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PŮVODNÍ PRÁCE

Donor Site Morbidity after Removal of Full-Thickness Peroneus Longus Tendon Graft for Anterior Cruciate Ligament (ACL) Reconstruction: 4-Year Follow-up

Morbidita odběrového místa po odebrání šlachového štěpu *m. peroneus longus* v plné tloušťce pro rekonstrukci předního zkříženého vazu (ACL): 4leté sledování

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ABSTRACT

PUSPOSE OF THE STUDY

Many studies have investigated the efficacy of peroneus longus tendon (PLT) in anterior cruciate ligament (ACL) reconstruction, and donor site morbidity has not been adequately studied.

MATERIAL AND METHODS

Fifty patients who underwent ACL reconstruction using PLT were included. Ankle strengths of the patients evaluated with an analog dynamometer. Ankle range of motion (ROM) was measured with a smart phone inclonometer application.

RESULTS

There was no significant difference between the postoperative ankle strength(eversion, plantar flexion) in the donor area and the preoperative period (p=0.6 and p=0.7, respectively) and contralateral healthy side (p=0.6, p=0.6, respectively). Ankle ROM angles (dorsiflexion, plantar flexion, eversion, inversion) were significantly lower in the post-operative period compared to the preoperative period and contralateral healthy side (p<0.05, p<0.05, p<0.05, p<0.05, respectively). There was no significant difference between pre-operative and post-operative AOFAS scores (p=0.2).

CONCLUSIONS

Although PLT can affect ROM angles, it is a promising alternative for ACL reconstructions without causing functional morbidity.

Key words: peroneus longus tendon, autograft, anterior cruciate ligament reconstruction, donor site morbidity.

INTRODUCTION

Anterior cruciate ligament (ACL) injuries often require reconstruction, especially in young and active patients. Autografts or allografts used in ACL reconstruction improve knee stability and function (7, 15).

The two most common autografts used for ACL reconstruction are patellar tendon and hamstring autografts. The patellar tendon provides rapid recovery and early rehabilitation by bone-to-bone healing and effective union of the tunnel and graft. Harvesting of the patellar tendon graft is an invasive approach. Patellar fracture may occur during graft harvesting. It also carries the risk of hoffa pad fibrosis and patellar tendon contracture in the donor area (1, 5, 11, 23). The hamstring autograft is easy to obtain with minimal donor site morbidity. However, negative consequences such as unpredictable graft size, saphenous nerve injury and a potential reduction in hamstring strength can occur (16). Moreover, hamstring strength is extremely important in protection after ACL reconstruction (6). An ideal graft for ACL reconstruction should have an acceptable amount of strength and sufficient length. Additionally, graft harvesting should be easy and safe. Therefore, the alternative use of the peroneus longus tendon (PLT) as a graft in ACL reconstruction has become popular. Zhao et al. reported that the anterior half of the PLT has sufficient length and strength to be biomechanically effective as a preferred autograft in ACL reconstruction (24). The increasing use of PLT as a graft has revealed the need for better examination of the donor site.

Some previous case series have reported good clinical outcomes and minimal donor site morbidity for autograft of the peroneus longus tendon in anterior cruciate ligament reconstruction (10, 12). However, negative outcomes due to donor site morbidity have also been reported (3). There are very limited studies on donor site morbidity in the literature. In this study, we com-

