Evaluation of ankle and foot functions after peroneus longus harvesting in anterior cruciate reconstruction: a prospective clinical study

Elsayed Morsi[a], Adel Elseedy[a], Ahmed Alzafarany[a], Aya Morsi[b], Mustafa Mesriga[a]

[a]Department of Orthopedic Surgery, Faculty of Medicine, Menoufia University, Menoufia, [b]Department of Pathology, Faculty of Medicine, Alexandria University, Alexandria, Egypt

Correspondence to Ahmed Alzafarany, BSc, Department of Orthopaedic Surgery, Faculty of Medicine, Menoufia University, Menoufia, Egypt
Tel: +20 100 052 7546;
e-mail: zafarany.ortho@gmail.com

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Background
Anterior cruciate ligament (ACL) injury is one of the most common knee injuries; with an estimated 200,000 injuries in the United States annually. ACL reconstruction is the gold standard for restoring knee stability to reduce the risk of secondary meniscal tears and symptomatic osteoarthritis. It requires either an autograft, allograft or artificial graft.
Objective
To evaluate the ankle and foot functions after harvesting in ACL reconstruction (ACLR).
Patients and methods
This prospective clinical study included 20 patients who underwent ACLR using the peroneus longus tendon as an autograft. American Orthopedic Foot and Ankle Society (AOFAS) score was used to assess the function of the foot and ankle after harvesting the peroneus longus tendon. The normal and the donor sides were compared.
Results
Three months postoperatively, the mean AOFAS score on the normal side was 100±0, while on the donor side, it ranged from 90 to 96 with a mean of 91.1±0.78 (highly statistically significant difference at $P<0.001$). At the same time, the mean dorsiflexion and plantar flexion on the normal side were 17.65±1.89 and 47.7±2.38, respectively. In contrast, on the donor side, the mean was 13.05±1.50 and 43.4±2.34 (highly statistically significant difference at $P<0.001$). At the 6-month follow-up examination, the mean AOFAS score on the normal side was 100±0, while on the donor side, it ranged from 98 to 100 with a mean of 99.7±0.95. (No statistically significant difference at $P<0.001$). Also, the mean dorsiflexion and plantar flexion on the donor side were 17.4±1.63 and 47.3±2.34, respectively, with no statistically significant difference.
Conclusion
There was a statistically significant difference in the functional outcomes between the donor and the normal sides three months postoperatively. However, at a 6-month follow-up, both the donor and the normal side had nearly the same functional outcomes.

Keywords:
anterior cruciate ligament, American orthopedic foot and ankle society score, longus harvesting, peroneus longus tendon, sound sides

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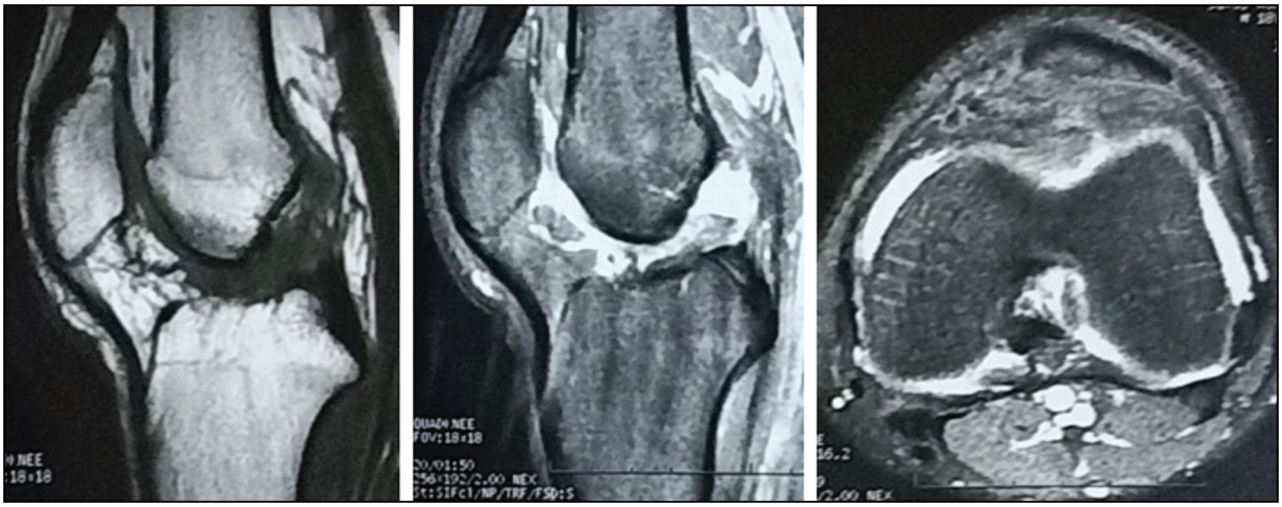
Introduction

