Conference Paper

Plastic Reconstruction of Dehenerative Achilles Tendon Ruptures Using the Bioprosthesis of Xenopericardium

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Abstract

Two methods for the plastic reconstruction of degenerative Achilles tendon ruptures have been developed, using biological xenopericardium prosthetics. 21 patients were operated. In cases of tendon gliding surface deformation, the insulating plastic reconstruction was used in 14 of them by wrapping the suture area with xenopericardium; the replacement plastic reconstruction was applied in 7 patients. In case of an unrecoverable defect, the tendons were replaced with a specially formed prosthesis. The long-term results of the use of xenopericardium prostheses were compared with the traditional methods. The study involved 120 patients, divided into 5 groups according to the type of surgery: the closed perirocous suture of the Achilles tendon (25 patients), the open stitching of the ruptured tendon (28 patients), the plastic tendon by Chernavsky (24 patients), the tendon plastics by the lavsan ribbon (22 patients) and the tendon grafting with xenopericardium bioprostheses (21 patients). The results were evaluated by the method of Leppilahti J. (1998). The results obtained suggest that the application of xenopericardial prosthetics leads to a significant increase in the number of excellent and good results in comparison with the other methods.

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1. Introduction

Current trends in the regenerative plastic surgery of the Achilles tendon are closely related to the search for bio-integrated materials. A long-term retrospective analysis of the results obtained by domestic and foreign authors [1, 5], who have used the autoplastic methods of Achilles tendon defects, revealed a significant decrease in the quality of life of patients due to prolonged immobilization, which leads both to muscle atrophy and joint contracture as well as to a high percentage of inflammatory complications. The proposed synthetic materials [6] allow eliminating the anatomical

defect of the Achilles tendon, although there is a significant drawback in using "synthetics" that limits its application in the Achilles tendon reconstruction - the difference lies in the biomechanical properties of these materials and the native tendon. This leads to complications such as joint stiffness, restriction in wearing shoes, atrophy and a decrease in the strength of the hind muscles of the shin, as well as a high risk of inflammatory complications [7]. In recent years, there have been reports of successful xenopericardium application in plastic surgery of aponeurosis defects [3], which indicates the possibility of its widespread clinical application in implantology.

The aim of our study was the development and clinical testing of xenopericardial prostheses for reconstructing the Achilles tendon defects.

2. Materials and methods of research

Based on the biomechanical properties and bio-integration data obtained in our early studies [2, 4], we developed two methods for the plastics of closed subcutaneous ruptures of the Achilles tendon by xenopericardium prostheses. Prostheses were made from the "xenopericardial plate" produced by Cardioplant LLC (Penza). The presence of a smooth surface in the xenopericardial plate, which remains intact during the biointegration for a long time, made it possible to use this property to restore the gliding surface of the tendon when it is being separated. At the same time, a twofold increase in mechanical strength of the xenopericardium as compared to the tendon made it possible to completely replace irreparable defects in chronic cases.

An insulating plastic surgery was used for fresh degenerative ruptures without diastasis with extensive fraying of tendon ends (**fig. 1**). A zone of the Achilles tendon damage was exposed with a stick-like incision along the outer surface of the lower third of the shank, the ends of the ruptured tendon were identified and stitched by the Kuehne, Kazakov, Rozov-Vodianov or any other sturdy suture. In degenerative ruptures, as a rule, a considerable deformation and the fraying of the gliding surface of the tendon remain after suturing. To restore the gliding surface of the tendon anterior surface towards the tibia, a xenopericardium plate was sutured two or three centimeters above and below the damaged area. The plate was wrapped around the tendon suture with a smooth surface outward, being villous to the tendon, and was attached by interrupted stitches. After that, the wound was closed in layers, with the mucous sheath of tendon being carefully sutured.

