RESEARCH ARTICLE

Functional Outcomes of Anatomic Single Bundle Primary ACL Reconstruction with Peroneus Longus Tendon (Without a Peroneal Tenodesis) Versus Hamstring Autografts

Kiran Acharya, MS(Ortho); Aashay Mody, MS(Ortho); Sandesh Madi, MS(Ortho)

Research performed at Kasturba Medical College, Manipal, Manipal Academy of Higher education, Manipal, Karnataka, India

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Abstract

Objectives: There is a paucity of comparative studies on the Peroneus longus tendon versus conventional hamstring autograft use in primary single-bundle ACL reconstruction. To date, there are no studies that reported donor ankle functional outcomes when a peroneus longus graft is harvested without performing a tenodesis to peroneus brevis.

Methods: A single-center retrospective comparative study was undertaken to evaluate the functional outcomes (IKDC & Tegner-Lysholm scores) of primary isolated single bundle anatomic ACL Reconstruction with Peroneus Longus tendon (PL group) versus Hamstring (HT group) autografts. Further, an evaluation of donor ankle morbidity using the AOFAS score for the PL group and persistent anteromedial thigh pain and paraesthesia around the knee for the HT group was also performed.

Results: 30 patients were evaluated in each group. The mean graft diameter was 8.61 +/- 0.66mm (HT) & 9.6 +/- 0.84mm (PL) and the mean graft length was 7.39cm (HT) & 7.86cm (PL) respectively. The mean IKDC scores were 58.2 (Pre-op) & 89.52 (1 year) for the HT group and 61.8 (Pre-op) & 90.9 (1 year) for the PL group respectively. The mean Tegner-Lysholm scores were 69.83 (Pre-op) & 91.96 (1 year) for the HT group and 70.66 (Pre-op) & 92.36 (1 year) for the PL group respectively.10% of the HT group had residual anteromedial thigh pain & 6.7% had paraesthesia at one-year follow-up. In the PL group, the mean AOFAS score was 96.37 +/- 2.49 at the end of one year. Two cases (6.66%) reported paraesthesia around the harvested site.

Conclusion: Peroneus longus tendon appears to be a better autograft choice than hamstrings for primary ACL reconstruction. Further, without a peroneal tenodesis, the functional outcomes of the donor ankle remained excellent.

Level of evidence: III

Keywords: ACL reconstruction, Ankle, Hamstring, Peroneus longus tendon, Tenodesis

Introduction

One of the most critical elements of successful ACL reconstruction is an appropriate choice of graft that has adequate length and diameter. Autograft options currently used include Hamstring tendon, Bone-Patella-Tendon-Bone (BPTB), Quadriceps tendon, Peroneus longus, and Ilotibial band. In recent years, it has been noted that the Hamstring tendon has become the most preferred autograft for many surgeons worldwide.[1] Iatrogenic injury to the saphenous nerve, potential deficits in knee flexion and internal rotation, altered dynamic knee stability, premature graft amputation during harvesting, and an unpredictable graft size are some concerns associated with this autograft.

In pursuit of an ideal autograft, the peroneus longus

Corresponding Author: Sandesh Madi, Department of Orthopaedics, Kasturba Medical College, Manipal, Manipal Academy of Higher Education, Manipal, Udupi, Karnataka, India

Email: sandesh.madi@gmail.com

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tendon has also emerged as a potential contender. Initial studies had raised some concerns about donor ankle functions,[2] however, many subsequent recent studies have demonstrated its excellent graft characteristics with minimal donor site issues.[3–10] Continued apprehension and skepticism have led to many surgeons recommending it as a choice for primary ACL or a graft option in revision or multi-ligament cases [11,12] or as an 'augmentation' for insufficient hamstring graft.[13] To minimize donor ankle morbidity some surgeons have also recommended a 'split' graft harvest (anterior half of tendon)[14,15] To further decrease potential morbidity of donor ankle functions, routine tenodesis of the distal end of the peroneus longus to peroneus brevis tendon has been strongly advocated.[16,17] However, there are no studies to justify or refute this surgical step.