Anterior cruciate ligament (ACL) injury is one of the most common knee injuries, with an estimated 200 000 injuries in the United States annually [1]. ACL reconstruction (ACLR) is the current gold standard for restoring knee stability to reduce the risk of secondary meniscal tears and symptomatic osteoarthritis [1].

Several autograft options are currently used for ACLR, such as bone-patellar tendon-bone and hamstring tendon (HT). Each of these autografts has advantages and disadvantages [2]. While having the most extended history of use, the bone-patellar-bone autograft can be complicated by anterior knee pain and associated with postoperative patella fracture, fat pad fibrosis, or patellar tendon contracture [3,4]. Another important drawback of this autograft is that the surgeon cannot control the length of the graft being harvested, which may further complicate the procedure if there is excessive shortening or lengthening of the bone.

Figure 1



MRI of the knee with anterior cruciate ligament tear.

An alternative to this is the HT autograft, which can be used but can cause a significant change in hamstring muscle strength [5]. If medial collateral ligament injury is present along with ACL injury, harvesting the HT can lead to medial instability of the knee joint. Normal hamstring function is essential in ACL reconstructed patients as it protects the newly reconstructed ACL from anterior drawer force excreted by quadriceps contraction [6,7].

The prerequisites for a donor site to be an ideal source of autografts should be that it has an acceptable amount of strength and can be safely and efficiently harvested with no apparent functional impairment after its removal from the donor site. The peroneus longus tendon (PLT) is a good choice as a potential autograft, as it has good bio-mechanical properties of high failure loading and stiffness [8]. This study aimed to evaluate the ankle and foot functions and compare the donor and sound sides after peroneus longus harvesting in ACLR.

Patients and methods

This prospective clinical study included 20 patients complaining of ACL injuries and presented to the orthopedic surgery clinics of Menoufia University Hospital and Rashid General Hospital from June 2023 to January 2024 and followed-up for 6 months after surgical intervention.

Ethical consideration

Approval from the ethical committee in University Hospitals was obtained, and Written informed consent was obtained from patients. Before patients were admitted to this study, the purpose and nature of the research and the risk-benefit assessment were explained to them.

Patient selection

This study included patients aged 18 years or older diagnosed with ACL tears on clinical and radiological examination (magnetic resonance imaging [MRI] (Fig. 1). All patients had normal ankles. However, we excluded associated ligaments or meniscal injuries of the knee, abnormal function of ankle or foot joints such as flat foot, pes cavus, history of ankle fracture, osteochondral injury, and ligamentous injury.

Demographic data

The age in the study population ranged from 19 to 45 with a mean±SD of 28.95±7.13 years. The were 15 (75%) male patients, and five females. Number of Smoking patients in the study was two (10%). The number of patients who were workers was six (30%), (Table 1).

Clinical examination

All patients were subjected to complete history taking including personal history (name, age, sex, occupation, smoking), complaint and its duration, medical diseases history, and history of previous operations.

General examination

Vital signs were examined including blood pressure, temperature, heart rate, and respiratory rate.

Local examination

Examination of the ankle and knee joints was done (Fig. 2). A gait examination was mandatory.