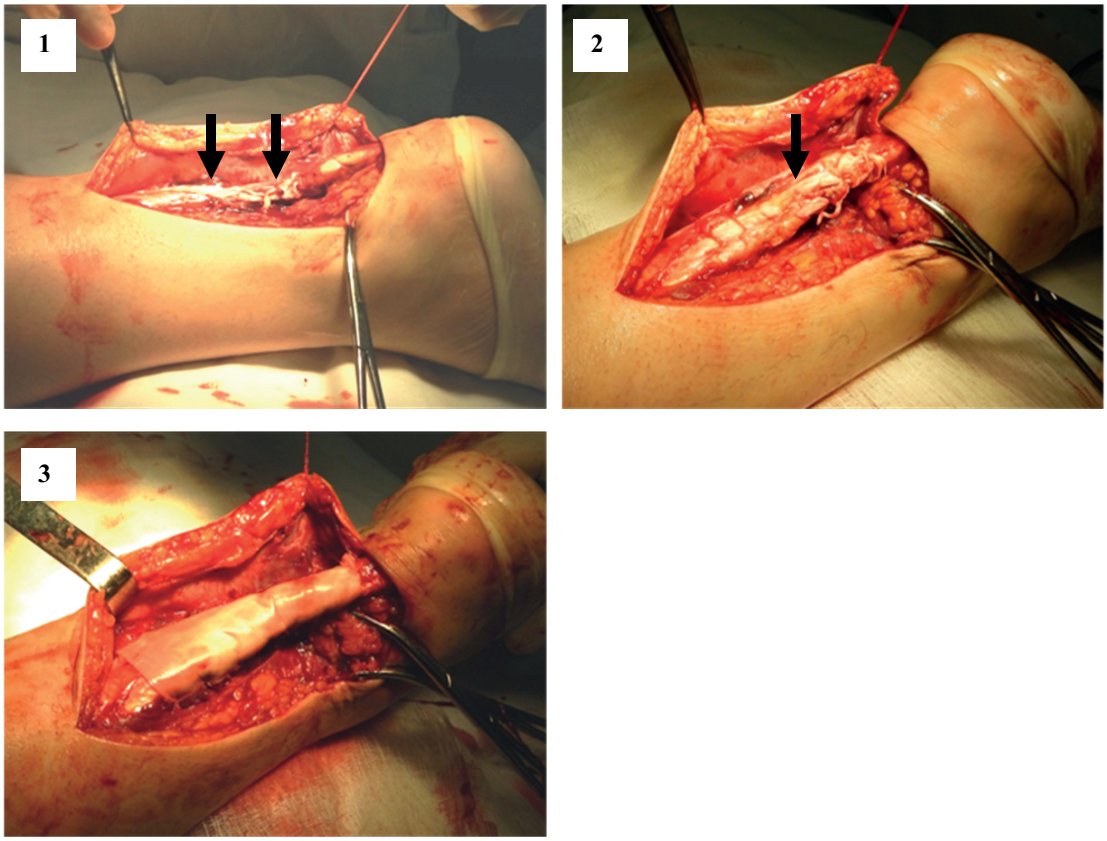

Figure 1: Stages of the insulating plastic surgery of the Achilles tendon. 1. The Achilles tendon injury zone is exposed 2. The suture of the tendon is performed, with the visible deformation of the gliding surface 3. The zone of the tendon suture is wrapped with xenopericardium, with the gliding surface being restored.

The main advantage of the method is an obstacle to the formation of adhesions and scars in the areas of surgical intervention. Due to this fact, the range of movements in the segment was restored completely.

The replacement plastic surgery was performed in cases of chronic ruptures of the Achilles tendon, when there was an unavoidable diastasis between the ends of the tendon (**fig. 2**). Using the similar surgical approach, the ends of the damaged Achilles tendon were identified and its diameter and diastase value were measured. For this purpose, the ankle joint was given a neutral position between flexion and extension, and the proximal end of the tendon was maximally relegated to the heel bone with a ligature stitched through it. A prosthesis was cut off from the xenopericardium plate during surgery. The prosthesis consisted of an applied part directly replacing the defect, and a covering cuff. Then the ends of the tendon were broken down on the frontal plane, and the ends of the prosthesis's applied part were placed into the formed scissures, with the subsequent suturing using interrupted stitches. After that, an area of plastic surgery was wrapped by the prosthesis cuff to restore the gliding surface of the tendon. The cuff was also sutured with fine interrupted stitches.