Only a few studies have compared the Peroneus longus tendon versus conventional hamstring autograft in primary ACL reconstruction.[8,18–21] This study was undertaken to perform a comparative study on functional outcomes of ACL reconstruction using Hamstring versus peroneus longus graft. The secondary objective was to evaluate the effect of skipping the peroneal tenodesis step during graft harvest on donor ankle functional outcomes.

Materials and Methods

A single-center retrospective comparative study was conducted at an Arthroscopy unit of a Medical College. Patients who had undergone arthroscopic primary ACL reconstruction between November 2017 and November 2019 were selected. Institutional Ethics Committee clearance was obtained before starting the study [IEC: 904/2020; approval date:12/03/2021]. Inclusion criteria were patients aged more than 18 years of both sexes with isolated ACL injury, who had undergone primary anatomic ACL reconstruction using HT or PL grafts and completed a minimum of one year of follow-up. Exclusion criteria were patients with multi-ligamentous injury, patients with pre-existing knee or ankle arthritis, flat foot, ankle deformities, neuromuscular disorders, and any incomplete records.

Demographic and surgical data of potential patients were retrieved from hospital records. An Arthroscopic Proforma was prepared to record the necessary data for each case. Data was collected based on findings at the time of presentation, intra-operative measurements, and subsequent follow-up at one year. Scores were assigned based on various certified Scoring Systems (IKDC, Tegner-Lysholm, and AOFAS scores) and relevant complaints of patients were noted. All patients were clinically examined by a senior surgeon (KA) at follow up and the data was meticulously recorded in the proforma.

ACL reconstruction Procedure

All patients were electively operated on by a single senior Arthroscopy surgeon (KA) under spinal or general anesthesia with the patient in the supine position and a tourniquet applied. Diagnostic arthroscopy was performed and all concomitant meniscal or cartilage procedures were completed before graft harvesting.

For the HT graft, a 3-4cm obliquely placed incision over the anteromedial border of the tibia near the tibial tuberosity was made. The sartorial fascia was carefully incised, and Semitendinosus and Gracilis tendons were identified and separated from each other near insertion. Any additional fascia bands attached to these tendons were identified and released. Each tendon was then whip-stitched at its distal end with sutures (#2 FiberWire Suture) and harvested one by one with the help of a tendon stripper.

For the PL graft, about 3cm proximal and 1cm posterior to the tip of the lateral malleolus, a 1-2cm long incision was placed [Figure 1a]. The common peroneal synovial sheath was incised, and Peroneus longus and brevis tendons were identified [Figure 1b]. With right-angle artery forceps, only the PL tendon was forced out [Figure 1c]. Sutures (#2 FiberWire Suture) were placed on the tendon [Figure 2a]. The tendon was divided without a tenodesis to brevis tendon [Figure 2b]. Using a long tendon stripper, the tendon was harvested about 5 cm distal to the fibular head to prevent injury to the peroneal nerve [Figure 2c]. The common peroneal sheath, subcutaneous layer, and skin were meticulously closed [Figure 2d].

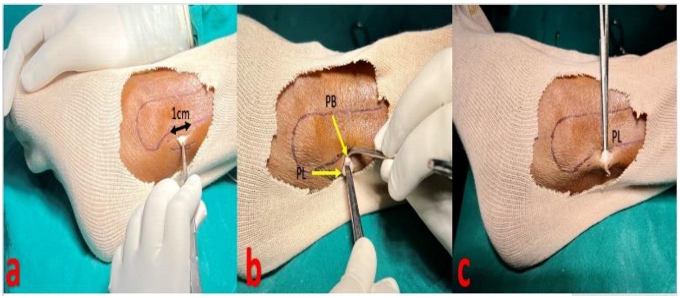

Figure 1. a - Placement of 1cm incision for Peroneus longus tendon harvest; b – identification of two peroneal tendons; c – peroneus longus levered out of skin incision