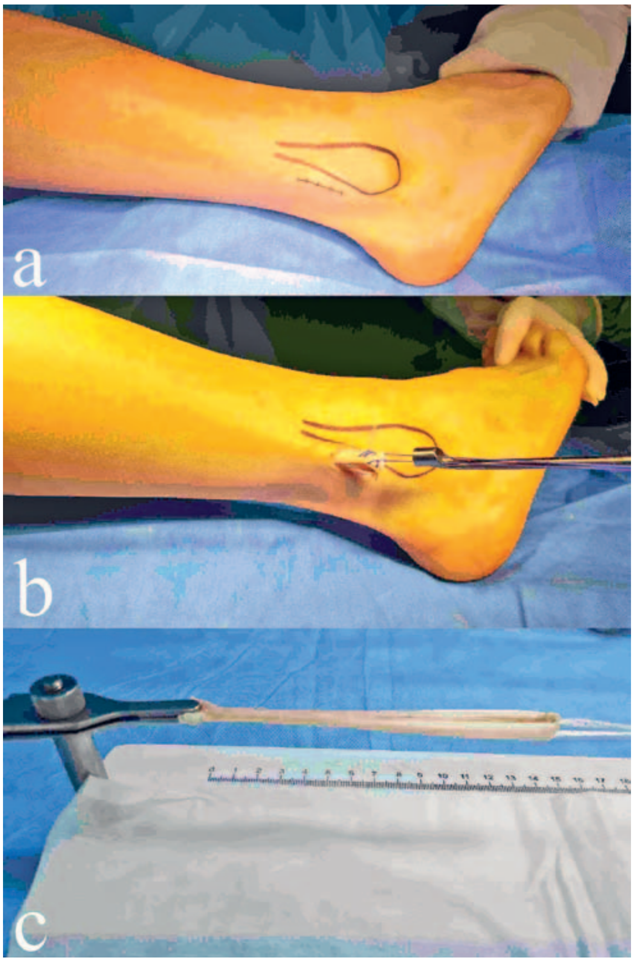

Fig. 1. *Determination of the incision line at the donor site for FTPLT graft retrieval (a), FTPLT graft retrieval phase (b), preparation of FTPLT graft by doubling (c).*

pared the dynamometric muscle strength, ankle range of motion and functional scores of 50 patients who received a full-thickness peroneus longus tendon (FTPLT) graft for ACL reconstruction before, after and on the healthy contralateral side. Unlike existing studies, we evaluated the results with a 4-year follow-up period.

MATERIAL AND METHODS

Study design and patient selection

Fifty patients (mean age 29.3±7.9 years) who underwent repair with FTPLT graft for isolated ACL reconstruction in our Orthopedics and Traumatology clinic between July 2018 and March 2019 were included in this single-center, retrospective study. Patients who had not had previous foot or ankle surgery and who had no permanent ankle injury were included in the study. Patients with foot and/or ankle trauma, history of surgery or peripheral neuropathy were excluded from the study. All surgeries were performed by a single surgeon. Written informed consent was obtained from each patient. The study protocol was approved by the institutional Ethics Committee Approval No: 220/139. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Surgical procedure

The ankle of the side to be reconstructed was used for the anterior cruciate ligament. A 2 cm longitudinal incision was made behind the lateral malleolus. The superior peroneal retinaculum was opened. PLT visualized and exposed. The distal portion of the tendon was cut and extended to the peroneus brevis muscle. Then the tendon was stripped with the help of a stripper. The tendon was folded in half and sutured and the graft was obtained (Fig. 1).

Rehabilitation protocol

All operated patients were included in the ACL rehabilitation program. Quadriceps and joint range exercises were performed and patients were mobilized with crutches at full load. Up to day 45, 90° knee flexion was allowed. Full flexion was allowed after 45 days. Straight running started when he was two months old. All patients were allowed to return to sports at six months. The corset was not used.

Evaluation of ankle muscle strength and range of motion

Ankle range of motion (ROM) (dorsiflexion, plantar flexion, eversion and inversion) was measured at the preoperative term, postoperative donor site and contralateral healthy side in the 4th year follow-up after the operation. Angles were measured using the smartphone inclonometer recording application (14). To measure the ROM of ankle dorsiflexion, plantar flexion, inversion and eversion, the knee was placed 90° flexion in the prone position. While measuring the ankle ROM, the digital inclinometer was positioned on the lateral

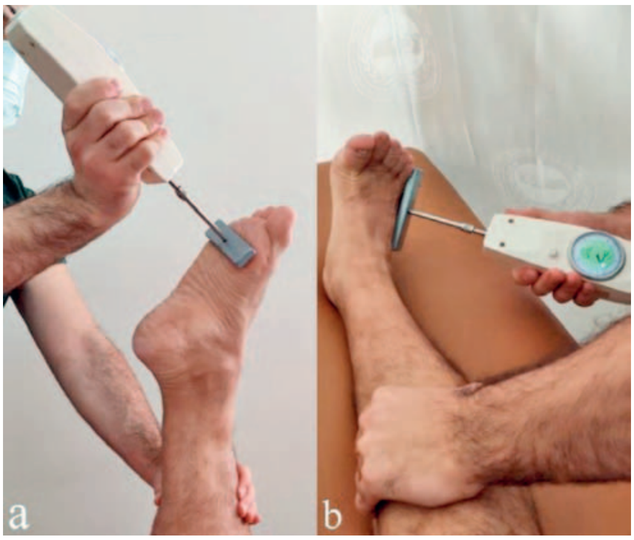

Fig. 2. *Measurement of plantar flexion muscle strength in the prone position with an analog dynamometer (a), measurement of foot eversion muscle strength by fixing the leg in neutral in the supine position with an analog dynamometer (b).*

Table 1. Demographic and clinical characteristics of the patients

		n	(Mean±SD)
Age (mean±SD)		50	29,3±7,9
		n	%
Gender	Female	21	(%42)
	Male	29	(%58)
Side	Left	18	(%36)
	Right	32	(%64)

side of the foot (in line with the fifth metatarsal bone). Verbal instructions were given for all measurements to ensure proper performance during measurement and to verify that the current range was reached.