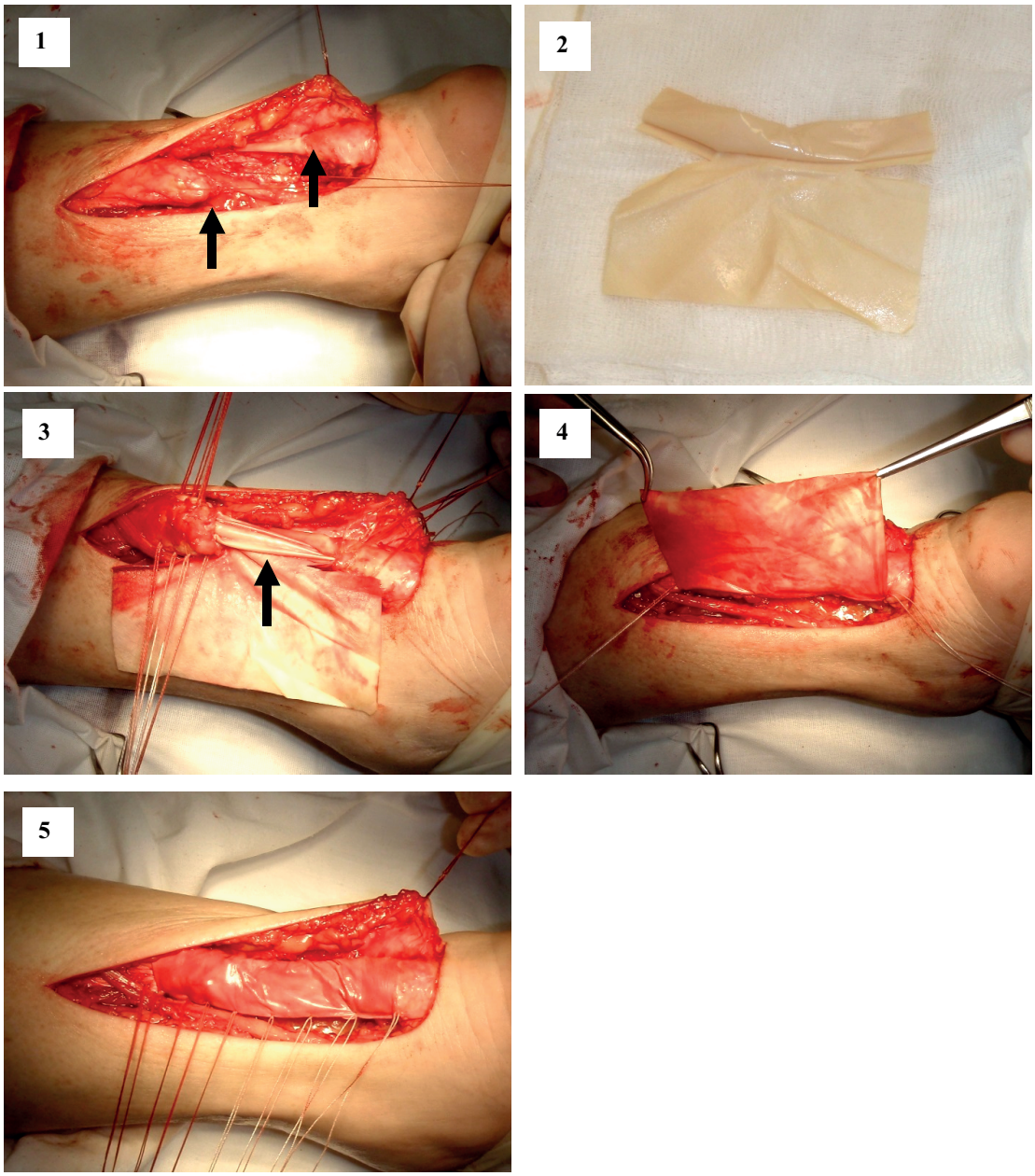

Figure 2: Replacement plastic surgery of the Achilles tendon. 1. The zone of tendon damage is exposed, the fatal sinus defect is 6 cm 2. The tendon prosthesis of the xenopericardium plate is prepared 3. The applied part of the prosthesis is sutured into the tendon defect 4. The covering cuff of the prosthesis is straightened 5. The area of the plastics tendon is wrapped with the cuff of the prosthesis, the gliding surface is restored.

