

Article

Effect of Peroneus Longus Tendon Harvesting in Anterior Cruciate Ligament Reconstructive Surgery on Ankle and Foot Biomechanics

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Abstract: Background: In this study, we concentrated on the peroneus longus tendon graft's effects on the ankle rather than the knee as in earlier research. Anterior cruciate ligament (ACL) injuries are often seen in sports-related injuries. Although the peroneus longus tendon graft has quickly garnered recognition in the literature, relatively little research has been done on the tendon's stability in the foot-ankle area. Purpose: To evaluate the effect peroneus longus tendon graft used in anterior cruciate ligament reconstruction (ACLR) on ankle eversion power, balance and 1st ray planter flexion strength. Methods: The study included 50 out of 62 patients who met the inclusion criteria and had ACLR using a peroneus longus tendon graft at the same orthopaedics and traumatology clinic between march 2022 and February 2026. The demographic characteristics of the patients were recorded. Ankle strength measurements were performed, and all the patients were tested with the flamingo test, the eyes closed balance test, and the standing on tiptoes test. Results: The dynamometer measurements of the donor side and the contralateral side were compared. No statistically significant difference was determined between the 2 sides with respect to the ankle eversion and plantar flexion strength measurements ($P = .084$, $P = .795$, respectively). A significant result was obtained in the flamingo test ($P = .054$). In the examination of ankle functionality, no statistically significant difference was determined in the Foot and Ankle Disability Index and the American Orthopedic Foot and Ankle Score of the 2 sides ($P = .674$, $P = .312$, respectively). Conclusion: The peroneus longus tendon can be safely used as an alternative autograft in ACLR without causing donor site morbidity or balance of foot.

Keywords: Anterior cruciate ligament reconstruction; peroneus longus tendon; tendon autograft; ankle biomechanics; ankle eversion strength; plantar flexion strength; balance.

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1. Introduction

One of the knee joint's most often damaged elements is the anterior cruciate ligament (ACL) [1]. Meniscal injuries, early osteoarthritic changes, and knee instability may result from untreated ACL injuries [2], [3]. Arthroscopic anatomic ACL repair (ACLR) is now the gold standard therapy for ACL rupture in young, active individuals [4]. Graft selection is still up for discussion, however. Grafts must have biomechanics comparable to the ACL, enable secure and robust fixation, facilitate quick biological integration, and result in little morbidity for the donor [5]. The iliotibial band, quadriceps tendon, hamstring tendon, bone-patellar tendon-bone, and peroneus longus are currently used autograft alternatives. The hamstring tendon, which is also utilised in ACLR, has been the most popular transplant in recent years [6], [7] The anatomical and functional relationship between the peroneus longus and peroneus brevis muscles makes the peroneal muscle group particularly suitable as a tendon source for reconstructive procedures. Since these muscles work together to contribute to ankle stability and movement, the functional consequences of harvesting the peroneus longus tendon can be minimized, even in

situations where tenodesis of both tendons is performed. This biomechanical advantage broadens the potential applications of the peroneus longus tendon as an autologous graft. Accordingly, its use may be considered in several ligament reconstruction procedures, including restoration of the deltoid ligament and reconstruction of the medial patellofemoral ligament. Furthermore, the relatively large diameter that can be obtained from the peroneus longus tendon represents an additional advantage in revision procedures, where a sufficiently robust graft may be required to address previous reconstruction failure and provide adequate structural support. Additional benefits include the absence of knee discomfort and thigh muscle atrophy. Patients who have had foot or ankle surgery and have neurovascular impairments should not utilise this tendon. The peroneus longus has become a potential candidate in the quest for the perfect autograft, however there are worries that it could cause ankle instability [8]. Some surgeons have suggested using a partial graft (the anterior half of the tendon) to minimise donor ankle morbidity [9], [10]. Regular tenodesis of the distal end of the peroneus longus to the peroneus brevis tendon has been highly recommended in order to further limit possible morbidity of donor ankle functions [11], [12].

The few studies in the literature that have compared the peroneus longus tendon with the conventional hamstring autograft in primary ACLR have shown a steady rise. Nevertheless, very few research have looked at the impact of ankle instability when using the peroneus longus as a graft.

The purpose of this research was to investigate the functional and clinical impacts of using the peroneus longus tendon as an autograft for ankle ACLR.