Table 1 Demographic and occupational data among the study population

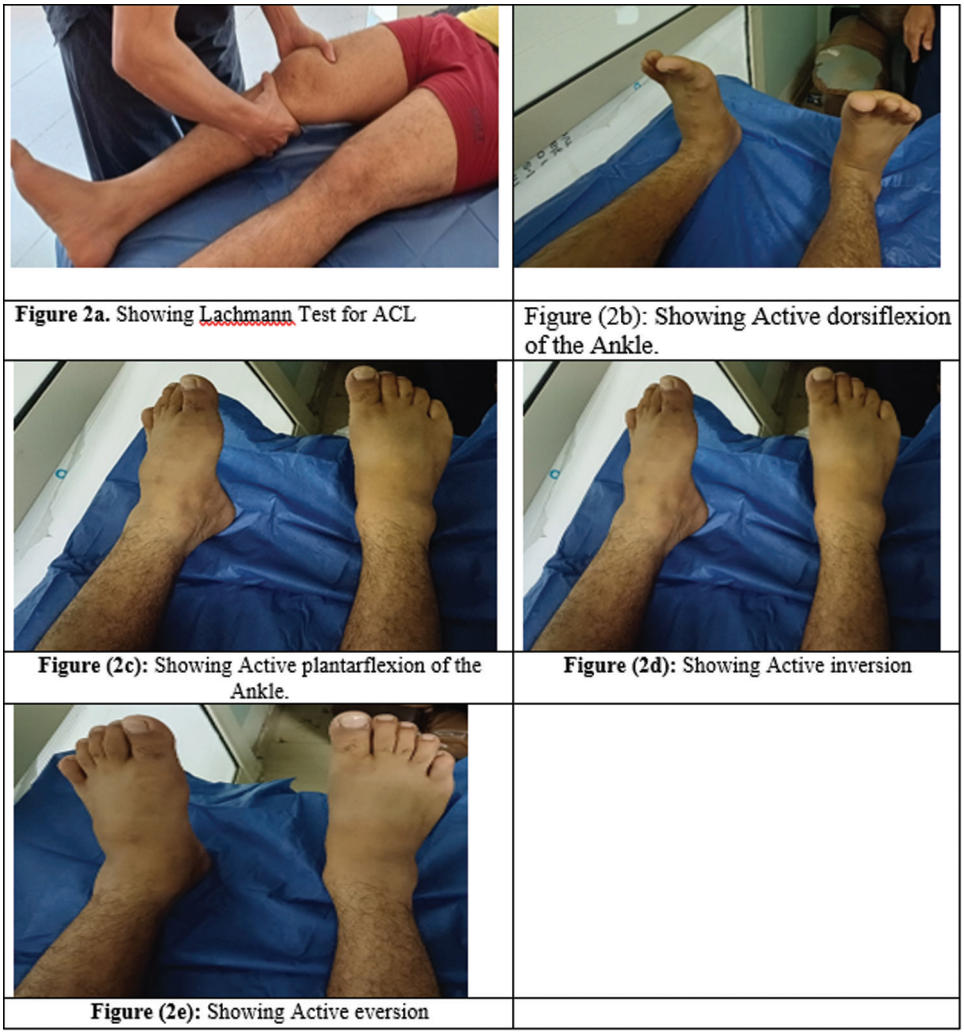
	Study population (*n*=20)
Age	
Mean±SD	28.95±7.13
Median (IQR)	27.5 (22.75–34)
Range (minimum–maximum)	26 (19–45)
Sex, *n* (%)	
Male	15 (75)
Female	5 (25)
Smoking, *n* (%)	
Yes	2 (10)
No	18 (90)
Occupation, *n* (%)	
Worker	6 (30)
Student	5 (25)
Accountant	2 (10)
Engineer	1 (5)
Employer	1 (5)
Nurse	1 (5)
Teacher	1 (5)
No	3 (15)

Surgical procedure

With patients in the supine position and knee in full extension, a 4 cm long longitudinal incision was made, 3 cm above and 1 cm behind the lateral malleoli. Dissecting through the subcutaneous tissue and superficial fascia, the PLT and peroneus brevis tendon were identified. PLT was sutured with peroneus brevis with nonabsorbable sutures and then divided. Then, PLT was stripped using a stripper until 5 cm below the fibular head to prevent peroneal nerve injury. The donor site was closed with vicryl sutures, and a sterile dressing was applied. Then, the length of the graft was noted.