In the postoperative patients, the limb was immobilized in the position of knee flexion at an angle of 120° and maximum flexion of the ankle for 4 weeks. Then, gradually, the knee joint was released, applying a shortened gypsum lingette from the upper third of the shin to the fingertips in the neutral position of the ankle between flexion and extension for 2 weeks. Six weeks after the operation, we began to restore the range of movements. Ability to work was restored 2.5 months after surgery. The regenerative process of the restored Achilles tendon was monitored by the ultrasound

and MRI diagnostics at the outpatient treatment stage. Control studies were performed 2.5 months after surgery before the patient was discharged to resume his working duties and a year after the operation.

Clinical case: *Patient K., 60 years old. She was injured while climbing the stairs (stumbled), felt a moderate pain in the n / 3 of the left shin. She did not seek medical assistance, and treated independently. After 4 months she went to the clinic, and a chronic subcutaneous degenerative rupture of the right Achilles tendon was diagnosed. During the operation, an Achilles tendon injury was found to be 3 cm above the calcaneal tuberge, and an unavoidable diastase of 6 cm was observed between the ends of the Achilles tendon. The replacement plastic surgery was performed using a xenopericardium prosthesis. The postoperative period was found to be within normal limits. A follow-up examination after 1.5 years showed a good restoration of the lower limb function (***fig. 3***). An MRI of the right leg was performed (***fig. 4***), ascertaining the restoration of the Achilles tendon structure along the entire length.*

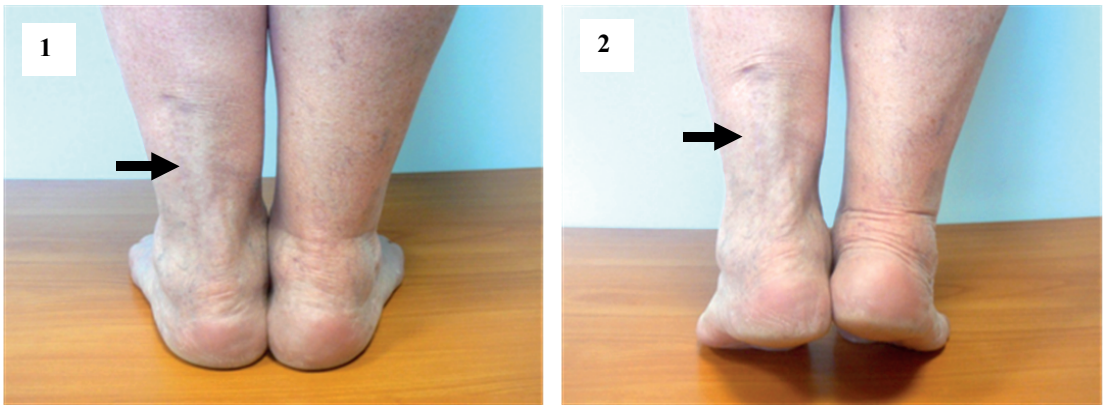

Figure 3: The long-term result of patient K. 1.5 years after the operation. 1. Operated shin, rear view. 2. Achilles tendon function restored.

3. Results and discussion

21 patients were operated on with the described methods, 14 patients underwent insulating plastic surgery, and 7 patients underwent replacement plastic surgery of the Achilles tendon. The results of treatment were compared with the results of patients operated on by traditional methods, divided into 4 groups: closed percutaneous suture (25 patients); open seam by Kuehne, by Kazakov, and by Rozov-Vodyanov (28 patients); plastics by Chernavsky (24 patients); plastics with lavsan ribbon (22 patients).