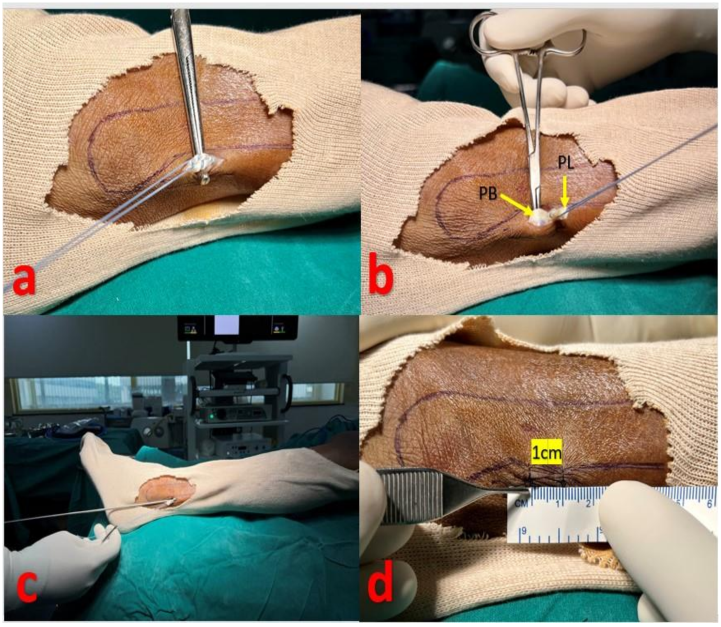

Figure 2. a – Peroneus longus tendon whip stitched; b- No peroneal tenodesis performed; c- tendon harvested using tendon stripper (Ankle is in plantar flexion at the time of graft harvest to avoid potential iatrogenic injury to sural nerve); d: final closure of 1cm incision

In both graft scenarios, the muscle fibers were stripped from the tendons over a graft board [Figure 3a & 3b]. Whipstitches were placed on both ends of the tendon with similar sutures. The graft was fashioned into multiple strands to obtain a minimum graft diameter of > 7.5mm in thickness. The final prepared graft was wrapped in a gauze pre-soaked in Vancomycin and placed over a graft tensioner [Figure 4]. From an accessory anteromedial portal, an anatomic femoral tunnel was prepared. An anatomic tibial tunnel was drilled at the native footprint of the ACL using an ACL tip aimer jig set between 45 to 50 degrees (Acufex, Smith, and Nephew, USA). The final graft was passed through the tunnels and fixed with a suspensory fixation (Tightrope, Arthrex, Florida, USA) on the femoral side. For preconditioning, the knee was routinely cycled for 15-20 times. A Bio-interference screw (Arthrex, Florida, USA) was used to secure the graft on the tibial side and fixed with the knee in 30 degrees of flexion.

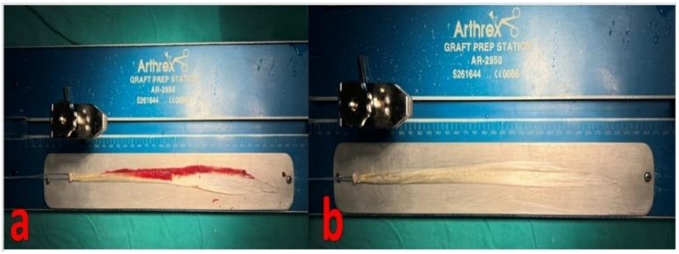

Figure 3. a – Harvested graft placed over graft board; b - Muscle fibres stripped from the tendon

