Peroneus Longus Autograft versus Hamstring Autograft in Anterior Cruciate Ligament Reconstruction: One-year Follow-up Comparative Study

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Abstract

Background: Most injuries to the knee ligaments that occur in sports and accidents involve the anterior cruciate ligament (ACL). ACL reconstruction (ACLR) aids in restoring knee function and stability. The main autograft options available are the hamstring tendon (HT) and the bone-patellar tendon-bone (BPTB).

Objectives: To compare the function and outcomes of the knee and ankle following ACLR using peroneus longus tendon (PLT) and hamstring tendon (HT) autografts.

Patients and methods: Patients who underwent isolated single-bundle ACL reconstruction were divided into two groups (hamstring tendon and peroneus longus tendon groups) and observed for one year. The functional scores of the knee (IKDC, Lysholm and modified Cincinnati) were assessed preoperatively and 1 year after surgery, as was the graft diameter intraoperatively. Ankle morbidity was assessed using the AOFAS, FADI and VAS-FA scores in the peroneus longus group, in addition to thigh circumference measurements in both groups.

Results: One hundred thirty patients fulfilled the inclusion criteria and were assigned to two groups (peroneus longus, n=65; hamstring, n=65). No significant differences in functional scores were observed between the groups. A significantly larger graft was observed in the peroneus longus group. The peroneus longus group showed excellent donor ankle function based on functional scores.

Conclusion: PLT full-thickness autografts provide a stable painless knee, with an excellent range of motion and improved quality of life, comparable to those of hamstring tendon autografts at the one-year follow-up, with less thigh hypotrophy and excellent ankle function.

Introduction

ACL tears represent approximately half of all knee joint injuries. ACLR is used to restore rotatory and anterior-posterior knee laxity. There are a variety of surgical procedures, grafts, and fixation systems available today. HT and BPTB autografts were regarded as the best grafts. Although autografts have advantages, they also have drawbacks. Specifically, employing a BPTB graft is associated with an increase in anterior knee pain, the likelihood of a contralateral ACL tear, and eventual osteoarthritis. The use of HT autografts may result in an imbalance between the knee flexors and extensors, increasing the risk of autograft failure. Xenografts and allografts are utilized infrequently because of a number of factors, including their high cost, high likelihood of graft failure, and persistence of Lachman and pivot shifts over time. The advancement of research and understanding of knee biomechanics and kinematics motivates the pursuit of novel surgical methods that maintain the joint's dynamic stability. The PLT is a potentially advantageous alternative due to its quick harvesting, optimal graft thickness, and minimal impact on knee joint stabilizers, all of which contribute to the reduction of potential complications. Nevertheless, there is still a lack of global knowledge regarding the potential of PLT autografts in arthroscopic ACLR and their effect on knee and ankle function. This highlights the need for
additional research in this area, specifically to compare results with those obtained with hamstring tendons, which are the most frequently utilized autografts. To address this deficiency, our research will compare and contrast hamstring tendon grafts and PLTs.

**Patients and Methods**

This prospective cohort study was performed at Al-Azhar University Hospitals, Cairo, Egypt, with formal approval from the ethics committee. This study involved ACL reconstruction between December 2021 and February 2023 in 130 males aged 18 to 45 years who were diagnosed with isolated ACL tears after providing informed consent.

Patients were excluded from the study if they had multiple ligamentous injuries, meniscal tears, significant chondral damage (greater than grade I), peri-articular knee fractures, preexisting pes planus, deformities of the ankle, neuromuscular conditions, or previous significant ankle injuries. Each patient was randomly assigned to one of two groups, the HT or PLT group, which underwent surgery followed by rehabilitation. All surgeries were conducted by the same knee surgeon.

The patients underwent follow-up for 1 year, and a single examiner recorded the outcomes. The functional scores tested before and 1 year after surgery included the International Knee Documentation Committee (IKDC), Lysholm, and modified Cincinnati scores. In both groups, the circumference of the thigh on the affected limb was measured 15 cm above the upper patellar pole and compared to that on the other side. The donor ankle site in the PLT group was evaluated using the American Orthopedic Foot and Ankle Scale (AOFAS), the Foot & Ankle Disability Index (FADI), and the Visual Analog Scale of the Foot and Ankle (VAS-FA).