The effectiveness of surgical treatment was assessed by the method of Leppilahti J., Forsman K. (1998) [7], which involves an assessment of such parameters as: pain (0-15

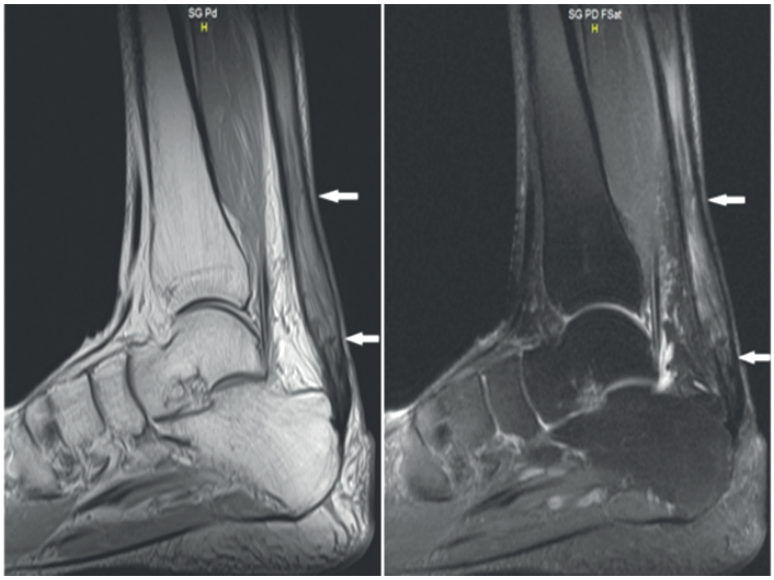

Figure 4: MRI of the left tibia of the patient K. Sagittal sections. The area of the Achilles tendon is designated by arrows.

points); stiffness (0-15 points); decrease in the strength of the hind muscles of the shin (0-15 points); restriction in wearing shoes (0-10 points); differences in the amplitude of movements compared with the contralateral joint (0-15 points); subjective result (0-15 points) and isokinetic muscle strength (0-15 points). The maximum possible score is 100 points. The score of 90 to 100 points is considered to be an excellent result; the score of 75-89 points is "good"; the score of 60-74 is"satisfactory"; <60 - "unsatisfactory".

The mean scores for each criterion in the patient groups are shown in *tab. 1*.

As can be seen from the table, there were statistically significant differences between the comparison group (No. 5) and the control group judging by the parameters of the pain severity in the operative intervention area, ankle joint stiffness, decrease in the strength of the shin hind muscles, differences in the movements amplitude. According to the parameter of the restriction in the wearing of shoes, statistically significant differences were also observed between the patients of group 5, who underwent plastics surgery with xenopericardium, and those of the control groups, except for group 1 (percutaneous suture). Isokinetic muscle strength was also higher in group 5 in comparison with groups 3 and 4. The subjective result was significantly higher in group 5 than in patients of groups 1, 3, 4, except for group 2 (open suture).

The worst results on parameters of pain in the surgical area - stiffness in the ankle joint, decrease in the strength of the shin hind muscles, and restriction in wearing shoes -were observed in groups of patients who underwent the plastics by Chernavsky and with lavsan ribbon.

Table 1: Mean scores by the evaluation criteria of long-term results in patient groups by the Leppilahti J., Forsman K. method.

