapy on the regeneration of tendon tissue are single, and the direction itself requires a further more detailed experimental and clinical justification [18; 36].

## Conclusions

Standards of surgical treatment and postoperative protocols of physical rehabilitation of patients with a clearly prescribed sequence of achieving normal or almost normal function are not yet available and this problem remains unsolved.

Taking into account the results of the research, it can be concluded that the results of the restoration of functional capabilities after the achilles tendon rupture depend not only on the use of plaster bandages, langets or brace, but also on the use of physical exercises after immobilization.

Interesting and necessary for the identification of long-term benefits is the study of long-term results of treatment and rehabilitation of patients after surgical treatment of achilles tendon ruptures.

**Prospects for further research** in this area are to develop a physical rehabilitation program and to test the effectiveness of its impact on the function of the lower limb and the quality of life.

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