The graft was pulled through the femoral tunnel and passed through the tibial tunnel. The graft was passed freely through the tibial and femoral tunnels until the quadruple graft portion occupied both tunnels. The graft is then pulled, and Tight Rope devices are fixed to the femur. The next step is to fix the inferior end of the quadruple graft to the tibia interference screw after

Figure 2



(a–e): Lachmann test for anterior cruciate ligament injury and preoperative foot and ankle movement.

Figure 3

(a–d): Postoperative foot and ankle examination. Figure (3a): Showing resisted dorsiflexion of ankle, (3b): Showing resisted plantarflexion of ankle, (3c): Showing active inversion, (3d): Showing active eversion.

pre-tensioning. Fixation is performed with the graft tensioned and the knee in 30° flexion.

Follow-up and outcome evaluation

Donor-site morbidity was assessed and compared with the normal side before surgery and at 3 and 6 months after surgery using American Orthopedic Foot and Ankle Society (AOFAS) scoring system, range of motion (ROM), and muscle strength scale (Fig. 3).

Postoperative medications including analgesics, prophylactic anticoagulants, and antibiotics were given for two weeks. The hospital stay was two days.

Statistical analysis

All data were collected, tabulated, and statistically analyzed using SPSS 26.0 for Windows (SPSS Inc., Chicago, IL, USA). Qualitative data were described using numbers and percentages. Quantitative data were described using range (minimum and maximum), mean, standard deviation, and median. The tests used were a χ^2 test of significance used to compare proportions between qualitative parameters and an Unpaired *t* test (*t*) For customarily distributed quantitative variables to compare two groups. All statistical comparisons were two-tailed, with a significant level of *P* value less than or equal to 0.001 indicating significance; *P* less than 0.001 indicates a highly significant difference, while *P* greater than 0.05 indicates a nonsignificant difference.

Results

Postoperative complications included one (5%) patient who had an Infection, one patient who had persistent ankle pain, and one patient who had Neurological complications (Table 2).

Three months postoperatively, AOFAS score on the sound side was 100±0, while on the donor side, it ranged from 90 to 96 with a mean 91.1±0.78. This is found to be the highly statistically significant difference at *P* less than 0.001. At 6 months follow-up examination, the AOFAS score on the donor side ranged from 98 to 100 with a mean of 99.7±0.95 with no statistically significant difference (*P*=0.166).

As regards the muscle strength scale, 100% of patients had grade 5 on the sound side, while after 3 months postoperatively, 50% of patients had grade 4 and the other 50% had grade 5. This is found to be the highly statistically significant difference at *P* less than 0.001. At 6 months of follow-up, only 5% of patients had grade 4 and the other 95% had grade 5 with no statistically significant difference (*P*=0.331).

Table 2 The intraoperative and postoperative complications distribution among the study population

	Study population (*n*=20)
Hemorrhage	0
Femur fracture	0
Tibial fracture	0
Button failure	1(5)
Screw failure	1 (5)
Infection	0
Acl failure	0
Ankle instability	0
Persistent ankle pain	1 (5)
Neurological complications	1 (5)

In this study, dorsiflexion of the ankle on the sound side ranged from 15 to 20 with mean±SD=17.65±1.89, while in the 3-month follow-up examination, dorsiflexion on the donor side ranged from 12 to 17 with mean±SD=15.05±1.50 (highly statistically significant difference at *P*1<0.001). Six-month follow-up examination showed that dorsiflexion on the donor side ranged from 15 to 20 with mean±SD =17.4±1.63 (no statistically significant difference at *P*=0.656).