Group №	1	2	3	4	5	p < 0.05
Group Criterion	Percutaneous suture n = 25	Open suture n = 28	Plastics by Chre-navsky n = 24	Plastics with lavsan ribbon n = 22	Xenopericardial plastics n = 21	
Pain in the surgical intervention area (median)	**10** Q_{25} = 10 Q_{75} = 10	**10** Q_{25} = 10 Q_{75} = 15	**5** Q_{25} = 2,5 Q_{75} = 7,5	**5** Q_{25} = 0 Q_{75} = 5	**15** Q_{25} = 15 Q_{75} = 15	1,2,3,4-5
Stiffness in the ankle (median)	**10** Q_{25} = 10 Q_{75} = 10	**10** Q_{25} = 10 Q_{75} = 10	**5** Q_{25} = 5 Q_{75} = 10	**5** Q_{25} = 0 Q_{75} = 5	**15** Q_{25} = 10 Q_{75} = 10	1,2,3,4-5
Decrease in the strength of the shin hind muscles (median)	**10** Q_{25} = 10 Q_{75} = 15	**10** Q_{25} = 10 Q_{75} = 15	**10** Q_{25} = 5 Q_{75} = 10	**5** Q_{25} = 5 Q_{75} = 10	**15** Q_{25} = 15 Q_{75} = 15	1,2,3,4-5
Restriction in wearing shoes (median)	**10** Q_{25} = 10 Q_{75} = 10	**10** Q_{25} = 5 Q_{75} = 10	**5** Q_{25} = 2,5 Q_{75} = 10	**10** Q_{25} = 5 Q_{75} = 10	**10** Q_{25} = 10 Q_{75} = 10	2,3,4-5
Difference in movements amplitude (median)	**10** Q_{25} = 10 Q_{75} = 15	**10** Q_{25} = 10 Q_{75} = 15	**10** Q_{25} = 5 Q_{75} = 10	**10** Q_{25} = 5 Q_{75} = 10	**15** Q_{25} = 15 Q_{75} = 15	1,2,3,4-5
Isokinetic muscle strength (median)	**15** Q_{25} = 10 Q_{75} = 15	**15** Q_{25} = 10 Q_{75} = 15	**10** Q_{25} = 10 Q_{75} = 10	**7,5** Q_{25} = 5 Q_{75} = 10	**15** Q_{25} = 15 Q_{75} = 15	3,4-5
Subjective result (median)	**15** Q_{25} = 15 Q_{75} = 15	**15** Q_{25} = 10 Q_{75} = 15	**10** Q_{25} = 5 Q_{75} = 10	**10** Q_{25} = 10 Q_{75} = 10	**10** Q_{25} = 10 Q_{75} = 15	1,3,4-5

In the group of patients who were performed plastics with xenopericardial prosthetics, the highest number of score was observed in almost all parameters.

The quality of long-term results in patient groups is presented in *tab. 2.*

As can be seen from the table, the mean score was higher in patients group 5, who underwent xenopericardial tendon plastic surgery compared to the patients in other groups. Excellent long-term results prevailed.

The "good" score was significantly more frequently observed in groups 1 and 2, while the score "unsatisfactory" and "satisfactory" were significantly higher in groups 3 and 4, respectively, compared to group 5.

Table 2: Mean scores by the evaluation criteria of long-term results in groups of patients by the Leppilahti J., Forsman K. method.

Group №	1	2	3	4	5	$p < 0.05$
Group	Percutaneous suture n = 25	Open suture n = 28	Plastics by Chre-navsky n = 24	Plastics with lavsan ribbon n = 22	Xenopericardial plastics n = 21	
Mean score	**78.8 ± 25**	**79.1 ± 28**	**53.3 ± 24**	**46.6 ± 22**	**94.1 ± 12**	1,2,3,4-5
excellent	28.0% (n = 7)	21.5% (n = 6)	0	0	85.7% (n = 18)	1,2,3,4-5
good	64.0% (n = 16)	71.5% (n = 20)	16.6% (n = 4)	4.5% (n = 1)	14.3% (n = 3)	1,2-5
satisfactory	0	3.5% (n = 1)	25.0% (n = 6)	13.6% (n = 3)	0	3-5
unsatisfactory	8.0% (n = 2)	3.5% (n = 1)	58.4% (n = 14)	81.9% (n = 18)	0	3,4-5

4. Conclusions

The results obtained suggest that the application of xenopericardial prosthetics leads to a significant increase in the number of excellent and good results in comparison with the other methods. We believe it is due to the full restoration of the Achilles tendon gliding surface. The worst results were obtained in patients with Achilles tendon grafting using the Chernavsky method or lavsan ribbon.

The developed methods are technically simple and can be proposed for a wide range of applications for surgical treatment of patients with fresh and chronic degenerative ruptures of the Achilles tendon.

Indication for the insulating plastic surgery of the Achilles tendon is the presence of defect-free degenerative ruptures. Indication for the replacement plastic surgery is the presence of an irreparable defect between the tendons ends.

Among the contraindications for the Achilles tendon grafting with xenopericardium are diabetes mellitus, general skin diseases and pyodermatites in the surgical area due to the possibility of the prosthesis rejection and development of purulent complications.

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