2. Materials and Methods

Patients who had ACLR utilising the peroneus longus tendon graft between 2022 and 2026 were included in this retrospective cohort research. Every patient completed an informed consent form before to the trial, which was created in accordance with the guidelines set out by the clinical research ethics committee.

Patients with isolated ACL injuries who were above the age of 18, of both sexes, had primary anatomic ACLR utilising the peroneus longus tendon graft, and finished at least nine months of follow-up were included in the research. Multiple ligament injuries, a history of arthritis in the afflicted knee or ankle, pes planus valgus, or neuromuscular problems with ankle deformity were all considered exclusion criteria for the research. Additionally, patients who were not located in the follow-up system were not included. For these patients, we favoured the peroneus longus tendon transplant because to its bigger graft diameter, smaller incision, and ability to strengthen the knee region more quickly during the postoperative phase. 62 individuals in all had surgery for the peroneus longus tendon transplant. The research comprised fifty patients in all who satisfied the inclusion criteria. Hospital records provided the patients' surgery and demographic information. The presenting results, intraoperative measurements, and follow-up exams performed at least 12 months after surgery served as the basis for the data. A specialised surgeon (S.E.K.) clinically evaluated each patient throughout the follow-up, and the information was meticulously documented. Every patient had their ankle and first ray strength tested using a dynamometer that was equivalent to the contralateral side.



Figure 1. Balance tests. (A) Flamingo test. (B) Eyes closed balance test. (C) Standing on tiptoe test.

Rehabilitation

Following surgery, patients participated in an ACL rehabilitation program. There was no specific workout regimen used for the foot or ankle. Before being permitted to utilise full weightbearing three weeks after surgery, patients were instructed to exercise the damaged limb using partial weightbearing. Following surgery, knee extension started right away. Up to three weeks after surgery, knee flexion was progressively raised from 0° to 90° until reaching complete flexion. After two months, the patient was permitted to jog. After completing functional outcome assessments after six months, patients were permitted to resume participating in sports [13].

Ankle Isokinetic Muscle Strength Test

Nine months after surgery, the outcomes of muscular strength tests were gathered. First ray plantarflexion and bilateral angle eversion were examined. The mean strength value was noted after each muscle strength assessment was carried out three times. To prevent research bias, all muscular strength measures were performed by the same operator, S.E.K.

The supine posture was used to measure eversion. The patients were instructed to evert their ankles. The fifth metatarsal was the point of resistance. Following surgery, patients completed an ACL rehabilitation program. The crural area was gently compressed to reduce the movement of other muscles, and muscular strength was measured in relation to the contralateral side. There was no specific workout regimen used for the foot or ankle. Before being permitted to utilise full weightbearing three weeks after surgery, patients were instructed to exercise the damaged limb using partial weightbearing. Following surgery, knee extension started right away. Up to three weeks after surgery, knee flexion was progressively raised from 0° to 90° until reaching complete flexion. After two months, the patient was permitted to jog. After completing functional outcome assessments after six months, patients were permitted to resume participating in sports [13].

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Figure 3. Eversion force measurement in the left ankle.

First ray plantarflexion was measured in the prone position. The ipsilateral knee joint was flexed 90°. The ipsilateral distal part of the crural region was maintained using the hands of the examiner's assistant to minimize the movement of other muscles. Patients were asked to make first ray plantarflexion movements. Muscle strength was recorded [13] also with comparison (fig.4).



Figure 4. First ray plantarflexion force measurement in the left ankle.

Surgical Technique

Every patient had elective surgery while under general or spinal anaesthesia, recumbent, and with a tourniquet in place. All of the grafts were harvested by two expert surgeons (S.E.K., R.D.). The fibula was designated two centimetres proximal to the distal end for the peroneus longus tendon transplant. The tendon that passed through the skin and subcutaneous tissue was above the incision line, which was determined to be around 2 cm. The more lateral and superficial peroneus longus was lifted after the tendon fascia was opened using a clamp. The distal portion of the tendon was sutured with a primary suture (two Vicryl sutures) (Ethicon), while the proximal portion was sutured with a

Krakow suture (two Vicryl sutures) (Figure 5). Using a knife, we split the peroneus longus tendon into its proximal and distal sections. Two Vicryl sutures are used to attach the distal portion to the peroneus brevis tendon (Figure 6). In order to avoid damage to the peroneal nerve, a finger placed 6 to 8 cm distal to the fibula head ensures that the tendon stripper does not continue upward (Figure 7) [14].