Additionally, the mean plantar flexion on the sound side was 47.7±2.38. At 3 months postoperatively, the Plantar flexion in the donor's ankle ranged from 42 to 50 with a mean of 45.4±2.34, with a statistically significant difference (*P*=0.003). This was improved at 6 months follow-up examination to be ranged from 44 to 52 with a mean of 47.3±2.34 with no statistically significant difference (*P*=0.59), (Table 3).

The mean eversion on the sound side was 16.55±1.46. In the donor ankle, the eversion ranged from 14 to 15.5 with a mean of 14.6±1.18 at 3 months follow-up. This had been improved to range from 15 to 17.5 with a mean 16.3±1.26 at 6 months postoperatively. Also, there is an inversion (degree) of follow up (FU) data among the study population.

Also, inversion on the sound side ranged from 30 to 35 with a mean of 31.65±1.63.

At 3 months of follow-up examination, Inversion on the donor's ankle ranged from 28 to 33 with a mean of 30.1±1.61, with a statistically significant difference (*P*=0.004). This had nearly returned to normal after 6 months, with a range from 29 to 34 with a mean 31.3±1.49 (no statistically significant difference at *P*=0.482), (Table 4).

Discussion

In the current study, the AOFAS score in the donor ankle after three months post-operatively ranged from 90 to 96 with a mean 91.1±0.78, with a highly statistically significant difference. In a 6-month FU examination, the AOFAS score ranged from 98 to 100 with a mean 99.7±0.95 with no statistically significant difference (*P*=0.166). Our results concur with the results of Trung *et al.* [9] who reported that the average AOFAS score 6 months after the operation was 97.2±1.6 points, ranging from 93 to 100. One patient had an AOFAS score of 88 points because of inadequate postoperative physical therapy. Similarly, a study on 16 patients conducted by Sasetyo *et al.* [10] found no significant ankle or foot disability in patients undergoing ACL reconstruction with peroneus longus grafting at a 6-month postoperative period. Another study by Hijas Ismail and Mammu [11] reported that the average AOFAS score preoperatively was 98.12; at 6 months postoperatively it was 95.44 and at 12 months postoperatively it was 96.4 (*P*=0.091).

In our study, postoperative complications included one (5%) patient who had an Infection, one patient who had persistent ankle pain, and one patient who had Neurological complications. In agreement with our study, Zhang *et al.* [12] reported that one patient experienced superficial peroneal nerve inflammation symptoms during follow-up. The symptoms gradually diminished and disappeared after 3 months with oral vitamin B and physical therapy. This complication may be related to blunt trauma during tendon harvesting. Moreover, Keyhani *et al.* [4] found no significant pain or donor site complications close to the lateral malleolus after harvesting the PLT.

Our study showed that there is a highly statistically significant difference between the normal and donor ankles in degrees of dorsiflexion and plantar flexion at 3 months follow-up. At 6 months postoperatively, both ankles had nearly similar functions and ROM. Zhang *et al.* [12] reported that statistical differences in ankle dorsiflexion and plantar flexion angles between the affected and unaffected sides were not observed, suggesting that the deficit of the PLT had no significant impact on the ankle dorsiflexion. This may be attributed to compensatory actions by muscles such as the soleus, gastrocnemius, posterior tibialis, and peroneus brevis. Another study by Shi *et al.* [13] found that no significant differences were observed in ankle dorsiflexion strength pre-operatively and at 12 and 24 months postoperatively of the PLT-resected donor ankle.