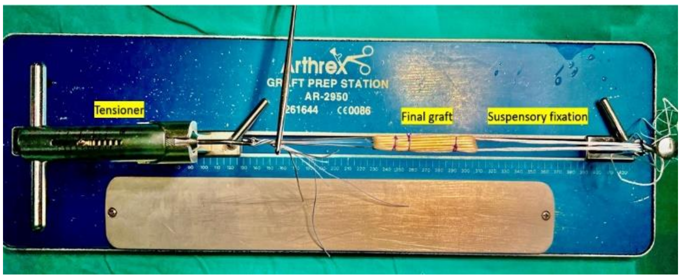

Figure 4. Final graft prepared over a suspensory button and tensioner applied

Post-operative Protocol & Rehabilitation

Similar rehabilitation protocols were followed in both groups regardless of the graft used in surgery. During the first four days, compressive dressing with a knee immobilizer was applied. Gait training with partial weight bearing using bilateral axillary crutches and knee flexion was started on the first postoperative day. Additional eversion and plantar flexion strengthening exercises were initiated in the PL group. The wound inspection was done on the fourth postoperative day. The criteria for discharge were pain-free knee and ankle mobilization and patient confidence with crutch walking. Patients were advised to use the walking aids for the first four weeks. In case of any concomitant meniscal repair performed, patients were kept non-weight-bearing for one month. Full weight bearing without crutches was permitted after one month. Strength training was initiated at the end of two months. Return to sports was allowed at the end of nine months to one year after satisfactory progress in rehabilitation and clinical assessment of knee stability.

Statistical Analysis

For continuous variables, descriptive statistics have been used. An Independent't-test' was used for group comparisons for continuously distributed data. The chi-square test was used for comparing categorical variables between the groups. Wilcoxon matched-pairs signed-ranks test was used for non-parametric data. $P < 0.05$ was considered to be statistically significant. All statistical analysis was computed using SPSS software (SPSS version 25.0, Chicago, Illinois).

Results

Statistical Analysis

During the study period, 68 patients underwent isolated arthroscopic anatomic single-bundle ACL reconstruction. 8 cases had to be excluded due to incomplete records. 30 patients in each group were available for undertaking this study. The demographic profile of the study population is shown in [Table 1]. The graft characteristics are reported in [Table 2]. Based on the demographic profile, the two groups were comparable (P value > 0.05). A larger mean graft diameter and length was noted in the PL group and the difference was statistically significant (P value <0.05). The difference in pre-operative and final follow-up knee functional outcomes (IKDC and Tegner Lysholm scores) between the two groups was not statistically significant. However, the difference in improvement of knee functional scores between pre-operative and final follow-up for each group was statistically significant (P value <0.05) [Table 3]. The mean AOFAS ankle hindfoot score in the PL group at the final follow-up was 96.37 +/- 2.49 (a score of 90-100 points is considered 'excellent'),[22] but the difference from pre-operative scores was statistically significant (P value <0.05) [Table 4].

Donor site morbidity (HT group)

2 patients complained of anteromedial thigh pain whilst 1 patient complained of persistent paraesthesia around the knee at the final follow-up.

Donor site morbidity (PL group)

Two cases (6.66%) reported paraesthesia around the harvested site and one patient reported bulging of the proximal stump. None of the patients in the PL group had any scar tenderness, infection, wound dehiscence, cosmetic issues, undue scarring, ankle stiffness, subsequent ankle instability or sprains, loss of foot arch architecture, or foot pain.

Lastly, a firm endpoint (grade 0 to 1 laxity) and no symptoms of knee instability were noted in all patients in both groups. There were no major complications such as graft ruptures, infections, contralateral ACL tears, or thromboembolic events in both groups.