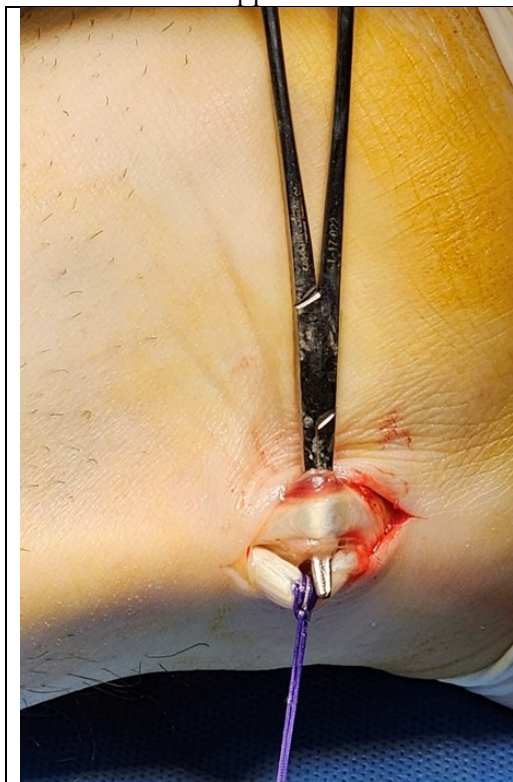


Figure 5. Isolation of the peroneus longus tendon for harvesting in the right ankle.

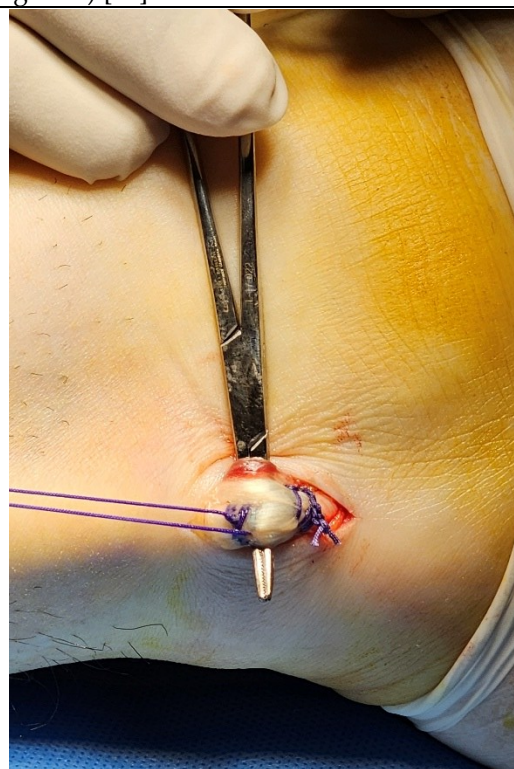


Figure 6. tenodesis of peroneus longus to peroneus brevis on right ankle



Figure 7. The peroneus longus tendon in the right ankle is stripped with a tendon stripper.

Statistical Evaluation

Data obtained in the study were analyzed statistically using Statistical Package for the Social Sciences for Windows Version 20.0 software (IBM). When comparing the data of groups separated according to the side of surgery, the median difference was examined with the Mann-Whitney *U* test. Conformity of the data to normal distribution was assessed with the Shapiro-Wilk test. Variables with a normal distribution were evaluated using the independent samples *t* test, and those not showing a normal distribution were evaluated using the Mann-Whitney *U* test. Statistical significance was set at $P < .05$. The power analysis of our study was performed, and according to the output of the G*Power program used for power analysis, when the effect size was taken as 0.8, the sample size was 20, and the power of the study was calculated as 0.80. This value demonstrates that our research is well-powered.