Shi *et al.* [13] found there were also no marked differences in ankle plantar flexion strength preoperatively (147.96±0.38 N) and postoperatively (147.76±0.25 N at 12 months and 150.22±0.35 N at 24 months) of the donor's ankle. Another study by Karanikas *et al.* [14] found no difference in isokinetic strength for first-ray

Table 3 Distribution of American orthopedic foot and ankle society, muscle strength scale, dorsiflexion, and Plantar flexion (degree) follow-up data among the study population

	Sound side (normal) (*n*=20)	3 months FU (donor side) (*n*=20)	6 months FU (donor side) (*n*=20)	*P* value
AOFAS Score				
Mean±SD	100±0	97.1±0.78	99.7±0.95	*P*1<0.001 *P*2=0.166
Median (IQR)	–	97 (96.5–98)	100 (99–100)	
Range (minimum–maximum)	–	2 (96–98)	2 (98–100)	
Muscle strength scale				
Grade 4	0	10 (50)	1 (5)	*P*1<0.001 *P*2=0.311
Grade 5	20 (100)	10 (50)	19 (95)	
Dorsiflexion (degree)				
Mean±SD	17.65±1.89	15.05±1.50	17.4±1.63	*P*1<0.001 *P*2=0.656
Median (IQR)	17.5 (16–20)	15 (14–16.5)	17.5 (16–19)	
Range (minimum–maximum)	5 (15–20)	5 (12–17)	5 (15–20)	
Plantar flexion (degree)				
Mean±SD	47.7±2.38	45.4±2.34	47.3±2.34	*P*1=0.003 *P*2=0.59
Median (IQR)	47.5 (45.5–49.5)	45 (43.5–47)	47.5 (45–49)	
Range (minimum–maximum)	7 (45–52)	8 (42–50)	8 (44–52)	

Table 4 Distribution of Eversion and Inversion (degree) follow-up data among the study population

	Sound side (normal) (*n*=20)	3 months FU (donor side) (*n*=20)	6 months FU (donor side) (*n*=20)	*P* value
Eversion (degree)				
Mean±SD	16.55±1.46	14.6±1.18	16.3±1.26	*P*1<0.001 *P*2=0.565
Median (IQR)	16 (15–18)	14.5 (14–15.5)	16 (15–17.5)	
Range (minimum–maximum)	4 (15–19)	4 (13–17)	3 (15–18)	
Inversion (degree)				
Mean±SD	31.65±1.63	30.1±1.61	31.3±1.49	*P*1=0.004 *P*2=0.482
Median (IQR)	31.5 (30–32.5)	30 (29–31.5)	31.5 (30–32)	
Range (minimum–maximum)	5 (30–35)	5 (28–33)	5 (29–34)	

plantar flexion of the donor versus the contra-lateral normal ankle. This could be because of intact patellar bone and tenodesis of the distal stump of peroneus longus to peroneus brevis. Goyal *et al.* [15] performed ACLR using the ipsilateral Peroneus Longus autograft in cases of ACL and multi-ligament knee injury. They found that all patients' ankle plantar flexion was not significantly different from the normal side. Therefore, they concluded that for a multi-ligament knee injury and ACL repair reconstruction, the Peroneus Longus autograft could be considered a potential autograft choice. These results indicate that using the PLT for ACLR is effective and has little impact on ankle joint function.

At the same time, eversion and inversion of the donor ankles decreased at 3 months post-operatively but returned to near normal at 6 months. Rhatomy *et al.* [16] revealed a comparative study of the ankle eversion and first-ray plantar flexion strength on the donor site vs. the contra-lateral site at 6 months postsurgery with no significant differences. Keyhani *et al.* [4] found that no significant differences were found in the ROM of the ankle (flexion/extension, inversion/eversion, and angle of rotation) at the donor site compared with the contralateral healthy ankle side.

Another study by Angthong *et al.* [17] revealed that the peak torque of inversion and eversion was significantly lower after harvesting the PLT graft. However, the study evaluated only ten patients for isokinetic testing at seven months follow-up. Their study compared the inverter strength (*P*=0.13) and first-ray plantar flexion strength (*P*=0.26) to the normal side.

Conclusion

There was a statistically significant difference between preoperative examination and three months postoperatively. However, no statistically significant difference in the functional outcomes between the normal and donor ankles at the 6-month follow-up. Further studies with larger scales are needed to confirm our results.

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Consent for publication: all authors have read and revised well for the manuscript and agree to publish.

Availability of data and material: All data supporting the study are presented in the manuscript or available upon request.

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Conflicts of interest
There are no conflicts of interest.

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