Ankle strengths (eversion, plantar flexion) were measured preoperatively, postoperatively at the donor site and contralateral healthy side at 4 years post-operatively (July 2018, 2022 and March 2019, 2023). An analog dynamometer was used to measure ankle strength (Fig. 2).

Plantar flexion was measured in the prone position. The ipsilateral distal part of the crural region was supported by the examining physician to minimize the movement of other muscles. Patients were asked to perform plantar flexion movements. The dynamometer was placed on the first and fifth distal metatarsals and muscle strength was recorded from the dynamometer (Fig. 2a).

Eversion was measured in the supine position. The patients were asked to make eversion movements of the ankle. The dynamometer was placed on the fifth metatarsal.

To minimize the movement of other muscles, the crural area of the patients was gently pressed and muscle strength was recorded from the dynamometer (Fig. 2b).

American Orthopedic Foot & Ankle Society (AOFAS) scores were measured for the preoperative and postoperative donor area. AOFAS is specific to the ankle and hindfoot region. The questionnaire contains 9 items distributed over 3 categories: pain (40 points), functional aspects (50 points) and alignment (10 points), a total of 100 points.

The systems incorporate both subjective and objective subscales into numerical scales to describe function, alignment, and pain. Subjective subscales filled in by patients included pain, activity limitations, and walking distance. Objective subscales evaluated by clinicians include gait abnormality, sagittal plane movement (flexion and extension), foot movement (inversion and eversion), and malalignment of the foot. It is not possible to clinically determine the range of motion of the isolated ankle joint; therefore, dorsiflexion and plantar flexion are measured using a goniometer and defined as sagittal movement (2).

All measurements were made by a single surgeon.

Statistical analysis

Statistical analysis was performed using SPSS version 29.0 software. Descriptive data were expressed as mean ± standard deviation (SD), median (min-max), or number and frequency when applicable. The normality distribution was checked using the Kolmogorov-Smirnov test. The significance of the difference between the mean values was examined using Student's t-test, Wilcoxon test and Mann-Whitney U test. For statistical significance, the p value was taken as less than 0.05.

RESULTS

The demographic characteristics of the patients are given in the table (Table 1). When the postoperative ankle strength (eversion and plantar flexion) in the donor area area were compared with the preoperative period, no significant difference was observed ($p=0.6$ and $p=0.7$, respectively) (Table 2). Ankle ROM angles (dorsiflexion, plantar flexion, eversion, inversion) were significantly lower in the postoperative period compared to the preoperative period ($p<0.05$, $p<0.05$, $p<0.05$, $p<0.05$, respectively) (Table 2).

There was no significant difference between postoperative ankle strength (eversion and plantar flexion) and contralateral healthy side strength ($p=0.6$, $p=0.6$, respectively) (Table 3).

In the postoperative period, ankle ROM angles (dorsiflexion, plantar flexion, eversion and inversion) of the donor site ankle were significantly decreased compared

Table 2. Comparison of patients' ankle joint muscle strength, joint range of motion measurements, AOFAS score measurements in the pre--operative and post-operative period

		Pre-operative	Post-operative	P
Ankle strength	**Eversion**	69.06±12.0	67.94±11.6	0.6
	Plantar flexion	154.40±15.2	153.26±15	0.7
Range of motion	**Dorsiflexion**	19.04±0.7	18.4±0.8	p<0.05
	Plantar flexion	47.32±2.8	46.48±2.5	p<0.05
	Eversion	18.52±1.4	16.84±0.9	p:<0.05
	Inversion	32.76±1.2	31.32±1.3	p:<0.05
AOFAS		97.96±1.7	97.54±1.7	0.2

Table 3. Comparison of patients' ankle joint muscle strength, joint range of motion measurements, AOFAS score measurements in the post-operative donor site and contralateral healthy side

		Post-operative	Contralateral	P
Ankle strength	Eversion	67.94±11.6	69.04±11.6	0.6
	Plantar flexion	153.26±15	154.82±15.26	0.6
Range of motion	Dorsiflexion	18.40±0.8	19.62±1	p<0.05
	Plantar flexion	46.48±2.5	48.72±1.3	p<0.05
	Eversion	16.84±0.9	19.48±0.9	p<0.05
	Inversion	31.32±1.3	33.32±1.1	p<0.05

to the contralateral healthy side ankle (p<0.05, p<0.05, p<0.05, p<0.05, respectively) (Table 3).