3. Results

The study included 50 patients who underwent evaluation, comprising 45 males and 5 females. The participants had a mean age of 31.32 ± 5.95 years, with individual ages ranging from 18 to 42 years. Clinical follow-up was conducted for an average duration of 11.5 months, with the observation period varying between 9 and 15 months. Regarding the side of knee involvement, injuries affected the right knee in 32 cases, whereas the remaining 18 patients had an injury involving the left knee. Sports-related trauma represented the predominant cause of injury and was reported in 38 patients. In addition, 5 cases were associated with occupational accidents, while 7 patients sustained their injuries in traffic-related accidents. During the surgical procedure, the harvested peroneus longus tendon graft was measured directly. The mean graft diameter was 9.52 ± 0.72 mm, ranging from 7 to 10 mm, while the average graft length was 22.8 cm, with measurements extending from 20.6 to 26.4 cm. These graft-related measurements are summarized in (Table 1). Because the peroneus longus tendon contributes substantially to ankle eversion and plantar flexion, postoperative ankle function was specifically assessed by measuring muscle strength during both movements, as presented in (Table 2).

Table 1. Characteristics of the Patients and Grafts

Age, years, mean $\pm$ SD (range)	31.32 $\pm$ 5.95 (18-42)
Sex	
Male	45
Female	5
Injured side	
Right	32
Left	18
Mechanism of injury	
Sport	38
Work injury	5
Traffic accident	7
Graft diameter, mm, mean (range)	8.4 (7-10)
Mean follow-up duration months (range)	11.5 (9-15)
Graft length, cm, mean (range)	22.8 (20.6-26.4)

Table 2. Strength Measurements of the Ankle in Eversion and Plantar Flexion

Strength, N	Donor Side		Contralateral Side		<i>P</i>
	Mean $\pm$ SD	Range	Mean $\pm$ SD	Range	
Eversion	90.10 $\pm$ 33.43	60-172	94.40 $\pm$ 24.69	67-142	.084
Plantar flexion	181.70 $\pm$ 31.67	143-257	183.62 $\pm$ 33.66	132-250	.795

The mean eversion strength was 85.10 $\pm$ 33.43 N on the donor side and 94.40 $\pm$ 24.69 N on the contralateral side. This difference was not statistically significant ($P = .084$).

The mean plantar flexion strength was 190.70 $\pm$ 31.67 N on the donor side and 187.62 $\pm$ 33.66 N on the contralateral side. This difference was not statistically significant ($P = .795$).

The balance test measurements were considered crucial for assessing the proprioception of the tendon graft in patients, and these measurements were taken and recorded in seconds (Table 3).

Table 3. The Durations of the Balance Tests of the Patients

Duration, Seconds	Donor Side		Contralateral Side		<i>P</i>
	Mean	Range	Mean	Range	
Flamingo test	67.50	28-90	86	30-100	.054
Eyes closed balance	16.50	3-40	23.50	7-45	.325
Standing on tiptoe	5.50	1-23	10	3-42	.111

The bold *P* value indicates statistical significance.

In the flamingo test, the mean times were 67.50 seconds on the donor side and 86 seconds on the contralateral side. This difference was statistically significant ($P = .054$).

In the eyes closed test, the mean times were 16.50 seconds on the donor side and 23.50 seconds on the contralateral side. This difference was not statistically significant ($P = .325$).

In the standing elevated on the tiptoes test, the mean times were 5.50 seconds on the donor side and 10 seconds on the contralateral side. This difference was not statistically significant ($P = .111$).

Although only the flamingo test showed a deficit, the measurements in the other tests are small and may be underpowered, which may represent a balance deficit.

the FADI and AOFAS scoring systems (Table 4).

Table 4. FADI and AOFAS Scores

Score	Donor Side		Contralateral Side		<i>P</i>
	Mean $\pm$ SD	Range	Mean $\pm$ SD	Range	
FADI	88.54 $\pm$ 0.54	87.50-100	90.56 $\pm$ 0.61	89.45-100	.674
AOFAS	97.80 $\pm$ 3.22	90-100	98.78 $\pm$ 3	90-100	.312

AOFAS, American Orthopaedic Foot and Ankle Society; FADI, Foot and Ankle Disability Index.

The mean FADI scores were 88.54 $\pm$ 0.54 on the donor side and 90.56 $\pm$ 0.61 on the contralateral side. This difference was not statistically significant ($P = .674$).

The mean AOFAS scores were 97.80 $\pm$ 3.22 on the donor side and 98.78 $\pm$ 3 on the contralateral side. This difference was not statistically significant ($P = .312$).