Table 1. Demographic profile of two groups

VARIABLE	HT GROUP	PL GROUP	P VALUE
AGE	28.56 +/-7.52 years	27.73 +/- 7.32 years	0.066 (NS)
GENDER	26 males/4 females	28 males/2 females	χ2 = 0.741, P = 0.671 (NS)
SIDE	14 right/16 left	16 right/14 left	χ2 = 0.267, P= 0.6 (NS)
INJURY MECHANISM	RTA (13)/ FALL (7)/SPORTS (10)	RTA (14)/ FALL (4)/SPORTS (12)	χ2 = 1.037, P= 0.59 (NS)
INJURY TO SURGERY	8.3+/-4.1 MONTHS	5.9 +/-4.6 MONTHS	0.13 (NS)
FOLLOW UP	13.6 (RANGE 12-20 MONTHS)	13.3 (RANGE 12-16 MONTHS)	0.40 (NS)
LATERAL MENISCUS TEAR	05 (2 REPAIRED)	06 (3 REPAIRED)	χ2 = 0.111, P= 0.73 (NS)
MEDIAL MENISCUS TEAR	13 (5 REPAIRED)	10 (3 REPAIRED)	χ2 = 0.634, P= 0.42 (NS)
CHONDRAL LESIONS (GRADE I/II)	8	10	χ2 = 0.317, P= 0.57 (NS)

Table 2. Comparison of graft characteristics

GRAFT	HT GROUP	PL GROUP	P VALUE
DIAMETER	8.61 +/- 0.66	9.6 +/- 0.84	<0.00001
LENGTH	7.39 +/- 0.65	7.86 +/- 0.63	<0.006
STRANDS	3 (2)/4(25)/5(2)/6(1)	3 (8)/4(22)	

Table 3. Knee Functional Outcomes

IKDC KNEE SCORE	HT GROUP	PL GROUP	P VALUE
PRE-OPERATIVE	58.2 +/- 9.45	61.79 +/- 9.31	0.14 (NS)
FINAL FOLLOW-UP	89.52 +/- 3	90.9 +/- 2.73	0.06 (NS)
P VALUE	<0.00001; W-value is 0	<0.00001; W-value is 0	
T-L KNEE SCORE			
PRE-OPERATIVE	69.83 +/- 8.17	70.66 +/- 10.18	0.72 (NS)
FINAL FOLLOW-UP	91.96 +/- 2.57	92.36 +/- 2.69	0.55 (NS)
P VALUE	<0.00001; W-value is 0	<0.00001; W-value is 0	

TABLE 4. Ankle functional scores in PL group

SCORES	PRE-OPERATIVE	FOLLOW-UP	RANGE	P VALUE	MEAN DIFFERENCE
AOFAS	100	96.37 +/- 2.49 (Excellent)	88 - 100	<0.00001; W-value is 0	3.63

Discussion

Two important findings are evident in this study: 1. The PL group had consistently larger graft diameter and length than the HT group. 2. The ankle functional scores in the PL group remained 'excellent' with minimal morbidity at one-year follow-up. This is the first study to report on satisfactory functional outcomes of a donor's ankle when the graft was harvested without performing a peroneal tenodesis.

An important surgical decision during ACL reconstruction is choosing a graft that can be easily fashioned to an appropriate diameter. However, even with two tendons (gracilis + semitendinosus), fashioning a sizeable graft can be challenging. In this study, the mean graft diameter in the HT group was 8.61 +/- 0.66mm, which satisfactorily meets the required dimensions. But in ACL surgeries, not only graft size matters, a larger diameter is desirable. In this study, the mean graft diameter in the PL group was 9.6 +/- 0.84mm and the difference was statistically significant (P<0.05).

Hamstring grafts are currently the mainstay in ACL reconstruction. However, donor site complications are not uncommon. Damage to the saphenous nerve during graft harvest appears to be the most common complication.[23] It may be argued that this complication can be avoided to some extent by performing meticulous dissection and adopting careful harvesting techniques. An obliquely placed incision, a posterior approach, or a minimally invasive technique are some of the methods devised to avoid this complication. At our institution, a Hamstring graft is always harvested by placing an oblique incision followed by careful dissection of sartorial fascia and appropriate release of all fascial bands around the tendon, before tendon stripping. Despite these measures, damage to the infrapatellar branch of the saphenous nerve remains unpredictable and a small proportion of patients may continue to experience variable degrees of anteromedial thigh pain or paraesthesia located around the graft harvest site. In the present study, 10% (n = 3/30 cases), complained of persistent sensory disturbances and thigh pain at the final follow-up.