**Operation procedures**

All procedures were conducted in the supine position under either general or regional (spinal) anesthesia. Additionally, a thigh tourniquet was applied. Initially, standard portals and diagnostic arthroscopy were performed, and thereafter, the graft was harvested from either the hamstring or peroneus longus.

**Peroneus longus tendon harvesting**

An incision measuring 3 cm in length was made vertically on the back of the distal fibula, 2 cm proximal to its tip, and proximal to the superior peroneal retinaculum. After careful excision of the fascia, the peroneal tendons were exposed. The PLT was found in the posterolateral position to the peroneus brevis tendon. Both tendons were sutured together. The proximal segment of the PLT was cut and sutured, after which a long tendon stripper was introduced proximally to a point 2 inches distal to the fibular head to avoid injury to the peroneal nerve. The skin was sutured using 2–0 nylon. The length of the harvested tendon was obtained after it had been released from the muscle tissue. The tendon was tripled using
polyester suture No. 2 (Ethibond, Arthrex, Naples, Florida, USA) to obtain an equal 3-strand autograft, and the tibial end was sutured.

**Hamstring tendon harvesting**

A vertical 3 cm incision was made on the anteromedial part of the upper tibia in the HT group. An open tendon stripper was used to retrieve the hamstring tendons (gracilis and semitendinosus). The tendons were folded to create four strands, and then a polyester suture No. 2 (Ethibond, Arthrex, Naples, Florida, USA) was used to join the tendon ends together by using a whip-stitch technique.

**Graft fixation technique**

The same procedure was utilized for all patients: the tunnels of the femur and tibia were drilled independently of their anatomical positions. The autograft that had been prepared was implanted. Femoral fixation was accomplished using ToggleLoc with ZipLoop (Zimmer Biomet, Warsaw, IN), while tibial side fixation was achieved using a ComposiTCP™ Interference Screw (Zimmer Biomet, Warsaw, IN), which is one size larger than the diameter of the tibial tunnel.

**Statistical analysis**

The statistical analysis was performed with SPSS software (version 23.0, SPSS Inc., Chicago, Illinois). Preoperative and postoperative data were compared utilizing t tests and chi-square tests for inferential statistics. Descriptive statistics were based on the mean and standard deviation. P values < 0.05 were considered to indicate statistical significance.

**Rehabilitation**

The patients were subsequently discharged with a knee immobilizer. The same postoperative protocol was applied for both patients. Shortly after surgery, patients started knee extension and ankle pump exercises. Partial weight-bearing and flexion from 0 to 90 degrees were allowed. At 5 to 6 weeks after surgery, full flexion was achieved along with full weight-bearing. After 3 to 4 months, running was allowed, and at 6 to 9 months postoperatively, patients returned to sports activities.

**Results**

**Demographic data:**

This study included 130 patients who underwent reconstruction of the ACL. Patients were divided into two groups: the hamstring tendon group (n=65) and the peroneus longus tendon group (n=65). They were monitored for a duration of one year. The demographic data of the study population are shown in Table 1.

Table 1 Demographic data of both groups:
The average diameter of the triple PLT graft was 8.89 ± 0.7 mm (ranging from 8 to 10 mm), while that of the four-strand HT graft was 7.61 ± 0.49 mm (ranging from 7 to 8 mm), demonstrating a notable difference (P<0.001).

Table 2 Graft diameter in both groups

<table>
<thead>
<tr>
<th>Graft diameter</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peroneus Longus Group</td>
<td>8.89±0.7</td>
</tr>
<tr>
<td>Hamstring Group</td>
<td>7.61±0.49</td>
</tr>
</tbody>
</table>

Clinical outcomes

According to the findings, the majority of patients in both groups exhibited satisfactory functional outcomes following ACLR surgery. Nonetheless, the functional scores of the two groups showed nonsignificant differences (see Table 3).