From the total of 50 patients in the present study, hypoesthesia in the incision line was observed in 4 patients, and swelling in the incision site in 7 patients after harvesting of the peroneus longus tendon graft. All of these complications completely recovered after 6 months. After this swelling, which was observed in the early period because of the knot remaining lateral to the 2 Vicryl sutures used for tenodesis between the peroneus longus

and the peroneus brevis, tenodesis was performed so that the 2 Vicryl sutures and the knot would remain more anteromedial. No other complications were observed.

To prevent peroneal nerve damage while using the tendon stripper, the other hand should be placed 6 to 8 cm distal to the fibula head so that the patient can feel the tendon stripper.

4. Discussion

The peroneus longus tendon graft is a viable graft option for ACLR despite concerns regarding donor site morbidity. The present study was conducted to examine the effects of peroneus longus tendon graft harvest on the donor ankle. The results of this study showed that in our sample of 50 patients undergoing ACLR using an ipsilateral peroneus longus autograft, ankle strength, stability, and functional scores were not significantly different from the contralateral side at a minimum of 12-month follow-up. The findings of Rhatomy et al [13] are in parallel with the present study results in this respect. However, in a study by Angthong et al, [8] concerns were raised about a decrease in ankle eversion strength and function. In this study, donor side morbidity was evaluated more objectively with the tests and measurements applied to the patients, and it was shown that the peroneus longus tendon graft can be used safely. However, there may be a deficit in balance. In a similar study by Vijay et al, [15] no statistically significant difference was found in ankle eversion strength on the donor side compared with the contralateral ankle eversion. No ankle instability or reduced ankle movement was reported (AOFAS mean, 96.43 ± 3.13).

The normal ACL strength [16] is 1725 ± 269 N. The peroneus longus tendon strength was defined as 1950 N by Kerimoğlu et al, [1] showing similar strength as the natural ACL. In recent literature, a graft diameter of ≥ 8 mm is now accepted in ACLR. It has been previously reported that the peroneus longus tendon graft is more advantageous than the hamstring in terms of diameter and tensile strength [17]. It is much more advantageous in the knee region compared with the hamstring graft, especially after ACLR. Vijay et al [18] evaluated knee functions in 140 patients and obtained better results compared with hamstring graft use in both the International Knee Documentation Committee (IKDC) and Mental Component Score scores ($P = .803$, $P = .161$, respectively). The 2-year follow-up results of patients who underwent ACLR with the peroneus longus tendon graft were reported, and excellent IKDC, mental component score, Tegner-Lysholm, AOFAS, and FADI scores were observed. A better graft diameter was obtained, along with less thigh hypotrophy, excellent ankle function results, and better results in a series of jumping tests [19]. In a systematic examination and meta-analysis of ACLR with hamstring and peroneus longus autografts in 925 patients by He et al, [14] the Lysholm and IKDC scores of the peroneus longus group were observed to have improved more than those of the hamstring group. However, there was no difference in the FADI score.

In a study of 82 patients by Cakar et al, [20] complications were observed: hypoesthesia in the distal foot in 15 patients, compartment syndrome in 2, and hyperalgesia over scar tissue in 2. The most common complication is iatrogenic damage to the distal fibres of the sural nerve. Hypoesthesia may be observed, as it provides a cutaneous branch to the skin on the lateral side of the foot. In that study, the procedure was performed with an incision from 3 different sites (fibula proximal-distal-lower end). In contrast, the method in the present study was performed with a single incision, which was considered to be sufficient and less invasive [20]. Unlike other studies, this study examined the balance status of patients to emphasize the importance of proprioception. Although significance was observed in the flamingo test ($P = .049$), no statistically significant results were obtained in the eyes closed balance test, the standing on tiptoe test, or the Y test. The times measured in the balance tests were shorter on the donor side, indicating the need to provide a proprioception-strengthening exercise program for all patients.

The limitations of this study are a small sample size, a short follow-up period, and a lack of comparison between pre- and postoperative results. Another shortcoming of this

study was its retrospective nature. Also, the small number of participants may leave some of the comparisons underpowered.

5. Conclusion

There remains an insufficient number of studies on this subject in the literature. The results of the present study demonstrated that the peroneus longus tendon can be safely used as an autograft in ACLR. After graft harvesting, patients should participate in a regular rehabilitation program supported by proprioception, balance, and strengthening exercises. In addition to the comfort and practicality of graft harvesting, it can be used as an autograft in many areas. There is also the cosmetic advantage of a small incision, which is not always visible, as a sock may cover it.

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