In contrast, PL graft harvesting is a less technically demanding and quicker procedure. Iatrogenic damage to the sural nerve can be prevented by two measures: precise placement of incision (two-finger breadth proximal and one finger breadth posterior to lateral malleolus) [6,24] and by keeping ankle plantarflexed at the time of tendon harvest.[25] In the present study, 6.66% (2/30 cases) complained of paraesthesia around the harvested site at the final follow-up. Even at three years of follow-up, 6.19% (7/106 cases) of paraesthesia and pressure pain at the harvested site has been reported.[26] Bulging of the proximal stump is another unusual symptom associated with PL grafts without any significant functional impairments. Only one patient reported this symptom in the present study. However, this symptom has been reported to be as high as 20.8% (5/24 cases).[2]

Another important point of concern with hamstring grafts is the magnitude of muscle power loss. Deficits in internal rotation and flexion strengths have been reported even one year after ACL reconstruction when both tendons are harvested.[27] incomplete semitendinosus tendon regeneration along with decreased muscle volume and length are some of the causative factors attributed to these strength deficits.[28] to overcome this issue, Hamstring-based strengthening rehabilitation programs are routinely incorporated in the postoperative period. Further, a gracilis-sparing Hamstring graft harvest approach could prevent the removal of both knee flexors. However, the semitendinosus tendon alone may be suboptimal for fashioning grafts with adequate diameter.

The motor deficits after PL harvest are a matter of utmost concern and remain controversial. In one study, significant eversion and inversion strength deficits were noted in the donor's ankle as compared with the opposite ankle at a seven-month follow-up.[2] However, several others did not observe these differences.[5,12] To further decrease potential morbidity, a tenodesis of PL distal stump to peroneus brevis tendon is routinely recommended.[16,17] However, we do not believe this exercise to be of any significant clinical benefit for several reasons. First, peroneus brevis alone appears to be sufficient for producing effective subtalar joint eversion.[29] Second, proud knots under the delicate subcutaneous surface can produce soft tissue irritation or wound complications. Lastly, there is a potential risk for inadvertent damage to the sural nerve when tenodesis is attempted and stitches are placed distally. We acknowledge that this aspect of PL graft harvesting needs further evaluation. However, in the present study, in the absence of a tenodesis, no deterioration in functional scores of the donor's ankle was observed.

There have been only a few comparative clinical studies between conventional HT grafts versus PL grafts. Common observations from these studies were PL grafts had a larger graft size, comparable knee functional outcomes, minimal hypotrophy of the thigh, and no significant donor ankle dysfunction.[8,19,21] The present study concurs with the findings of these comparative studies in terms of superior outcomes for PL graft. In all these studies, routine peroneal tenodesis was performed. This is the first study to report excellent ankle functional scores even without a tenodesis.

Limitations

As a retrospective comparative study, data collection and analysis depend on patients' records. To ensure accurate documentation an institution-designed ACL proforma was devised and data was meticulously recorded and archived by the same operating team members. Secondly, clinical assessment was performed using only functional scoring systems. The objective assessment for strength and stability was not evaluated. Thirdly, AOFAS scores are classified as 'fair', 'good', and 'excellent'; which is controversial and somewhat arbitrary. Although a statistically significant difference was noted between pre-operative and final AOFAS scores, the mean AOFAS score in the PL group was excellent. In a recent systematic review, it has been observed that a slight decrease in AOFAS scores is usually expected from PL graft harvest.[30]

Conclusion

Peroneus longus tendon appears to be a better autograft choice than hamstrings for primary ACL reconstruction. Further, without a peroneal tenodesis, functional outcomes of the donor's ankle remained excellent. However, further studies exploring the consequences of this surgical step are warranted.

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Kiran Acharya MS(Ortho)[1]
Aashay Mody MS(Ortho)[1]
Sandesh Madi MS(Ortho)[1]

1 Department of Orthopaedics, Kasturba Medical College, Manipal, Manipal Academy of Higher Education, Manipal, Udupi, Karnataka, India

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