Table 3 Preoperation and 1-year postoperative Knee Scores

<table>
<thead>
<tr>
<th>Score</th>
<th>Group</th>
<th>Preoperative</th>
<th>1 Year</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IKDC</td>
<td>Peroneus Longus</td>
<td>54.46±2.92</td>
<td>95.22±4.81</td>
<td>40.76±5.8</td>
</tr>
<tr>
<td></td>
<td>Hamstring</td>
<td>52.59±3.29</td>
<td>94.2±2.05</td>
<td>41.61±3.25</td>
</tr>
<tr>
<td>P value</td>
<td></td>
<td>0.3084 (n.s.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lysholm</td>
<td>Peroneus Longus</td>
<td>52.8±5.45</td>
<td>98.06±4.62</td>
<td>45.27±6.81</td>
</tr>
<tr>
<td></td>
<td>Hamstring</td>
<td>51.77±3.94</td>
<td>97.63±1.99</td>
<td>45.86±3.44</td>
</tr>
<tr>
<td>P value</td>
<td></td>
<td>0.5812 (n.s.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modified Cincinnati</td>
<td>Peroneus Longus</td>
<td>56.11±3.31</td>
<td>96.13±4.78</td>
<td>40.02±6.08</td>
</tr>
<tr>
<td></td>
<td>Hamstring</td>
<td>55.73±3.87</td>
<td>95.75±1.78</td>
<td>40.02±4.24</td>
</tr>
<tr>
<td>P value</td>
<td></td>
<td>1.0000 (n.s.)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Differences in thigh circumference**

The average differences in thigh circumference on the affected side (in cm) compared to the healthy side were analyzed and recorded. The thigh circumference in the PLT group showed a significant increase, with a difference of 1.52±0.24 cm from the healthy side before surgery to 0.24±0.14 cm at the one-year follow-up. In the HT group, there was a decrease from 1.57±0.22 cm from the normal side before surgery to 0.89±0.25 cm at the end of follow-up, as demonstrated in Table 4.

Table 4: Differences in thigh circumference between the two groups

<table>
<thead>
<tr>
<th>Difference in thigh circumference</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preoperative</strong></td>
<td><strong>1 Year</strong></td>
</tr>
<tr>
<td>Peroneus Longus Group</td>
<td>1.52±0.24</td>
</tr>
<tr>
<td>Hamstring Group</td>
<td>1.57±0.22</td>
</tr>
<tr>
<td><strong>P value</strong></td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

**Donor ankle morbidity and function**

During the study, we used measurements such as the AOFAS, FADI, and VAS-FA to evaluate ankle function after harvesting the PLT. Notably, none of the patients had any ankle joint dysfunction or difficulty participating in sports. By the end of one year, the VAS-FA scores were not significantly different, but the AOFAS and FADI scores were significantly different between the two sides (Table 5).

Table 5: Average ankle scores on the donor and contralateral sides

<table>
<thead>
<tr>
<th></th>
<th>Donor’s side</th>
<th>Contralateral side</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOFAS</td>
<td>98.28±1.61</td>
<td>98.62±1.19</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>FADI</td>
<td>98.45±1.4</td>
<td>98.74±1</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>VAS-FA</td>
<td>99.16±0.79</td>
<td>99.32±0.74</td>
<td>0.2518</td>
</tr>
</tbody>
</table>

There was a significant difference in the AOFAS and FADI scores, while no significant difference was found in the VAS-FA scores at the end of follow-up between the donor’s side and the contralateral side.

There was no pain or complaint about ankle joint weakness, vascular or neurological problems, or any discomfort at the donor site. There was no evidence of significant instability or complications in either group.

**Discussion**
Our study revealed that at one year following injury, activity levels were nearly similar to preinjury levels, and no reruptures were observed at subsequent follow-up visits (except for one patient who reinjured).

One of the most critical concerns during knee ACLR surgery is the choice of autograft. We found a statistically significant difference in graft diameter between the two groups, with a 1.28 mm mean difference in favor of the PLT. Previous research has shown a 1.7% revision rate for grafts 8.5 mm in diameter. Furthermore, for grafts between 7 and 9 mm in diameter, every 0.5 mm increase in diameter reduces the likelihood of revision by 0.82 times. 9

The impact of the autograft diameter and the possibility of re-rupture and revision have been widely investigated. Several studies have shown that a decrease in hamstring graft diameter is related to a greater rate of revision. [10]

Another study revealed an improvement in the IKDC score for each 1 mm increase in diameter and a greater revision rate for grafts less than 8 mm in diameter. [11]

Previous biomechanical research investigating the tensile strength of the same cross-sectional surface area among four-strand HTs revealed that the PLT did not significantly differ, with values of 405.8 ± 202.9 and 446.1 ± 233.2, respectively. Further investigations revealed that the PLT peak tensile strength was 2500 N, while that of the native ACL was 1725 N. [12]

The functional scores of patients in the two groups were similar across all follow-up assessments.