There was no significant difference between pre-operative and post-operative AOFAS scores in the donor area (p=0.2) (Table 2).

DISCUSSION

PLT graft, which is used in many orthopedic surgeries, has recently started to gain popularity in ACL reconstruction. There are studies comparing PLT autograft with other alternative grafts and showing its superiority (17,19). Despite this, studies on the morbidity of the donor site are still not sufficient. Rhatomy et al. evaluated the donor site morbidity in 31 patients who underwent ACL reconstruction with PLT graft. This study investigated the strength of eversion and first ray flexion, dynamometric measurements and functional scores by comparing them with the donor site and the healthy side after surgery and found no significant difference. (21). In another study, after ACL reconstruction in 28 ankles, no functionally significant difference was found in the donor site in the preoperative and postoperative periods (20). Goyal et al., in a prospective case series, dorsiflexion, plantar flexion, eversion strengths and functional scores were compared with the healthy side in 37 patients who received PLT graft for ACL reconstruction, and no significant difference was found in the 2-year follow-up (8). In our study, no significant difference was found between the dynamometric muscle strength in the donor site and the contralateral healthy ankle before and after surgery. Despite this, we found that the joint range of motion in the donor area was significantly reduced. Similarly, Barzegar et al. found a significant decrease in flexion and extension angles, but did not observe a significant difference in eversion and inversion angles (4). It was concluded that removal of the PLT had no effect on gait parameters and ankle instability and could be used as a graft in orthopedic surgeries. Based on the results of this study, as we determined in our study, the angle measurement values of the joint range of motion in the donor area may vary. We think that PLT graft may be a suitable alternative for ACL reconstruction, since we did not detect any significant changes in functional and clinical outcomes after graft retrieval.

Kerimoglu et al. evaluated 12 patients who received full-thickness PLT grafts for ACL reconstruction at 52 months with MRI to compare the donor area with the healthy side, and regeneration potential was demonstrated (13). In a case series of 21 patients who received PLT grafts, there was no significant difference in plantar flexion strength before and after surgery at a 31.8-month follow-up. However, there was a significant decrease in the eversion strength in the postoperative period. In addition, they detected regeneration in the PLT during MRI controls (22). The current results demonstrate the safety of the donor site with a full-thickness PLT graft with satisfactory clinical ankle results and the potential for regeneration after removal of the PLT.

There is also controversial evidence evaluating ankle functional outcomes after PLT graft removal. In a meta-analysis of 23 studies, He et al. reported that the AOFAS score decreased moderately in 5 studies (9). It was concluded that the moderate low level of functional AOFAS score should be taken into account when graft removal. Angthong et al. reported that eversion and inversion peak torques at the donor site were low in 24 patients who received PLT graft for ACL reconstruction. They did not recommend the use of PLT grafts, although functional results were good (3). Another study reported that the first ray flexion after PLT removal a defect in plantar flexion (12). The function of PLT is to bring the foot to first ray plantar flexion with plantar flexion and eversion of the foot at the ankle joint. First ray plantar flexion of the foot is important for the stance phase of gait. However, the pushing force provided by first ray plantar flexion is important for athletes. We didn't observe such a clinical result in any of the patients since our study consisted of non-athletes. When considering the other function of the PLT, foot eversion, the loss of eversion strength is not as significant as the peroneus brevis is thought to be a more effective ankle evertor. This supports the assumption that there is no significant loss of function in removing the peroneus longus tendon (18).

Although different studies show different results, we did not detect functional and clinically significant morbidity. When we evaluate our study results, removal of the PLT graft may lead to changes in joint range of motion in the donor area. FTPLT graft harvesting provides safe clinical results when applied with the appropriate technique in suitable patients and can be considered as an alternative graft option for ACL reconstruction.

Limitations

This study has some limitations. First, it has a single-center, retrospective design. Second, we were unable to evaluate peroneal tendon regeneration, hypertrophy, or atrophy in the grafted area because postoperative donor site MRI was not performed. Third, the changes in gait stages could not be evaluated because the patients did not have pre-operative and postoperative gait analysis.

CONCLUSIONS

FTPLT autografts are a promising alternative to other autografts in anterior cruciate ligament reconstructions without causing functionally significant morbidity. Large-scale prospective studies evaluating the safety of the technique are needed.

Levels of evidence: *Retrospective study, IV.*

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