At the end of the 1-year period, the IKDC score was 95.22 ± 4.81 for the PLT group and 94.2 ± 2.05 for the HT group. Similarly, according to the Lysholm score, the PLT group had a score of 98.06 ± 4.62, while the HT group had a score of 97.63 ± 1.99. According to the modified Cincinnati scoring system, the PLT group scored 96.13 ± 4.78, and the HT group scored 95.75 ± 1.78. These findings suggest comparable outcomes between the two groups.

No patient in any group experienced flexion or extension loss at the end of one year.

Research conducted by Rhatomy S et al. revealed nonsignificant differences in functional scores (IKDC, Lysholm, and modified Cincinnati scores) among the groups. [13]

In their study, He, J., Tang et al. reported increased Lysholm scores in the PLT group. [14]

Anghong et al. evaluated ankle morbidity following PLT harvesting and reported potential dysfunction and concerns regarding stability. [15]

We assessed ankle function by the AOFAS-Hindfoot Scale, the FADI and the VAS-FA. The mean scores of the donor side for the AOFAS, FADI, and VAS-FA were 98.28 ± 1.61, 98.45 ± 1.4, and 99.16 ± 0.79, respectively. The contralateral side exhibited scores of 98.62 ± 1.19 for the AOFAS score, 98.74 ± 1 for the FADI score, and 99.32 ± 0.74 for the VAS-FA score. Our results showed excellent function of the donor ankle after harvesting the PLT.
Some studies have suggested that the key issue at the donor site (ankle) is ankle instability and eversion deficits during the stance phase of gait. [16]

No patient in our study expressed such issues. This is probably due to the dominant role of the peroneus brevis in ankle eversion, as well as the regeneration capacity of the harvested graft. This implies that harvesting of the peroneus longus tendon causes negligible morbidity to the ankle, and its removal has little to no impact on the joint. [17]

We assessed the thigh circumference of the affected limb before surgery and compared it to that of the healthy limb. The PLT group patients showed greater improvements concerning their preoperative values, with a 0.24 cm average difference at one year from 1.52 cm (preoperative), while the HT group had a 0.89 cm average difference at one year from 1.57 cm (preoperative). Rhatomy S et al. reported similar findings, with significantly less thigh hypotrophy in the PLT group after one year of follow-up. [13]

Harvesting of the hamstring tendons led to thigh hypotrophy, strength reduction, an imbalance in knee dynamic stability and quadriceps-hamstring asymmetry. [18]

Hence, it is clear that the PLT group had a longer recovery period, with less thigh hypotrophy.

**Conclusion**

Our findings showed that using peroneus longus tendon autografts for arthroscopic single-bundle ACL reconstruction had outstanding functional success and postoperative knee stability comparable to those of a quadruple hamstring tendon graft. It showed minimal donor site morbidity and improved thigh muscle hypotrophy (a greater response to rehabilitation than did the HT group), indicating that it is an acceptable and reliable autograft option for r ACL reconstruction.

**Abbreviations**

- ACL
- ACLR
- PLT
- HT
- IKDC
- AOFAS
- AOFAS
- FADI
- VAS-FA
Declarations

- Ethics approval and consent to participate: Ethical approval was obtained from the ethics committee before starting the study, and all patients consented to participate in this study.
- Consent for publication: This study was obtained from all participants.
- Availability of data and materials: All data and materials are available
- Competing interests: No financial or nonfinancial competing interests
- Funding: No funding was received from any party, and all patients were covered by national insurance.
- Authors' contributions: All the authors mentioned contributed to this work. Dr. Ibrahim: performed the arthroscopic procedures, Dr. Emad: followed up on the patients, Dr. Islam: analyzed and interpreted the data and wrote the manuscript.
- Acknowledgments: Not applicable

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